Child-rearing, Social Security and Married Women's Labor Supply over the Life Cycle*

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Abstract

This paper studies how career interruptions during child-rearing years affect the labor market trajectory, lifetime earnings, and Social Security benefits of married women in the United States. To this end, I develop a dynamic structural life-cycle model of female labor supply, savings, and Social Security benefit claiming and estimate the model using the Method of Simulated Moments for the 1943-1954 cohort. I use the estimated model to quantify the effect of three revenue-neutral counterfactual policy reforms: (i) introducing a Social Security caregiver credit that covers the lost earnings during the first 5 child-rearing years through changes in retirement benefits, (ii) combining the introduction of caregiver credit with the elimination of spousal and survivors benefits, and (iii) removing spousal and survivors benefits. I find that the gender gap in average career earnings at the Social Security Early Retirement Age reduces significantly under all three counterfactual scenarios, with the largest effect of 12.77% decline under the second reform. The findings suggest that instituting caregiver credit for child-rearing in the absence of the marriage-based Social Security benefits would offset a substantial portion of the motherhood penalty in lifetime labor earnings of married women and increase their retirement benefit adequacy.

Keywords: Caregiver Credit, Female Labor Supply, Life-cycle Model, Social Security
JEL Classification Codes: D15, E21, H55, I38, J13, J21, J26

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1 Introduction

In the United States, despite making significant progress in the labor market over the last decades, women still face challenges to balance work and child care responsibilities (Cortes & Pan, 2020; Goldin, 2014).[1] Women's dominant role in child care often limits their career progression and leads to a substantial loss in wage earnings, accumulated work experience, and lifetime earnings. The impact of this motherhood penalty on lifetime earnings may result in lower Social Security retirement benefits if mothers claim benefits based on their own labor earnings record. Longer life expectancies of women further aggravate threats to the economic security of elderly American women. One key question is, therefore, how important is the role of children in determining women's lifetime earnings and financial security in retirement?

The current Social Security system in the United States offsets a portion of the lost earnings due to child-rearing by providing spousal and survivors benefits. These marriage-based benefits are based on the spouse's (usually the husband's) earning history and have no relation to the recipient's (usually the wife's) work history. Many argue that these noncontributory family benefits are primarily designed to reward marriage as opposed to rewarding parenthood (Herd, 2006). Moreover, more women in the post–World War II birth cohorts are earning eligibility for Social Security retirement benefits based on their own earnings record and relying less on the receipt of spousal benefits (Iams, 2016; Rutledge, Zulkarnain, & King, 2017). To address mothers' retirement income gap, some policy experts have proposed introducing caregiver credit for child care to the Social Security system that would compensate mothers for the impact of children on their lifetime earnings and retirement benefits. The policy would provide up to five years of earnings credit for child care and supplement the mother's earning record to one-half of the average wage in each child care year for the purpose of computing Social Security benefits. This policy concern motivates the main contribution of this paper, which is to evaluate the implication of this child-related policy by examining whether and to what extent implementing caregiver credit to the Social Security system would help reduce the motherhood earnings penalty over the life cycle.

To answer the questions described above, I develop a partial equilibrium dynamic life-cycle model of married households. In this model, forward-looking married women make decisions on savings, labor market participation, and whether or not to apply for Social Security benefits. The arrival of children is exogenous, and the household pays child care costs if the mother works during the child-rearing years. Children influence household spending and savings by increasing consumption needs as well as by altering the mother's participation

[1] As documented by Albanesi and Kim (2021), during the COVID-19 recession, employment losses were larger for mothers due to limited availability of in-person childcare and schooling options.

decision. Labor earnings of women are determined by work experience, which accumulates or depreciates depending on their participation decision. When making these decisions, the households face several forms of uncertainty: wage shocks, uncertainty associated with out-of-pocket medical expenditure, and survival risk. The model allows households to save in order to insure themselves against adverse shocks as well as for retirement, but they are not allowed to borrow against future labor income and Social Security benefits to smooth out consumption in the face of shocks to household resources. I explicitly model the Social Security system, a realistic schedule of federal income taxation, the payroll tax structure, and the differential tax treatment of married and widowed households. The model includes the provision of spousal and survivors benefits and accounts for the actuarial adjustment of claiming retirement benefits at any point between age 62 and 70. The detailed depiction of the Social Security system allows us to understand how the public pension system in the US interacts with women's career decisions over the life cycle.

A key element of the model is the influence of a woman's participation decision, accumulated work experience, wage earnings, and Social Security benefit claiming decision on her average career earnings. Her average career earnings not only affect the incentives and preferences for work, but also determine how much retirement benefit she receives if she claims based on her own earnings history. Thus, the framework fully accounts for how career interruptions due to childbirth would interact with married women's human capital accumulation, lifetime earnings, and Social Security benefit entitlement. Most importantly, this framework allows us to study the dynamic implications of reforming the Social Security system by adding earnings credits for child care to the calculation of a mother's average career earnings.

I estimate the model using the Method of Simulated Moments (McFadden, 1989; Pakes & Pollard, 1989) and match data for the cohort born in 1943-1954. There are two reasons for choosing this cohort: first, this cohort represents the early and mid-baby boomers. As documented in the vast literature on female labor supply, there was a significant increase in the labor force participation rate of married women born in this cohort (Attanasio, Low, & Sánchez-Marcos, 2008; Eckstein & Lifshitz, 2011; Toossi & Morisi, 2017). Second, the actuarial adjustment of Social Security benefits is the same for everyone born in this cohort. I estimate a subset of the structural parameters of the model using data from two data sets: the Panel Study of Income Dynamics (PSID) and the Health and Retirement Study (HRS). I then use numerical simulation of the model to recover the remaining preference parameters.

Having estimated the model parameters, I use the model to simulate behavior in counterfactual scenarios and assess the welfare implications. I conduct three revenue-neutral policy exercises that have direct effect on the labor market trajectory and retirement benefits of women: (1) introduce Social Security caregiver credit that covers the lost earnings during the first 5 child-rearing years through changes in retirement benefits, (2) combine the introduction of Social Security caregiver credit with the elimination of marriage-based noncontributory Social Security benefits (spousal and survivors benefits), and (3) remove Social Security spousal and survivors benefits.

The results point towards two main findings. First, the model predicts that introducing the provision of earning credits for child care in the Social Security system would reduce participation of married women during the child-rearing years, but the contributory nature of the caregiver credits creates incentive to work in the post-childrearing period. Increased participation beyond child-raising years is more substantial in the second counterfactual scenario when the child-related credit is instituted in the absence of the spousal and survivors benefits. This is partly intuitive: as the unavailability of marriage-based noncontributory benefits reduces insurance against health expenditure risks in the later stage of the life cycle, women have more incentive to increase their contributory Social Security benefits by boosting their earnings record. Increased attachment to the workforce under the second reform also increases accumulated work experience at the Social Security Early Retirement Age (ERA) of age 62 by 3.74%.[2]

Second, lifetime pre-tax labor earnings of married women increase significantly under reform 2 and reform 3. Most importantly, the gender gap in average career earnings at the ERA reduces significantly under all three counterfactual scenarios. The largest effect is observed under reform 2 with 12.77% decline in the difference between average career earnings of married men and that of married women at the ERA of age 62. This effect is mainly driven by two channels that boost the average career earnings of married women. The first channel works through the returns to work experience: increased participation over the life cycle leads to higher accumulation of human capital, resulting in higher future labor earnings. The second channel works through the caregiver credit, which provides earning credits for the child-rearing years if the mother chooses to stay away from the workforce to take care of her children. Overall, these findings suggest that implementing the provision of caregiver credit for child-rearing in the absence of the marriage-based Social Security benefits would offset a substantial portion of the motherhood earnings penalty over the full life cycle and increase retirement benefit adequacy of married women if they claim Social Security benefits solely on their own work history.

Related Literature. This paper builds on several different strands of the literature. First,

[2] The Social Security Early Retirement Age (ERA) refers to the minimum age at which a worker can start claiming Social Security retirement benefits.

this paper contributes to a growing literature that seeks to understand how the changes in the Social Security benefit rules affect female labor supply over the life cycle. Knapp (2013), Kaygusuz (2015), Sánchez-Marcos and Bethencourt (2018), Nishiyama (2019) and Groneck and Wallenius (2021) find that eliminating Social Security spousal and survivor benefits would increase female labor participation. Groneck and Wallenius (2021) also explore the role of Social Security spousal and survivor benefits as redistributive instruments. A recent paper by Borella, De Nardi, and Yang (2019) find that marriage-based tax and social insurance policies, such as Social Security spousal and survivor benefits and joint income taxation, provide strong disincentive to work to married women, and the elimination of these rules raises participation of married women over their adult lives. My paper complements and extends this literature by examining the effect of instituting the provision of caregiver credit to the US Social Security system on married women's labor supply, lifetime earnings and retirement benefits. To the best of my knowledge, this is the first paper that attempts to quantify the behavioral and welfare implications of introducing caregiver credit to the US Social Security system using a dynamic structural life-cycle model setup. A smaller set of papers predict that caregiver credits would do better than spousal benefits at reducing poverty and redistributing to the women at the bottom of the lifetime earnings distribution (Favreault & Sammartino, 2002; Favreault & Steuerle, 2007; Herd, 2006).

Second, this paper contributes to a large literature that studies female labor supply over the life cycle and explores how women's labor market trajectory and earnings evolve after the arrival of children. Attanasio, Low, and Sánchez-Marcos (2008) and Eckstein and Lifshitz (2011) construct life-cycle models of female labor participation and study the role of decreasing the cost of child-rearing in explaining changes in participation rates of married women across birth cohorts. Olivetti (2006) constructs a life-cycle model of married couples that includes the home production of child care and the human capital accumulation process based on learning-by-doing. Her results show that higher returns to labor market experience is a critical factor for the increase in female market work hours. Guner, Kaygusuz, and Ventura (2020) and Hannusch (2019) show how child-related transfers affect employment rates of married women. Altonji, Hynsjo, and Vidangos (2021) examine what determines the family income that men and women experience over the life cycle by estimating a dynamic model of earnings, nonlabor income, fertility, marriage, and divorce. Blundell, Pistaferri, and Saporta-Eksten (2018) highlight the interaction between children and labor supply, and their results suggest that the reduction of mother's child care time is critical to any analysis of the consequences of policies that generate incentive for mothers with young kids to participate in the workforce. My paper contributes to this strand of literature by uncovering the channels through which career breaks during child-rearing years shape married women's lifetime earnings and retirement security.

Third, this paper draws from the vast literature on the "motherhood penalty" or "child penalty" that studies reduction in labor earnings for women when they become mothers and throughout the course of their lifetime.[3] Using data from Germany, Adda, Dustmann, and Stevens (2017) find that about three-quarters of the life-cycle career costs associated with children is due to intermittent or reduced labor supply. Using Danish administrative data, Gallen (2018) find that about 8 percentage points of the 12 percent residual pay gap between men and women can be explained by the decrease in productivity by mothers. In a recent paper by Blundell, Costa-Dias, Goll, and Meghir (2021), the authors estimate a life-cycle model of female labor supply and human capital accumulation through work experience and training. They evaluate a policy of subsidizing work-related training for mothers with young children and show that the policy increases lifetime disposable income of women who left education after completing high school.

Using reduced form approaches, a few recent papers have argued that lower lifelong earnings due to sporadic employment during child-rearing years and greater returns to additional work beyond mid-life have raised the cost of early retirement for women (Goldin & Katz, 2017; Goldin & Mitchell, 2017; Maestas, 2017). Moreover, in the past few decades, the growth in the earnings of married women has outpaced the growth in the earnings of married men across cohorts (Eckstein, Keane, & Lifshitz, 2019). Since Social Security retirement benefits are determined as a function of earnings over a 35-year period, this narrowing gender gap in lifetime earnings plays a central role in determining women's retirement security. Maestas (2017) points out that working beyond the ERA of 62 until age 70 would significantly increase the lifetime benefits of married women such that the gain in years worked at old ages would offset early gaps in the earning record on account of childbearing. The present paper extends this literature by evaluating how instituting the Social Security caregiver credit would interact with the earnings profile of married women and quantify the extent to which this policy helps reduce the gender gap in average lifetime earnings.

The rest of the paper is organized as follows. Section 2 describes the institutional details of the Social Security system in the US. Section 3 describes the model. Section 4 discusses the data and the estimation method of the model parameters. Section 5 reports the parameter estimates of the model. Section 6 discusses the counterfactual analysis. Section 7 concludes.

[3] For a comprehensive survey of this strand of literature, see Cortes and Pan (2020).

2 Institutional Context

In the United States, Social Security retirement benefits are essential to the economic well-being of older workers. Created by the Social Security Act of 1935, the Old-Age, Survivors, and Disability Insurance (OASDI) program provides monthly public pension benefits to qualified retired workers. As of June 2020, about 65 million Americans received monthly Social Security benefits.

Social Security replaces a percentage of a worker's pre-retirement income based on their lifetime earnings. Individuals who receive contributory benefits based on their own labor earnings record are referred to as "retired-worker beneficiaries". The Social Security system also provides noncontributory family benefits to qualified spouses and survivors of the retired workers.[4] The Social Security spousal benefit establishes that the spouse with lower lifetime earnings (usually the wife) is entitled to the highest between benefit based on her own earnings and up to 50 percent of her husband's full pension once both of them start claiming benefits. The widows (or the widowers) can collect the Social Security survivor benefits, at rates ranging from 71.5 percent to 100 percent of the deceased spouse's Social Security benefit. These auxiliary benefits work as a minimum retirement benefits for the secondary earner in a married household. The auxiliary benefit recipients are classified into two categories: first, women who do not qualify for benefits based on their own work record, but qualify for up to 50 percent of their spouse's retired-worker benefit, are referred to as "spouse-only beneficiaries"; and second, women who qualify for benefits based on their own work record and a spouse or survivor benefit based on their spouse's work record, are known as "dually entitled beneficiaries". Generally, the Social Security Administration (SSA) pays the highest between the two benefits.

As per the SSA, the proportion of women aged 62 or older receiving a Social Security benefit based on their own earnings record has been increasing over the last few decades. The fraction of dually entitled women increased from 5 percent in 1960 to 28 percent in 2010. Women receiving spouse-only benefits declined from 33 percent in 1960 to 10 percent in 2010, while those receiving only retired-worker benefits increased from 39 percent in 1960 to 46 percent in 2010. One of the main factors driving this increase is the larger participation of married women in the labor force. Given this empirical trend, this paper seeks to understand to what extent Social Security compensates women for their lost earnings due to motherhood if the women claim benefits based on their own earnings history.

[4]Benefits are also paid to eligible children and parents of the retired, disabled, and deceased workers. I abstract from considering this small group of beneficiaries in this paper.

Caregiver Credit. In most developed countries, except the United States, the public pension systems recognize child care duties by rewarding caregiver pension credits for the time spent away from the labor market while caring for children. Since countries vary in terms of the primary objective for which this policy is designed, there is a wide variation in the caregiver credit programs across countries.[5] These credits usually complement a universal public pension to serve multiple goals, for example, reward unpaid care, improve retirement benefit adequacy, encourage new mothers to return to the workforce, or promote higher fertility rates.

In the United States, advocates of caregiver credits have proposed a bill to amend the Social Security Caregiver Credit Act of 2021 (House of Representatives, Congress, 2021). The bill creates a Social Security earnings credit, equal to half of the average national wage earnings, to the mothers who leave the workforce to care for their children.[6] The credit could be claimed for up to 5 years, and the credit would be added to the calculation of average career earnings that determines their future Social Security benefits. The main objective for including caregiver credits in Social Security is to reward women for raising children by supplementing their worker benefits and improving their retirement benefit adequacy. Given the fiscal budget constraint, one challenge is how to finance the extra cost of establishing caregiver credits. In order to address this concern, I evaluate the effect of instituting caregiver credits in a revenue-neutral setup. Since the Social Security system in the United States is set up to be self-financing, one way to achieve revenue-neutrality is to increase the Social Security tax rate. I further evaluate the effects under a counterfactual scenario where caregiver credit is introduced in the absence of auxiliary marriage-based benefits. Elimination of the spousal and survivor benefits would also offset the cost of introducing the provision of caregiver credit to some extent.[7]

3 The Life Cycle Model

I develop a finite-horizon, discrete-time, partial equilibrium, dynamic life cycle model to understand the role of children in determining married women's career, lifetime earnings and Social Security retirement benefits. Below, I describe the model components in detail before presenting the exact recursive formulation of the model.

[5] Jankowski (2011) documents the details of the caregiver provisions under public pension programs in the European countries.

[6] Although the bill introduces caregiver credit for providing care to any "dependent relative", in the context of the present paper, I discuss the feature of the proposed bill that applies to mothers of young children.

[7] Favreault and Steuerle (2007) conduct a similar expenditure-neutral exercise using the dynamic microsimulation model of the US population.

Household Composition. I assume that unitary households maximize expected lifetime utility.[8] All households are initially made up of two adults who remain married. Husband's labor supply is modelled in an exogenous fashion.[9] To keep the model tractable, I assume that fertility is exogenous and I abstract from modelling possibility of divorce and endogenous marriage and separation over the life cycle. Households dissolve through death and I assume that there is no possibility of remarriage after death of spouse.[10]

Model Period and Stages of the Life Cycle. Let t be the wife's age $\in \{t_0, ..., T\}$, with $t_0 = 25$ and $T = 90$ being the maximum possible life span. Agents enter the model at the start of working life, at age 25. Time is discrete, a model period is a year. I set husband's age as $t+3$ as tracking both spouses ages separately will increase the state space substantially.[11]

The dynamic model is solved for 3 stages of the life-cycle: (1) working stage (from age 25 till age 61), (2) retirement transition stage (from age 62 till age 70), and (3) full retirement stage (from age 71 till the maximum age of 90). Individuals begin their working stage of life at age 25 (t_0) and remain in that stage till age 61 ($T^{ER} - 1$). The retirement transition stage spans from the Social Security Early Retirement Age of 62 (T^{ER}), the minimum age at which people can start claiming Social Security benefits, till age 70 (T^{FR}), the maximum age at which delayed retirement credit can be claimed. The full retirement stage begins at age 71 ($T^{FR} + 1$) and death occurs with certainty after period T (at age 91).

During the working stage, the household makes decisions on consumption, savings, and the wife's labor force participation. Husbands always work in this stage. Both spouses face risks associated with earning shocks. During the retirement transition stage, households make decision regarding consumption, savings, wife's labor force participation and choose whether or not the wives start claiming benefits (if they have not already started claiming).[12] They also face risks associated with earning shocks. Husbands stop working in this stage, and they start claiming benefits. During the full retirement stage, everyone stops working and receives Social Security benefits until death; the household makes decision on

[8]The unitary model is the most commonly used intertemporal household model as it can account for the intertemporal allocation of resources at the household level.

[9]The assumption that the husband's labor force participation is taken as predetermined in the female labor supply decision is standard in the papers that model dynamic labor supply decisions of married women. For example, Attanasio et al. (2008), Eckstein and Lifshitz (2011), Sánchez-Marcos and Bethencourt (2018), among others assume husband's labor supply to be exogenous.

[10]No remarriage after widowhood is a simplifying assumption. It is a reasonable assumption for older couples since rate of remarriage drops significantly among older population.

[11]Several papers make similar assumption, for example, see Lee (2020).

[12]Note that when to claim Social Security benefits is a financial decision, and this decision is different from retirement decision about when to exit from the labor force.

consumption and savings. In this stage, both spouses face survival risks and the household face out-of-pocket health expenditure risks.

Preferences. Households derive utility from consumption and disutility from female labor supply. I consider instantaneous utility function of an individual household is defined as:

$$u(c_t, P_t; n_t) = \frac{(\frac{c_t}{n_t})^{(1-\gamma)}}{1-\gamma} - \psi_t P_t, \text{ with } \gamma \geq 0 \text{ and } \psi_t > 0 \tag{1}$$

where c_t is household consumption, $P_t \in \{0, 1\}$ is a discrete female labor supply choice that takes value 1 if the woman decides to participate in the labor force and 0 otherwise, and n_t is the number of adult equivalents in the household. γ measures the degree of risk aversion over consumption, and ψ_t measures disutility from work. Utility cost of a woman's work depends on her age:

$$\psi_t = \begin{cases} \psi_y, & \text{if } t_0 \leq t \leq T^{ER} - 1 \\ \psi_o, & \text{if } T^{ER} \leq t \leq T^{FR} \end{cases}$$

I assume that $\psi_o > \psi_y$. This captures higher cost of working for older workers. The utility function is constant relative risk aversion (CRRA) and is separable in consumption and participation in the labor market. Women can freely exit and re-enter the labor force in the working stage as well as in the retirement transition stage.

Returns to Work Experience and Labor Income over the Life Cycle. Since husbands are continuously employed until retirement, their earnings are simply a function of their age $(t + 3)$ and stochastic shocks. Female earnings are endogenous as I assume that women accumulate human capital, x_t, through participation in the labor force. I assume that both female and male earnings are subject to permanent income shocks. In particular, I assume that earnings of spouse $j \in \{h, w\}$ are governed by the following processes:

$$log(y_t^h) = a_0^h + a_1^h(t + 3) + a_2^h(t + 3)^2 + Z_t^h \tag{2}$$

$$log(y_t^w) = a_0^w + a_1^w x_t + a_2^w x_t^2 + Z_t^w \tag{3}$$

where Z_t^j denotes the permanent component of spouse j's labor income process.

Assuming learning-by-doing technology, wife's experience at the beginning of period $t+1$ is given by:

$$x_{t+1} = \begin{cases} x_t + 1, & \text{if } P_t = 1 \\ x_t - \delta, & \text{if } P_t = 0 \end{cases} \tag{4}$$

where x_t is the total number of years of labor market experience in period t. If a woman participated in the work force in the previous period, her human capital, measured in terms of years of work experience, increases by one year. If she did not participate in the previous period, her human capital is subject to depreciation at rate δ. The endogeneity of wages through learning-by-doing technology is an important feature in studying female labor supply decisions because it captures how labor market spells related to child-bearing and child-rearing have a trade-off in terms of future wages (Sánchez-Marcos & Bethencourt, 2018). The accumulated work experience over the life cycle also determines average career earnings that is used to compute the amount of Social Security benefits.

Labor income of husband and wife, y_t^h and y_t^w, are subject to permanent income shocks, Z_t^j. In particular, I assume that the permanent component follows a random walk process:

$$Z_t^j = Z_{t-1}^j + \zeta_t^j \tag{5}$$

where the shocks are distributed as follows:

$$\begin{pmatrix} \zeta_t^h \\ \zeta_t^w \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} -\sigma_{\zeta^h}^2/2 \\ -\sigma_{\zeta^w}^2/2 \end{pmatrix}, \begin{pmatrix} \sigma_{\zeta^h}^2 & \rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w} \\ \rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w} & \sigma_{\zeta^w}^2 \end{pmatrix}\right)$$

Permanent innovations are uncorrelated within persons over time. In the spirit of Attanasio et al. (2008), Blundell et al. (2018), and Haan and Prowse (2017), I allow income shocks to be correlated across spouses in the same households.[13] I assume that variances and covariances of the income shocks are constant over the life cycle. More details on the income processes are described in Appendix C.1.

Average Career Earnings and Social Security Benefits. Each spouse receives a constant amount of Social Security benefit which is a concave function of their Average Indexed Monthly Earnings (AIME) that captures the progressivity of the US Social Security system. In practice, AIME equal a worker's average labor income during his or her 35 highest earnings years, adjusted for inflation. Precise calculation of AIME requires keeping track of a worker's entire earnings history. In order to avoid the need to keep track of every individual's historical earnings record, I approximate $AIME_t$ as a function of average career earnings, E_t.[14]

During the working career of a woman, her average career earnings are updated in the

[13]Several empirical papers find evidence of a correlation between the labor market earnings of married couples. For more details, see Hyslop (2001).

[14]Several studies, such as Borella et al. (2019), French and Jones (2011), Nishiyama (2019), Van der Klaauw and Wolpin (2008), adopted similar approach to approximate AIME.

model according to her endogenous participation decision, earnings and accumulated work experience:

$$E_{t+1}^{w} = \mathbb{I}_{\{t<t_{cl} \text{ \& } x_t \leq 35\}} \left[\frac{1}{(t+1-t_0)} \left[(t-t_0)E_t^w + min(y_t^w, y_{max}) \times P_t \right] \right] + \mathbb{I}_{\{t \geq t_{cl} \text{ or } x_t > 35\}} \left[E_t^w \right] \tag{6}$$

where $\mathbb{I}\{\cdot\}$ is an indicator function that returns 1 if the condition holds and 0 otherwise, t_{cl} is the age at which the woman claimed Social Security Benefits for the first time, t is the current age, and t_0 is the age at the beginning of the life cycle. If a woman chooses to work, her average career earnings are updated by adding the minimum between yearly labor market earnings, y_t^w, and maximum taxable earnings, y_{max}. If she does not work, the amount earned is counted as zero. A woman's work experience also represents the number of years she has contributed to the Social Security system. If she worked fewer than 35 years, Social Security credits her with zero earnings for each year up to 35. For individuals who work less than 35 years, working more years automatically increases their average career earnings; and for those who have already worked more than 35 years, working more years increases their benefits only if labor income earned later is higher than income earned in some previous years. For computational simplicity, I assume that for a woman who hasn't started claiming benefits her current earnings update average career earnings only if her work experience is less than or equal to 35 years. This approximation of average career earnings thus captures incentive to work implicit in the formula for AIME.

Average career earnings for husbands are updated by taking into account his exogenous labor supply behavior and earnings:

$$E_{t+1}^{h} = \mathbb{I}_{\{t-t_0+1 \leq 35\}} \left[\frac{1}{(t+1-t_0)} \left[(t-t_0)E_t^h + min(y_t^h, y_{max}) \right] \right] + \mathbb{I}_{\{t-t_0+1 > 35\}} \left[E_t^h \right] \tag{7}$$

I assume that average career earnings of a husband is updated during the first 35 periods of the model.

The Average Indexed Monthly Earnings for spouse j, $AIME_t^j$, is computed as spouse j's average career earnings (measured at age t) divided by 12:

$$AIME_t^j = \frac{E_t^j}{12}, \text{ for } j \in \{h, w\} \tag{8}$$

Appendix A describes in detail how Social Security benefits are computed as function of $AIME$.

Taxes. Households pay federal income taxes, $\tau_{fed}(rA_t, y_t^w, y_t^h)$, on household's taxable income, which is composed of earned interest on asset, rA_t, and labor earnings of the two spouses (y_t^w and y_t^h). Households also pay a proportional payroll tax, $\tau_{payroll}(y_t^j, y_{max})$ on labor income of spouse $j \in \{h, w\}$, up to a maximum taxable earnings, y_{max}. I assume that Social Security benefits are not taxable.[15] See Appendix B for details on how taxes are computed.

Government Transfers and Minimum Consumption Floor. Following the work of Hubbard, Skinner, and Zeldes (1995), I assume that government transfer payments TR_t guarantee a minimum consumption level $\underline{c}$ for low-income households. Thus, $\underline{c}$ represents a consumption floor that is available to households when household earnings fall to zero. The insurance provided by means-tested programs such as the Supplemental Nutrition Assistance Program (SNAP), the Supplemental Security Income (SSI), and the Medicaid is represented by $\underline{c}$. Thus, the government transfers bridge the gap between a household's total resources and the minimum consumption floor $\underline{c}$. In order to make these transfers consistent with public social insurance programs, I impose that if the total household resources in period t is less than the minimum consumption floor $\underline{c}$, $c_t = \underline{c}$ and $A_{t+1} = 0$

Fertility and Child Care Costs. I model exogenous arrival of children by assuming that childbirth occurs at predetermined ages of the mother: a woman has her first child at age 26, a second child arrives two years after the first child, and no further children are born. I assume that, if a woman with children decides to work, then the household incurs child care expenses, chc_t. Child care costs depend on the age of the mother and evolve exogenously with household composition, in particular, with the number and age of children living in the household. I assume that children reside in their mother's household until they reach 18 years of age.

Out-of-Pocket Medical Costs. Households face out-of-pocket medical expenditure risk in the fully retired stage. Since the distribution of out-of-pocket health expenditure has a long right tail and a high probability of very minimal expenditures, I model the conditional expectation of health costs given wife's age as follows:

$$\mathbb{E}(m_t^j | t^w) = m_t^j \times Pr(m_t^j > 0 | t^w) \tag{9}$$

[15] For some people, a portion of Social Security benefits is subject to federal income taxes if their modified adjusted gross income (AGI) exceeds a certain amount. For more details on taxes on Social Security benefits, see: https://www.ssa.gov/benefits/retirement/planner/taxes.html

The conditional distribution of positive out-of-pocket medical expenditure is assumed to be log-normal. The log of medical expenses is modeled as a function of the wife's age. For married households,

$$log(m_t^{hh}) = \pi_0^{hh} + \pi_1^{hh} t^w + \nu_t^{hh} \ , \ \nu_t^{hh} \sim N(0, \sigma^2_{\nu^{hh}}) \tag{10}$$

where m_t^{hh} is the sum of out-of-pocket medical expenditure of both spouses. For widowed households,

$$log(m_t^{wd}) = \pi_0^{wd} + \pi_1^{wd} t^w + \nu_t^{wd} \ , \ \nu_t^{wd} \sim N(0, \sigma^2_{\nu^{wd}}) \tag{11}$$

where m_t^{wd} is the out-of-pocket medical expenditure of the widow.

Mortality risk. In the full retirement stage, both spouses face mortality risk, which is assumed to be exogenous and independent of all other risks. If alive in period t, spouse j survives to period $t+1$ with probability $surv_{t+1}^j$. Mortality shocks of each spouses are also independent of each other. There exists a date, T, such that the probability of living after T is zero.

3.1 Borrowing Constraint and Intertemporal Budget Constraint

In the model, consumption choices are subject to a borrowing constraint that requires household asset to be non-negative at all times: $A_t \geq 0$. This constraint prevents a household from borrowing against its future income. This is partly due to the fact that borrowing against future labor income, Social Security benefits and means-tested program benefits is not allowed.

During the working stage, the husband always works, and the wife chooses whether to participate in the work force. Therefore, the household's budget set depends on a wife's participation status. The household intertemporal budget constraint for this stage can be written as follows:

$$\begin{aligned} c_t + A_{t+1} =& (1+r)A_t + y_t^h + (y_t^w - chc_t) \times P_t - \tau_{fed}(rA_t, y_t^h, y_t^w \times P_t) \\ & - \tau_{payroll}(y_t^h, y_t^w \times P_t, y_{max}) + TR_t \end{aligned} \tag{12}$$

where c_t is household consumption, A_t is household assets, r is the interest rate (rA_t thus denotes interest income), y_t^h is husband's earning, y_t^w is wife's earning if she decides to work, TR_t is government transfers, τ_{fed} represents federal income taxes on the sum of labor income of both spouses and the returns from assets, $\tau_{payroll}$ represents Social Security payroll taxes on labor income up to Maximum Taxable Earning, y_{max}. If a woman works, the household faces child care expenses chc_t. In this stage, TR_t is parameterized as:

$$\begin{aligned} TR_t = min\{\underline{c}, max\{0, \underline{c} - ((1+r)A_t + y_t^h + (y_t^w - chc_t) \times P_t - \tau_{fed}(rA_t, y_t^h, y_t^w \times P_t) \\ - \tau_{payroll}(y_t^h, y_t^w \times P_t, y_{max}))\}\} \end{aligned} \tag{13}$$

where $\underline{c} = \underline{c}^{y,k}$ for households with young kids and $\underline{c} = \underline{c}^{y,nk}$ for households with no young kids.[16]

During the retirement transition stage, the household budget constraint depend on wife's employment status as well as on her benefit claiming status. The household faces the following budget constraint:

$$\begin{aligned} c_t + A_{t+1} =& (1+r)A_t + b_t^h \times (1 - B_t) + b_t^{couple} \times B_t + y_t^w \times P_t - \tau_{fed}(rA_t, y_t^w \times P_t) \\ & - \tau_{payroll}(y_t^w, y_{max}) \times P_t + TR_t \end{aligned} \tag{14}$$

where TR_t is parameterized as:

$$\begin{aligned} TR_t = min\{\underline{c}, max\{0, \underline{c} - ((1+r)A_t + y_t^w \times P_t + b_t^h \times (1 - B_t) + b_t^{couple} \times B_t \\ - \tau_{fed}(rA_t, y_t^w \times P_t) - \tau_{payroll}(y_t^w, y_{max}) \times P_t)\}\} \end{aligned} \tag{15}$$

where $\underline{c} = \underline{c}^{y,nk}$ for households with no young kids. Details on computation of the household Social Security benefits are documented in Appendix A.

During the full retirement stage, both spouses exit from the labor force and receive Social Security benefits. The household retirement benefit, b^{couple}, is the sum of the husband's benefit and the wife's benefits, subject to the maximum family benefit amount, PIA_{fmax}. The household spends money on consumption, c_t , and on household out-of-pocket medical expenditures, m_t^{hh}. Since both spouses are retired in this stage, they do not pay payroll taxes, or taxes on labor income. Household pays federal income tax on non-labor income. The rest of the household's money is the household assets saved for the next period, A_{t+1}. Therefore, the budget constraint for a married household is given by:

$$c_t + A_{t+1} = (1+r)A_t + b_t^{couple} - \tau_{fed}(rA_t) - m_t^{hh} + TR_t \tag{16}$$

where b_t^{couple} denotes total social security benefits received by husband and wife. In this case,

[16] In this paper, I specify kids in the age group 0-10 as "young" kids. When a woman's age is between 26 and 38, the household has young kids.

TR_t is parameterized as:

$$TR_t = min\{\underline{c}, max\{0, \underline{c} - ((1+r)A_t - \tau_{fed}(rA_t) + b_t^{couple} - m_t^{hh})\}\} \tag{17}$$

where $\underline{c} = \underline{c}^{o,M}$ for retired married households.

In case of widowhood, I assume that the household assets stay with the surviving spouse. In the full retirement stage, the budget constraint for a widowed household is given by:

$$c_t + A_{t+1} = (1+r)A_t + b^{widow} - \tau_{fed}(rA_t) - m_t^{wd} + TR_t \tag{18}$$

For the widowed household, TR_t is parameterized as:

$$TR_t = min\{\underline{c}, max\{0, \underline{c} - ((1+r)A_t - \tau_{fed}(rA_t) + b^{widow} - m_t^{wd})\}\} \tag{19}$$

where $\underline{c} = \underline{c}^{o,W}$ for retired widowed households.

3.2 Recursive Formulation of Household's Decision Problem

In this section, I present the decision problem of the households for different stages of the life cycle in terms of recursive formulation.

The Value Function during the Working Stage

In each period of the working stage, women optimally solve for continuous decisions (consumption, equivalently savings), conditional on the discrete decisions (binary labor force participation choice) taking as given state variables that period and next period's value function. Thus, the optimization problem can be represented in terms of choice-specific value functions which give the lifetime discounted value of a vector of discrete and continuous choices, for a given set of state variables. In each period t, if the woman chooses to participate, the value function is given by:

$$V_t^{M,1}(\Omega_t) = \max_{c_t}\Big\{u(c_t, P_t = 1, n_t) + \beta\mathbb{E}_t\Big[\max\Big\{V_{t+1}^{M,0}(\Omega_{t+1}), V_{t+1}^{M,1}(\Omega_{t+1})\Big\}\Big]\Big\}$$

where β is the discount factor, and $\mathbb{E}_t$ is the expectation operator conditional on information at time t. If she decides not to participate, the value function is given by:

$$V_t^{M,0}(\Omega_t) = \max_{c_t}\Big\{u(c_t, P_t = 0, n_t) + \beta\mathbb{E}_t\Big[\max\Big\{V_{t+1}^{M,0}(\Omega_{t+1}), V_{t+1}^{M,1}(\Omega_{t+1})\Big\}\Big]\Big\}$$

The maximization is subject to the budget constraint faced by a married household in the working stage. The household chooses optimal consumption that maximize each value function conditional on all discrete choice alternatives. Once consumption is substituted out of each value function the discrete labor supply decisions can be made. The woman decides to participate in the labor force in period t if:

$$V_t^{M,1}(\Omega_t) > V_t^{M,0}(\Omega_t)$$

The state space, Ω_t, consists of age, beginning of the period household assets, beginning of the period female labor market experience, average career earnings of both spouses, and permanent income shocks of both spouses. The household's participation choice and consumption choice at period t determine the evolution of the endogenous state variables (assets, female labor market experience, and female average career earnings) at the start of the next period, $t+1$.

The Value Function during the Retirement Transition Stage

In this stage, in addition to labor force participation choice and consumption choice, a woman can choose whether or not apply for Social Security benefits. Let the indicator variable $B_t \in \{0, 1\}$ denote a woman's Social Security benefits claiming decision; it takes value one if the woman has applied for benefits in period t, and zero otherwise. The woman solves for continuous choice $C_t = c_t$ (consumption choice) and two discrete choices, $D_t = (P_t, B_t)$ (decisions regarding labor force participation and Social Security benefit claim), taking as given state variables that period and next period's value function. Each period, a set of 4 discrete alternatives is available to the households: $D_t = \{(P_t = 1, B_t = 1),$ $(P_t = 1, B_t = 0)$, $(P_t = 0, B_t = 1)$, and $(P_t = 0, B_t = 0)\}$, and the households optimally choose c_t, conditional on the discrete action $d_t \in D_t$. Proceeding backwards, the solution for the optimal continuous and discrete choices can be computed in two stages: first, optimal continuous choices are computed conditional on each discrete choice alternative, $d_t \in D_t$ (inner maximization); second, the household chooses the discrete option that yields highest value (outer maximization).

The optimization problem can be represented in terms of choice-specific value functions which give the lifetime discounted value of a vector of household choices, (D_t, C_t), for a given set of state variables, Ω_t. The value function for a household in period t is given by:

$$V_t^M(\Omega_t) = \max_{d_t \in D_t} \left[\max_{c_t} u(c_t, d_t = k, n_t) + \beta \mathbb{E}_t V_{t+1}^M(\Omega_{t+1}) | d_t = k \right]$$

subject to the budget constraint faced by a married household in the retirement transition stage.

In this stage, the state space, Ω_t, consists of age, beginning of the period household assets, beginning of the period female labor market experience, permanent income shocks, average career earnings of both spouses, and an indicator of whether the wife has started claiming benefits before period t. As in Casanova (2010), I define retirement status of the wife as a function of her participation decision. If the wife chooses not to participate in the work force in this stage (that is at any age between the ERA of 62 and age 70), she is considered as retired. Wife's retirement is not an absorbing state as she can re-enter the labor force in any period during this stage. Wife's benefit claiming is an absorbing state such that entitlement to Social Security benefits is determined the first time the wife claims benefits, and it is not possible for her to accrue more benefits in future periods. In this stage, the husband is retired as he stops working and starts claiming benefits.

The Value Function during the Full Retirement Stage

In the terminal period, $t = T$, households consume all available resources.[17] In preceding periods ($T^{FR} < t < T$), households solve for optimal consumption.

$$V_t^M(\Omega_t) = \max_{c_t}\Big\{u(c_t, n_t) + \beta\Big[\ surv_{t+1}^h surv_{t+1}^w\ \mathbb{E}_t[V_{t+1}^M(\Omega_{t+1})] \\ +(1 - surv_{t+1}^h) surv_{t+1}^w\ \mathbb{E}_t[V_{t+1}^W(\Omega_{t+1})]\Big]\Big\}$$

$V_{t+1}^M(\cdot)$ is the value function of a married household. $V_{t+1}^W(\cdot)$ is the value function of a widowed household, and it is specified as follows:

$$V_t^W(\Omega_t) = \max_{c_t}\Big\{u(c_t) + \beta\Big[\ surv_{t+1}^w\ \mathbb{E}_t[V_{t+1}^W(\Omega_{t+1})]\Big]\Big\}$$

The probability that spouse $j \in \{h, w\}$ survives up to age $t + 1$, conditional on surviving up to age t is given by $surv_{t+1}^j$. In this stage, the state space, Ω_t, consists of age, beginning of the period household assets, average career earnings of both spouses, an indicator of whether the wife has started claiming Social Security benefits before period t, and idiosyncratic out-of-pocket medical expense shocks.

Solution Method. The model is solved numerically since there is no analytical solution. The households face a known finite horizon, therefore the decision rules are solved recursively, starting at the final period of life, which I set at $T = 90$. Since death occurs with certainty after period T, the agent consumes all remaining household resources at that point. This implies that $V_T(\Omega_T)$ is known and the model can be solved by iterating backwards. The

[17] I abstract from modelling bequest motive of the representative household.

continuous variables in the state space are discretized. For asset grid and work experience grid, I concentrate more grid points at lower values. The decision rules are obtained for points on the grid by backward induction from the last period. At each age, I solve the value function and optimal decision rules, given the current period state variables and the solution to the value function in the next period. In order to solve the optimization problem at a given point in the state space, I use grid search over the feasible set of policies for each state. To evaluate the value function at points off the grid, I use linear interpolation. For integration of earnings shocks and medical expense shocks, I use Gauss-Hermite quadrature following the procedure explained in Appendix C.2.

4 Estimation Methodology and Data

I estimate the model parameters by adopting a two-step estimation strategy which is similar to the one used by Gourinchas and Parker (2002), French (2005), Blundell, Costa Dias, Meghir, and Shaw (2016). In the first step, I estimate or calibrate certain parameters that can be identified without explicitly using the model. For example, I directly estimate the parameters of the health expenditure process and the labor income process from the data. I set some parameters with reference to the existing literature. Given the parameter values from the first step, I estimate the remaining parameters using the Method of Simulated Moments (MSM). First, I numerically solve the model for a given initial guess of the parameter values and simulate forward to generate the simulated moments. I update the parameter guess on the basis of the fit between the model simulated moments and the data moments and repeat this process until I find the parameter values that generate the closest fit between the model simulated moments and the data moments. In essence, this method compares simulated life-cycle pattern with those in the data and seeks to minimize the distance between theoretical and actual life-cycle patterns. A close match between the data moments and the model simulated moments indicates empirical evidence supporting the life-cycle model as a plausible description of individual behavior.

I use two main longitudinal datasets to estimate the auxiliary processes and the parameters of the model: the Panel Study of Income Dynamics (PSID) and the Health and Retirement Study (HRS). The purpose of using these longitudinal datasets is twofold: first, they have rich information on a wide range of demographic, economic and social characteristics including work history, retirement, health expenses, etc.; and second, a large part of the life-cycle of the 1943-1954 cohorts are covered by these two datasets, that is, I not only observe complete or almost complete labor market histories for the birth cohort I am studying but I also get rich information on other relevant variables over the working period and the retirement period.

4.1 The PSID Data

The PSID started in 1968 collecting longitudinal information on a sample of about 5,000 US households. The PSID interview data were collected annually until 1996 and biennially starting in 1997. The interview data provides key information of demographics, family composition, labor force participation, work history, income. In this paper, I use interview data from the 1968–2017 sample period. I focus on households with married couples in which the wife belongs to the birth cohort 1943-1954 and is aged 25–70. I further restrict the sample to married households with same head and spouse across all waves. Data on hourly wages are constructed using data on labor earnings and total hours worked. Nominal hourly wages are deflated to 2015 dollars using CPI-U of the previous period since respondents in year t report their earnings in year $t-1$. Finally, I winsorize log of hourly real wages at the top and bottom 1 percent to avoid the influence of outliers, similar to the selection used by Blundell, Pistaferri, and Preston (2008).

4.2 The HRS Data

I rely on data from the Health and Retirement Study (HRS) to obtain the estimates of the parameters associated with out-of-pocket health expenditure processes. The HRS is a biennial longitudinal data set of a representative sample of individuals over age of 50 and their spouses. I use the RAND HRS Data file (v2), a cleaned and streamlined version of 15 waves (from 1992 to 2016) of the HRS, that contains variables covering broad range of comprehensive measures related to aging population in the United States. It provides extensive information on demographics, income, labor status, social security claiming status, health expenditure etc. In my estimation sample, I combine observations from the 1924 to 1942 cohort with observations from the 1943-1954 cohort because few individuals from the 1943-1954 cohort have reached age 70 and above in the existing data. I use the data on medical expenditure from the older cohorts to estimate the evolution of these cost over the remaining span of the life cycle. I run the regression using cohort fixed effects, this takes care of the fact that different cohorts are likely to differ in several observable and unobservable aspects, and the old cohorts may have lowe average ou-of-pocket health expenditure than the 1943-1954 cohort.[18] I run the regressions separately for married and widowed households. I drop observations if the respondent is not alive or did not respond. The main variable of

[18] Casanova (2010) adopted similar approach.

interest is the out-of-pocket medical expenditure.[19] I consider only non-imputed values of out-of-pocket medical expenditure, and the nominal medical expenditure values are deflated to 2015 dollars using CPI-U of the previous period since respondents in year t report their earnings in year $t-1$. I winsorize log of out-of-pocket medical expenditure at the top 1 percent to avoid the influence of outliers.

5 Identification and Estimation

In this section, I provide details about how each model parameter is either set or estimated.

5.1 Step 1: Exogenous Parameters and Estimation of Auxiliary Processes

5.1.1 Exogenous Parameters

I take some of the parameters of the model from preexisting estimates. Table 1 reports the set of exogenous parameters. The coefficient of relative risk aversion, γ, is set to 1.5. This value is consistent with the empirical evidence on the elasticity of intertemporal substitution in the US provided by Attanasio and Weber (1995). I set the discount factor to 0.98, and the interest rate to 3%.

Consumption Floor.– Following Blundell et al. (2018), the consumption floor for married households with young children is set at \$13043.40 (in 2015 dollars) which is consistent with the average allowance provided by the Temporary Assistance for Needy Families (TANF) and the Supplemental Nutrition Assistance Program (SNAP), and non-elderly mar-

[19]In Wave 1 of the HRS, there are no questions asked about the costs of health care services. In Wave 2A, only the Financial Respondent is asked to estimate out-of-pocket expenses in the last 12 months for the entire household for two service categories: nursing home stays and all other medical expenditures without specific reference to any of the reported utilization. In Wave 2H (1994), and in all waves going forward, both Financial and non-Financial Respondents are asked whether health care costs are covered fully or partially by insurance and asked to estimate out-of-pocket medical expenditures since the previous interview (for re-interviews) or in the previous two years (for new interviews). If Respondents are unable to provide exact estimates, the survey asks a series of follow-up unfolding bracket questions. In Wave 2H, Respondents are asked to report an estimate of out-of-pocket expenditures that considers all service categories together. From Waves 3-5, Respondents are asked about out-of-pocket spending in four categories: (1) hospital and nursing home costs; (2) doctor, dentist and outpatient surgery costs; (3) average monthly prescription drug costs; and (4) home health care and special facilities or services costs. Beginning in Wave 6, the number of categories expands to eight: (1) hospital costs; (2) nursing home costs; (3) doctor visits costs; (4) dentist costs; (5) outpatient surgery costs; (6) average monthly prescription drug costs; (7) home health care; and (8) special facilities costs. Beginning in Wave 10, a ninth category seeks to capture any additional out-of-pocket medical expenditures that cannot be assigned to any of the other existing categories.

ried households without young kids are guaranteed to get minimum level of consumption worth \$4786.92 (in 2015 dollars). Consumption floor for low-income elderly retired households consider guaranteed minimum income from Medicaid. Following Borella et al. (2019), I set the values of consumption floor at \$12868.17 and \$8578.78 (in 2015 dollars) for elderly married households and for elderly widowed households, respectively.[20]

Table 1: Exogenous Parameters

Parameter		Value	Source
Annual return, risk-free assets	r	0.03	Voena (2015)
Discount factor	β	0.98	Voena (2015)
Relative risk aversion	γ	1.5	Attanasio and Weber (1995)
Wife's human capital depreciation rate	δ	0.074	Attanasio et al. (2008)
Annual Consumption Floor			
Household with young kids	$\underline{c}^{y,k}$	\$13043.40	Blundell et al. (2018)
Household with no young kids	$\underline{c}^{y,nk}$	\$4786.92	Blundell et al. (2018)
Old married household	$\underline{c}^{o,M}$	\$12868.17	Borella et al. (2019)
Old widowed household	$\underline{c}^{o,W}$	\$8578.78	Borella et al. (2019)

Notes: All monetary values are in 2015 dollar.

Equivalence Scale.– I use McClements scale (n_t) to deflate household consumption based on the number of adults in the household and the number of children with their respective ages. Table 2 reports the original McClements scale normalized for one adult.

Table 2: McClements Scale

			+1 child, by age:						
1 adult	2 adults	1+ adults	0-4	2–4	5–7	8–10	11–12	13–15	16 –18
1	1.64	+0.75	+0.148	+0.295	+0.344	+0.377	+0.41	+0.443	+0.59

Child Care Cost.– Following Borella et al. (2019), I consider that the per-child child care cost of having a child age 0-5 and 6-11 are 30% and 7% of a woman's wage earnings, respectively.[21]

Survival Probability.– The annual survival rates of men and women are taken from the Social Security Administration Actuarial Life Tables (Bell & Miller, 2005). I use the reported

[20] Borella et al. (2019) set the consumption floor at \$13030.50 and \$8687 (in 2016 dollars) for elderly couples and elderly singles respectively.

[21] Borella et al. (2019) estimated these child care cost for the 1941-1945 cohort.

survival rates for females born in 1948 since most women in the estimation sample are born between the years 1943 and 1954. For husbands, I use the survival rates for males born in 1948 as well.

5.1.2 Estimation of Spouses' Labor Income Processes

I estimate the labor income parameters for the couple using spouses' hourly wage data from the PSID. Since wages are observed only for women who are participating in the work force, I estimate the equations using only working women and correct for sample selection using the standard Heckman two-step correction method (Heckman, 1979). In the first step, I estimate the selection equation by performing a probit regression of wife's labor force participation with polynomial of wife's age, number of children in the household, age of the youngest child, and real hourly wage of husband as additional exclusion restrictions. In the second step, I regress log of hourly wage on wife's work experience polynomials and the inverse Mill's ratio obtained from the first step. Table 3 reports the estimated coefficients of the two stage Heckman selection correction procedure. Panel A of table 3 reports the estimates of the deterministic experience profile parameters of wife's wage earning process. Table 4 reports estimates of the deterministic age profile parameters of husband's wage earning process. These coefficients are obtained by regressing log of husband's hourly wage on husband's age polynomials.

Table 5 presents the parameters associated with the stochastic components of wage processes of the spouses. Identification of the income shock parameters are described in detail in Appendix D.

5.1.3 Estimation of Out-of-pocket Medical Expenditure Processes

The log of household health costs is modeled as a function of the wife's age. I estimate the coefficients by performing OLS regression. For married households, I focus on households with married couples in which both the husband and the wife are aged 71-100.[22] For each household, the main outcome variable is constructed by taking the log of sum of out-of-pocket health cost of the husband and that of the wife. For widowed households, I restrict the sample to widowed women aged 71-100. The dependent variable is constructed by taking the log of out-of-pocket health cost of the surviving spouse. Table 6 reports the coefficient estimates of Equation (10) and Equation (11).

[22]In the sample, I keep couples who report their marital status to be "married". I do not consider observations that reports marital status to be "married, spouse absent" or "partnered" as the tax and social security policy rules for such couples are not modeled in this paper.

Table 3: Parameter Estimates of the Wife's Labor Income Process

		Estimate	Robust S.E.
Panel A: Wage Equation			
Dependent Variable: $log(y_t^w)$			
experience	a_1^w	0.0710	0.0069
experience^2	a_2^w	-0.0017	0.0002
constant	a_0^w	2.2130	0.0697
Panel B: Selection Equation			
Dependent Variable: $Pr(P_t = 1)$			
experience		0.1572	0.0072
experience^2		-0.0035	0.0002
age		0.0286	0.0114
age^2		-0.0007	0.0001
number of children		-0.1562	0.0143
age of the youngest kid		0.0258	0.0030
real hourly wage of husband		-0.0025	0.0006
constant		-0.2120	0.2236
inverse Mill's ratio		0.1267	0.0792
observations		29,920	

Notes: Results are based on a sample of PSID who were born between 1943-1954, Dependent variable of wage equation in Panel A: log of real hourly wage of wives. Dependent variable of the Probit estimation of selection equation in Panel B: log of real hourly wage of wives. Wage is expressed in year 2015 prices using the CPI-U. Robust standard errors are clustered at the individual level because of the longitudinal nature of the data set.

Table 4: Parameter Estimates of the Husband's Labor Income Process

		Estimate	Robust S.E.
Dependent Variable: $log(y_t^h)$			
husband's age	a_1^h	0.0538	0.0047
husband's age^2	a_2^h	-0.0006	0.0001
constant	a_0^h	1.9883	0.0945
observations		32,356	

Notes: Results are based on a sample of PSID. Dependent variable: log of real hourly wage of husbands. Wage is expressed in year 2015 prices using the CPI-U. Robust standard errors are clustered at the individual level because of the longitudinal nature of the data set.

Table 5: Parameter Estimates of the Income Shocks

Variable	Parameter	Estimate	S.E.
Variance of permanent shocks to husband's wages	$\sigma^2_{\zeta^h}$	0.0366	0.0027
Variance of permanent shocks to wife's wages	$\sigma^2_{\zeta^w}$	0.0453	0.0045
Variance of log(wage) at time 0, husband	σ^2_{0,y^h}	0.2757	0.0094
Variance of log(wage) at time 0, wife	σ^2_{0,y^w}	0.3779	0.0099
Covariance of permanent shocks between spouses	$\rho^{h,w}_{\zeta}\sigma_{\zeta^h}\sigma_{\zeta^w}$	0.0078	0.0025

Notes: See Appendix D for the details on identification of the income shock parameters. Standard errors are computed by bootstrap to account for first stage estimation errors.

Table 6: Parameter Estimates of the Household Health Expenditure Process

		Estimate	Robust S.E.
Panel A: Married Households			
Dependent Variable: log(m^{hh}_t)			
wife's age	π^{hh}_1	-0.0041	0.0031
constant	π^{hh}_0	8.1603	0.2342
s.d. of residual	$\sigma_{\nu^{hh}}$	1.2198	0.0101
observations		10,642	
Panel B: Widowed Households			
Dependent Variable: log(m^{wd}_t)			
wife's age	π^{wd}_1	0.0102	0.0035
constant	π^{wd}_0	6.6254	0.2834
s.d. of residual	$\sigma_{\nu^{wd}}$	1.3882	0.0129
observations		7,615	

Notes: Standard errors of the estimate of standard deviation of residuals are obtained from 1000 bootstrap replications.

5.2 Step 2: Estimation of Preference Parameters by the Method of Simulated Moments

I use simulated profiles to estimate the preference parameter $\theta = \{\psi_y, \psi_o\}$ by employing the method of simulated moments (McFadden, 1989; Pakes & Pollard, 1989). Given an initial guess of the value of θ, I simulate the model for 10000 households to compute a vector of simulated moments, $M_s(\theta)$.[23] The MSM estimator, $\hat{\theta}_{MSM}$, is given by:

$$\hat{\theta}_{MSM} = \arg\min_{\theta} \big((M_{data} - M_s(\theta)\big)' W \big(M_{data} - M_s(\theta)\big)$$

where M_{data} is the vector of data moments and W is a diagonal weighting matrix that uses the inverse of the variance-covariance matrix of the data along the diagnal and zero otherwise.[24]

I calculate the standard errors of the parameter estimates using the following formula:

$$var(\hat{\theta}_{MSM}) = (J'WJ)^{-1}(J'WSW'J)(J'WJ)^{-1}$$

where $J = \frac{\partial M_s(\theta)}{\partial \theta}\big|_{\theta=\hat{\theta}_{MSM}}$ is a matrix of partial derivatives of the moment conditions with respect to the model parameters evaluated at $\theta = \hat{\theta}_{MSM}$, and S is the variance-covariance matrix of the data moments. I compute J using numerical derivative (using two-step finite differences method). I calculate S using bootstrap.

5.2.1 Parameter Estimates

To estimate the utility cost of working for younger and older married women, I target moments related to employment rate of married women in the data that should be informative about these parameters. I calculate these moments for different age groups. Table 7 reports the estimated parameter values.

Table 7: Estimates of Preference Parameters

Parameters	Description	Estimated Value	S.E.
ψ_y	Disutility from work, young workers	0.0028	0.0241 ($\times 10^{-7}$)
ψ_o	Disutility from work, old workers	0.0042	0.4144 ($\times 10^{-7}$)

[23] The parameter estimates are robust to increasing the number of simulated households.

[24] Although the inverse of the variance-covariance matrix is asymptotically efficient, Altonji and Segal (1996) show that the efficient choice of weight matrix can introduce finite sample bias in small samples. For this reason, the diagonal weighting matrix is commonly used in empirical papers using MSM.

The estimated value of ψ_y is 0.0028 which is within the range of reported values from previous studies. For instance, Sánchez-Marcos and Bethencourt (2018) estimated disutility from work for younger women to be 0.0021. The estimated value of ψ_o, 0.0042, is greater than the estimated value of ψ_y. This captures that utility cost of working is higher for older married women.

5.2.2 Model Fit

Table 8 shows the internal fit of the model by reporting the data moments along with the simulated moments. I estimate 2 parameters targeting 5 moments, hence we have an overidentified case.

Table 8: Model Fit

Targeted Moments	Data	Model
Mean employment rate of Married Women		
Age 25-30	0.2032	0.3937
Age 31-40	0.6062	0.5272
Age 41-50	0.6945	0.5781
Age 51-61	0.6580	0.5135
Age 62-70	0.3239	0.3009

Overall, the model does a good job at predicting the share of married women participating in the workforce. It overpredicts the employment rate of married women at the beginning of the working life (that is, for the age group 25-30), but overall performs well in fitting the employment rate of married women over the life cycle.

6 Counterfactual Policy Analysis

In this section, I discuss the results of three policy experiments. In the first experiment, I introduce the Social Security caregiver credit. Following the changes proposed in the bill for the Social Security Caregiver Act of 2021 (House of Representatives, Congress, 2021), I introduce the policy that if a mother leaves the labor force completely to care for her children (under age six), she will receive annual pension credit for the first 5 years (or 60 months) of child-rearing.[25] The amount of credit for each year of child care would equal one

[25] Caregiver credits are applied sequentially from the birth of the first child. In the model, a representative woman is aged 26 to 30 during the first 5 years of child rearing.

half of the average national earnings. The credit would be added to the calculation of the mother's average career earnings (or equivalently, to the calculation of AIME), which would be used to determine her Social Security retirement benefits. This is achieved by changing the equation for the average career earnings for women:

$$
\begin{aligned}
E_{t+1}^{w} = & \mathbb{I}_{\{t=t_0 \text{ and } x_t \leq 35\}} \Big[min(y_t^w, y_{max}) \times (P_t = 1) \Big] \\
& + \mathbb{I}_{\{26 \leq t \leq 30 \text{ and } x_t \leq 35\}} \Big[\frac{1}{(t+1-t_0)} \big[(t-t_0) E_t^w \\
& + min(y_t^w, y_{max}) \times (P_t = 1) + 0.5 \times NAWI \times (P_t = 0) \big] \Big] \\
& + \mathbb{I}_{\{31 \leq t < t_{cl} \text{ and } x_t \leq 35\}} \Big[\frac{1}{(t+1-t_0)} \big[(t-t_0) E_t^w + min(y_t^w, y_{max}) \times (P_t = 1) \big] \Big] \\
& + \mathbb{I}_{\{t \geq t_{cl} \text{ or } x_t > 35\}} \Big[E_t^w \Big]
\end{aligned}
$$

where $NAWI$ is the National Average Wage Index. In 2015 dollar terms, $NAWI$ takes value \$48, 098.63.[26] The motivation for this exercise is to evaluate the effect of a policy that cover the lost earnings during child-rearing years through changes in retirement benefit.

In the second experiment, I combine the introduction of the Social Security caregiver credit with the removal of the provision of Social Security spousal and survivor benefits. Traditionally, the Social Security system in the US recognizes the caregiving role of married women by providing spousal and survivors benefits (Munnell & Eschtruth, 2018). It is also worth noting that with the increase in married women's labor force participation and labor earnings in the recent cohorts, more women are claiming Social Security benefits based on their own earning history and relying less on spousal and survivor benefits (Butrica & Smith, 2012; Rutledge, Zulkarnain, & King, 2021; Wu, Karamcheva, Munnell, & Purcell, 2013). As estimated by Rutledge et al. (2021), the share of women receiving Social Security spousal benefits has dropped from 35 percent in 1960 to 18 percent in 2019. Therefore, by shutting down the provision of spousal and survivors benefits, we can capture the pure effect of the caregiver credit in offsetting the lost earnings due to child-rearing.

In the third experiment, I eliminate the provision of Social Security spousal and survivor benefits. The motivation for this exercise is to quantify the effect on labor supply of married women in the absence of the benefits based on their husband's earning records. Under this scenario, the motherhood penalty on lifetime earnings can only be offset through the gain from the Social Security's progressive benefit formula, which replaces a higher share of

[26] Historical values of the National Average Wage Index can be obtained from the SSA's website: https://www.ssa.gov/oact/cola/AWI.html

pre-retirement labor earnings for lower earners.

In order to make the counterfactual policies comparable with the baseline scenario, I set the policy experiments to be revenue-neutral such that they give rise to the same government budget deficit, expressed in dollar terms relative to the government budget deficit in the baseline model. This revenue-neutrality is achieved by adjusting the proportional Social Security tax (part of the payroll taxes). For each policy experiment, I use an iterative procedure to find the adjusted tax rate that generate deficit under the policy to be equal to deficit under the status quo. The tax rate is increased by 0.83 pp. and to 0.48 pp. to fund the first and the second policy reforms, respectively. While eliminating the spousal and survivors benefits in the third experiment, the government runs a budget surplus. Therefore, the tax rate is decreased by 0.305 pp. to hold constant the deficit under the third reform.

Table 9: Policy Analysis: Effect on Labor Supply Outcomes over the Life Cycle

	Reform 1		Reform 2		Reform 3	
Employment Rate of Married Women	%Δ	pp.Δ	%Δ	pp.Δ	%Δ	pp.Δ
25-30	-23.09	-9.09	-20.80	-8.19	9.12	3.59
31-35	1.25	0.57	10.49	4.78	9.30	4.24
36-40	0.22	0.13	6.30	3.77	6.15	3.68
41-45	0.15	0.09	5.62	3.43	5.56	3.39
46-50	0.79	0.43	6.68	3.65	5.91	3.23
51-55	0.15	0.08	5.95	3.22	5.71	3.09
56-61	0.27	0.13	6.86	3.36	6.59	3.23
62-70	1.40	0.42	5.82	1.75	4.05	1.22
Employment Rate of Married Women, 25-66	-2.21	-1.07	3.86	1.87	6.83	3.31
Employment Rate of Married Women, 25-70	-1.99	-0.94	3.72	1.76	6.44	3.05

Notes: All effects are percentage changes (%) or percentage points (pp.) changes with respect to the benchmark as marked. "Reform 1" is the counterfactual scenario where the Social Security Caregiver Credit is introduced. "Reform 2" is the counterfactual scenario where the introduction of the Social Security Caregiver Credit is combined with the elimination of the Social Security spousal and survivors benefits. "Reform 3" indicates the counterfactual scenario where the Social Security spousal and survivors benefits are eliminated. Reforms are revenue-neutral by adjusting the Social Security tax rate. Federal income tax rates and Medicare tax rate are kept the same as in the baseline scenario.

The labor supply implications for married women from the three policy reforms are summarized in Table 9. Not surprisingly, the provision of the caregiver credit reduces the participation of married women by 9.09 pp. during the child-rearing years. I observe positive but small increase in participation in the post-child rearing period. The disincentive to work during child-rearing years, generated by the caregiver credit, is potentially too large such that it dampens the increment in participation in the later stages of the life cycle. This results in an overall decline in the employment rate of all married women (within the 25 to 70 age group) by 1.99% and decrease in the accumulated work experience at the ERA by 2.71% (as shown in Table 10). The reform also reduces the aggregate lifetime labor earnings of married women by 1.3%. However, since the caregiver credit compensates for the lost earnings during the child-rearing years, the average career earnings of married women at the ERA increases by 10.71%, and consequently the difference between the average career earnings of married men and married women at their ERA drops by 8.09%.

Table 10: Policy Analysis: Effect on Accumulated Work Experience, Average Career Earnings, and Lifetime Earnings

	Reform 1	Reform 2	Reform 3
%Δ Number of Years of Work Experience of Married Women Aged 62	-2.71	3.74	7.40
%Δ Total Lifetime Labor Earnings of Married Women Aged 25-70	-1.30	3.94	5.78
%Δ Average Career Earnings of Married Women Aged 62	10.71	16.91	7.31
%Δ Gap between Average Career Earnings of Married Men and Married Women at 62	-8.09	-12.77	-5.52

Notes: All effects are percentage changes (%) with respect to the benchmark as marked. "Reform 1" is the counterfactual scenario where the Social Security Caregiver Credit is introduced. "Reform 2" is the counterfactual scenario where the introduction of the Social Security Caregiver Credit is combined with the elimination of the Social Security spousal and survivors benefits. "Reform 3" indicates the counterfactual scenario where the Social Security spousal and survivors benefits are eliminated. Reforms are revenue-neutral by adjusting the Social Security tax rate. Federal income tax rates and Medicare tax rate are kept the same as in the baseline scenario. Total lifetime labor earnings is computed using before tax labor earnings.

The elimination of the spousal and survivors benefits increases the average employment rate of married women over the full working life. The effects are more pronounced in response to the second policy reform when the provision of caregiver credit is combined with the removal of spousal and survivors benefits, except for the child-rearing years. All in all I find a sizeable effect of reform 2 and reform 3 on the employment rate of married women, with an average increase of 3.72% in the presence of caregiver credit (in reform 2) and 6.44% in the absence of the caregiver credit as well as the spousal and survivors benefits. Their average work experience at the ERA increases by 3.74% and 7.40% in response to reform 2 and reform 3, respectively.

Note that the absence of spousal and survivor benefits foster participation beyond the ERA (that is, in the age group 62-70) as married women have strong incentive to increase their average career earnings, which in turn increases their Social Security benefits. In contrast to reform 1, increased participation and substantial returns to labor-market experience under reform 2 and reform 3 boost their lifetime earnings by 3.94% and 5.78%, respectively. Under reform 2, I observe a considerably large effect (16.91% increase) on the average career earnings of married women at age 62 when they become eligible to claim Social Security benefits. In other words, assuming that women start claiming benefits at age 62 based on their own earnings history, on average, they will receive 16.9% extra Social Security retirement benefits under reform 2 compared to the baseline scenario. This implies that if married women get Social Security benefits solely on their own earnings record, the provision of caregiver credit for child-rearing would offset a substantial portion of the reduced earnings throughout the mothers' working lives and increase economic security in the retired stage of their life cycle. Reform 2 also helps to bring down the gender gap in retirement income as the gap between average career earnings of married men and that of married women declines by 12.77% compared to the status quo.

Overall the model predicts that the average employment rate of married women within the 25 to 66 age group increases by 6.83% from the status quo value of 0.4845 (or equivalently by 3.31 pp. from the status quo value of 48.45%) in response to the loss of spousal and survivors benefits. This result is in line with previous studies that predict an increase in the employment rate of married women in the absence of the provision of spousal and survivors benefits. However, there is substantial variation in the magnitude of the previous estimates. Kaygusuz (2015) estimates that the loss of spousal and survivors benefits would increase labor force participation of married women by 4.7%. The author does not account for the returns to experience and labor market uncertainty in this paper. Nishiyama (2019) predicts that the effect on the labor force participation of married women is about 1.5-1.6%. A recent paper by Groneck and Wallenius (2021) predicts a substantially larger increase, with married women's employment rising by 12.2 pp. Their model incorporates a part-time work option and endogenous male labor supply, which can potentially amplify the effect of the policy reform. Sánchez-Marcos and Bethencourt (2018) predict that the participation of married women is, respectively, 3.30, 5.66, and 7.29 pp. higher at ages 25-29, 30-34, and 35-39. I find a similar effect for the early stages of the life cycle, however the predicted effects for the age groups beyond age 40 are smaller in our model in comparison to the estimates obtained by Sánchez-Marcos and Bethencourt (2018). This difference could be due to the fact that Sánchez-Marcos and Bethencourt (2018) assume that all women retire from the labor market not later than 66 years of age (that is, at the FRA), whereas in our model women are allowed to work till age 70.

Table 11: Policy Analysis: Effect on Pubic Expenditure and Public Revenue

	Reform 1	Reform 2	Reform 3
%Δ Total Payroll Taxes paid by Married Women	8.59	10.32	2.29
%Δ Total Payroll Taxes paid by Married Men	10.58	6.12	-3.88
%Δ Total Payroll Taxes paid by Households	9.90	7.55	-1.78
%Δ Total Federal Taxes paid by Households	-0.54	2.28	3.06
%Δ Total Tax Revenue	2.69	3.91	1.57
%Δ Total Social Security Benefits	2.68	3.90	1.55

Notes: All effects are percentage changes (%) with respect to the benchmark as marked. "Reform 1" is the counterfactual scenario where the Social Security Caregiver Credit is introduced. "Reform 2" is the counterfactual scenario where the introduction of the Social Security Caregiver Credit is combined with the elimination of the Social Security spousal and survivors benefits. "Reform 3" indicates the counterfactual scenario where the Social Security spousal and survivors benefits are eliminated. Reforms are revenue-neutral by adjusting the Social Security tax rate. Federal income tax rates and Medicare tax rate are kept the same as in the baseline scenario.

Table 11 reports the impact of each revenue-neutral reform on income tax revenue and on Social Security expenditure. In all three reforms, Social Security expenditure increases. While instituting caregiver credits is expected to increase government expenditure, the elimination of spousal and survivors benefits is expected to reduce government expenditure to some extent. A potential reason for the higher Social Security expenditure could be due to the fact that in this model, unlike most of the previous studies, I allow women to delay their benefit claiming decision till age 70, and women can stay in the workforce till age 70. Thus, returns to additional work beyond midlife until age 70 and delaying benefit claiming beyond the Social Security early retirement age of 62 would increase married women's average career earnings and the lifetime Social Security benefits. Change in the payroll taxes paid by the married men is purely driven by the adjustment in the Social Security tax rate to make the policy reforms revenue-neutral, whereas change in the payroll taxes paid by the married women reflects combined effect of change in participation behavior of women in repose to the policy reforms and change in the tax rate for revenue-neutrality. Revenue from federal income taxes declines by 0.54% as a result of reform 1 but increases by 2.28% and 3.06% in response to reform 2 and 3, respectively.

Welfare Analysis. To measure the welfare consequences of the policy reforms, I use an equivalent variation based welfare metric. Specifically, I define the welfare value of an counterfactual environment as the proportional adjustment in consumption over the life cycle in the baseline environment that a household is willing to pay ex-ante to be indifferent between the baseline and the counterfactual scenario. I compute the lifetime expected utility of households in the baseline economy as:

$$
\begin{aligned}
\mathbb{E}_0 U(baseline, \tau^{ss}_{baseline})\big|_{\pi} =& \mathbb{I}_{\{t \le T^{FR}\}} \left[\sum_{i=1}^{N} \sum_{t=0}^{T^{FR}} \beta^t \left(\frac{\left((1-\pi)\frac{c_t}{n_t}\right)^{(1-\gamma)}}{1-\gamma} - \psi_t P_t \right) \right] \\
&+ \mathbb{I}_{\{t > T^{FR}\}} \left[\sum_{i=1}^{N} \sum_{t=T^{FR}+1}^{T} \left\{ \beta^t surv^h_{t+1} surv^w_{t+1} \left(\frac{\left((1-\pi)\frac{c_t}{n_t}\right)^{(1-\gamma)}}{1-\gamma} \right) \right. \right. \\
&+ \left. \left. \beta^t (1 - surv^h_{t+1}) surv^w_{t+1} \left(\frac{((1-\pi)c_t)^{(1-\gamma)}}{1-\gamma} \right) \right\} \right]
\end{aligned}
$$

where $\mathbb{E}_0$ represents the expectation at the beginning of working life, before initial conditions are known. Similarly, for each counterfactual scenario, I compute the lifetime expected utility of households as:

$$
\begin{aligned}
\mathbb{E}_0 U(reform, \tau^{ss}_{reform}) =& \mathbb{I}_{\{t \le T^{FR}\}} \left[\sum_{i=1}^{N} \sum_{t=0}^{T^{FR}} \beta^t \left(\frac{\left(\frac{c_t}{n_t}\right)^{(1-\gamma)}}{1-\gamma} - \psi_t P_t \right) \right] \\
&+ \mathbb{I}_{\{t > T^{FR}\}} \left[\sum_{i=1}^{N} \sum_{t=T^{FR}+1}^{T} \left\{ \beta^t surv^h_{t+1} surv^w_{t+1} \left(\frac{\left(\frac{c_t}{n_t}\right)^{(1-\gamma)}}{1-\gamma} \right) \right. \right. \\
&+ \left. \left. \beta^t (1 - surv^h_{t+1}) surv^w_{t+1} \left(\frac{(c_t)^{(1-\gamma)}}{1-\gamma} \right) \right\} \right]
\end{aligned}
$$

where $\tau^{ss}_{reform} = \tau^{ss}_{baseline}$ without revenue-neutrality, and τ^{ss}_{reform} takes values 7.03%, 6.68% and 5.895% for reforms 1, 2, and 3, respectively, with revenue-neutrality. I solve for π such that

$$
\mathbb{E}_0 U(baseline, \tau^{ss}_{baseline})\big|_{\pi} = \mathbb{E}_0 U(reform, \tau^{ss}_{reform})
$$

Therefore, π can be interpreted as the proportion of lifetime consumption that the average households are willing to pay ex ante to avoid the policy reform and remain in the baseline regime. In other words, π captures the welfare cost or benefit of introducing the policy reform. Table 12 reports value of π in terms of percentage change in lifetime consumption of going from the baseline to each policy regime with and without revenue-neutrality adjustment.

Considering revenue-neutral policy reforms, I find that the households are willing to pay

0.61% and 0.41% of lifetime consumption to avoid reform 1 and 2, respectively, and remain in the baseline regime. It is worth noting that in case of revenue neutral policy reforms (reform 1 and reform 2) the welfare gain from caregiver credit is dominated by the welfare loss from increased Social Security tax. In contrast, without the revenue-neutrality adjustment, reform 1 and 2 are welfare improving as the households appear to gain from the introduction of the caregiver credit.

Table 12: Welfare Analysis

	With Revenue Neutrality	Without Revenue Neutrality
Welfare cost of going from baseline to policy reform		
Reform 1	0.61%	-0.30%
Reform 2	0.41%	-0.09%
Reform 3	-0.04%	0.27%

Notes: "Reform 1" is the counterfactual scenario where the Social Security Caregiver Credit is introduced. "Reform 2" is the counterfactual scenario where the introduction of the Social Security Caregiver Credit is combined with the elimination of the Social Security spousal and survivors benefits. "Reform 3" indicates the counterfactual scenario where the Social Security spousal and survivors benefits are eliminated.

7 Conclusion

In this paper, I examine how career interruptions related to child-raising duties affect married women's lifetime earnings and Social Security retirement benefits. To do so, I develop and estimate a dynamic life-cycle model of female labor supply, savings, and Social Security benefit claiming that accounts for the uncertainties associated with labor earnings, survival, and medical cost. This framework captures the complex interdependencies between women's participation decisions, accumulated work experience, lifetime earnings, and public pension benefits in a unified way. Having estimated the model to match the data for the cohort born in 1943-1954, I analyze the implications of reforming the Social Security system in the US in a way that compensates for the earnings penalty for child-rearing through retirement benefits. The paper contributes by analyzing the behavioral implications and welfare consequences of three policy experiments: (1) introduce Social Security caregiver credit that compensates lost earnings during the first 5 child-rearing years through changes in public pension benefits, (2) institute the caregiver credit in the absence of Social Security spousal and survivors benefits, and (3) eliminate both spousal and survivors benefits.

I find that introducing the provision of caregiver credits for child care would reduce participation of married women during the child-rearing years but increase participation beyond child-raising years. The effects are more considerable under the second reform, as the incentive to return to the workforce following childbirth is stronger in the absence of marriage-based benefits. A key substantive result is that: lifetime labor earnings of married women increase significantly under the second and the third reform, and the gender gap in average career earnings at the Social Security Early Retirement Age reduces significantly under all three reforms. Overall, the findings suggest that implementing the provision of caregiver credit for child-rearing in the absence of the marriage-based Social Security benefits would significantly increase lifetime earnings of married women such that the gain in years worked beyond the child-raising years would cover the early loss in the labor earnings on account of child-bearing and child-rearing.

There are a number of potential avenues along which the framework developed in this paper can be extended. First, future analysis needs to address several design issues associated with the caregiver credits. For example, how the phasing out of the credit should work, whether both parents should receive the credit, how to adjust for additional children, etc. Second, future studies need to consider the heterogeneity in the burden of child-rearing across households. Although most households need time off when children are very young, for some households, behavioral problems in the teen years would require more time at home for supervision.

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Appendices

A Social Security Benefits

This section describes how Social Security Benefits are computed in the model. The Primary Insurance Amount (PIA), i.e., the retirement benefit a person would receive if he/she starts claiming benefits at his/her Normal Retirement Age (NRA), is computed from the piece-wise linear function of AIME (Average Indexed Monthly Earnings) with 2 bend points:

$$
\begin{aligned}
PIA^j = {} & 0.9 \times min\{AIME^j, b_1\} + 0.32 \times min\{max\{AIME^j - b_1, 0\}, b_2 - b_1\} \\
& +0.15 \times max\{AIME^j - b_2, 0\}, \text{ for } j \in \{h, w\}
\end{aligned}
$$

where b_1 and b_2 are the bend points at which the progressive replacement rates (90%, 32% and 15%) change.[27] This ensures redistribution in favour of low income earners.

Since in the model one period corresponds to one year, I compute the amount of annual Social Security retirement benefits received by spouse j as follows:

$$
b^j = 12 \times \lambda^j \times PIA^j, \text{ for } j \in \{h, w\}
$$

where λ^j is the actuarial benefit adjustment factor. For computational purpose, I set $\lambda^h = 1$ assuming that the husband receives 100% of PIA. For the wife, benefits are adjusted by λ^w according to her age when she starts claiming benefits (t_{cl}). In particular, the value of λ^w is set depending on whether she starts claiming before or at or after NRA.

Table A.1: Actuarial Adjustment Factor for a Woman's Own Social Security Benefits by Claiming Age

t_{cl}	62	63	64	65	66	67	68	69	70
λ^w	0.75	0.8	0.867	0.933	1	1.08	1.16	1.24	1.32

Notes: Values are taken from the SSA's website: https://www.ssa.gov/oact/quickcalc/early_late.html.

At the NRA, the benefit is neither reduced for early retirement nor increased for delayed retirement. If she starts claiming benefits before NRA, the benefits are reduced by $x^{penalty}$% for every year before NRA. If she starts claiming benefits after NRA, she is rewarded with an additional x^{reward}% of PIA per year till age 70.

[27] Bend points are scaled each year by average nominal wage growth in the economy.

Table A.2: Actuarial Adjustment in Social Security Benefits for the 1943-54 Birth Cohort

NRA	Normal Retirement Age	66
$x^{penalty}$ %	Penalty for Early Retirement	6.67%
x^{reward} %	Credit for Delaying Retirement	8.0%

Notes: Values are taken from the SSA's website: https://www.ssa.gov/OACT/ProgData/ar_drc.html.

Household retirement benefits are computed as the sum of both spouses' retirement benefits based on their average lifetime earnings. I use the fact that the secondary earners (usually the wife) are eligible for (up to) 50% of the primary earner's (usually the husband) PIA and that the total amount of benefits payable to a married household is capped at a maximum family benefit amount(PIA_{fmax}). PIA_{fmax} is computed as follows:

$$PIA^j_{fmax} = 1.5 \times min\{PIA^j, b^f_1\} + 2.72 \times min\{max\{PIA^j - b^f_1, 0\}, b^f_2 - b^f_1\}$$
$$+1.34 \times min\{max\{PIA^j - b^f_2, 0\}, b^f_3 - b^f_2\} + 1.75 \times max\{PIA^j - b^f_3, 0\}, \text{ for } j \in \{h, w\}$$

Table A.3: Parameters for PIA and Maximum Family Benefit Amount, for year 2015

b_1	first bend point for PIA	\$826
b_2	second bend point for PIA	\$4980
b^f_1	first bend point for Maximum Family Benefit	\$1056
b^f_2	second bend point for Maximum Family Benefit	\$1524
b^f_3	third bend point for Maximum Family Benefit	\$1987

Notes: I obtain the values of the bend points from the SSA's website: https://www.ssa.gov/oact/cola/bendpoints.html.

When both spouses are alive, the household social security benefits are calculated as follows:

$$b^{couple} = max\{b^h + b^w, min\{(b^h + \lambda^{sp} \times 0.5 \times b^h), PIA^h_{fmax}\}\}$$

where λ^{sp} is adjustment factor for spousal benefits based on claiming age of wife.

Table A.4: Actuarial Adjustment in Social Security Spousal Benefits for the 1943-54 Birth Cohort

t_{cl}	62	63	64	65	66 or higher
λ^{sp}	0.70	0.75	0.8333	0.9167	1

Notes: Values are taken from the SSA's website. For a spouse who is not entitled to benefits on his or her own earnings record, this adjustment factor is applied to the base spousal benefit, which is 50% of the primary worker's PIA.

If the wife choose to claim spousal benefit before reaching her NRA, she receives a reduced amount of spousal benefit ($\lambda^{sp} \times 0.5\times$ husband's benefits).

Survivor Benefits. Since the model introduces possibility of widowhood in the full retirement stage, I assume that the surviving spouse receives either her own benefit or survivors benefit (100% of the deceased spouse's benefit), whichever is higher.[28] Since widowhood is introduced in the full retirement stage of the model, I assume that the surviving spouse qualifies for 100% of the deceased spouse's benefits.

$$b^{widow} = max\{b^h, b^w\}$$

where b^h is the benefits based on deceased spouse's record and b^w is the widowed spouse's own benefit.

B Tax

This section describes how taxes are computed in the model. Households pay federal income tax on labor and non-labor income and payroll taxes on labor income. I do not model state taxes due to wide variation in state tax codes. For married couples, I assume that spouses file taxes jointly.

Payroll Tax. Payroll tax consists of Social Security tax and Medicare tax (or Hospital insurance tax). Social Security tax is collected in the form of a payroll tax mandated by the Federal Insurance Contributions Act (FICA) or a self-employment tax mandated by the Self-Employed Contributions Act (SECA).[29] Since 1990, the Social Security tax rate for employees is 6.2% of earnings up to Maximum Taxable Earning, while the Medicare tax rate is 1.45% of earnings.[30] Therefore, each spouse's payroll tax contribution is specified as

[28] If the surviving spouse is already drawing Social Security benefits on her own work record, she will receive survivor benefits only if they exceed her own benefits. SSA will pay the higher of the two benefits amount. If the surviving spouse already receive spousal benefits, her benefits will automatically switch to survivors benefits after the death of the husband.

[29] The Social Security tax rate is 12.4%. Half of the tax (that is, 6.2%) is paid by the employer, and the employee is responsible for paying the other half (that is, the remaining 6.2%). For more details on payroll tax rates, see https://www.ssa.gov/oact/ProgData/taxRates.html.

[30] Social Security's Old-Age, Survivors, and Disability Insurance (OASDI) program limits the amount of earnings subject to Social Security taxation for a given year. This amount is commonly referred to as the "Maximum Taxable Earning" or "Taxable Maximum". This limit changes each year with changes in the national average wage index. For more details, see https://www.ssa.gov/oact/COLA/cbb.html. Moreover, workers pay an additional 0.9 percent Medicare tax on income exceeding certain thresholds. In this paper, I do not consider this additional Medicare tax as the paper focuses on well-being of the low-income households.

follows:

$$\tau_{payroll}(y_t^j, y_{max}) = \tau_{ss} \times \min\{y_t^j, y_{max}\} + \tau_{med} \times y_t^j, \text{ for } j \in \{h, w\}$$

Table B.5: Payroll Tax Parameters

τ_{ss}	Social Security tax rate	6.2 %
τ_{med}	Medicare tax rate	1.45 %
y_{max}	Maximum Taxable Earning (in 2015)	\$118,500

Federal Income Tax. Federal income tax is a progressive tax on labor and non-labor income. The taxable household income in the working stage is defined as follows:

$$I_t = max\{rA_t + y_t^h + (y_t^w \times P_t) - d, 0\}$$

where d denotes the amount of standard deduction.[31] I use $d = \$12,600$ based on the standard deductions for married couples filing jointly in 2015. The taxable household income in the retirement transition stage is specified as follows:

$$I_t = max\{rA_t + (y_t^w \times P_t) - d, 0\}$$

In the full retirement stage, the taxable household income of a married household is given by:

$$I_t = max\{rA_t - d, 0\}$$

The federal income tax has progressive tax rates that are applied to taxable income brackets. Table A.2 reports the amount of federal income tax that the household pays based on taxable household income I_t. I use the 2015 income tax brackets for married households filing jointly.[32]

For a widowed household, pre-tax income is defined as follows:

$$I_t = max\{rA_t - d, 0\}$$

For more details, see https://www.ssa.gov/pubs/EN-05-10024.pdf.

[31] While filing taxes individuals have two options for their taxable income deductions: they can either itemize all of their deductions or accept the annual standard deduction. The standard deduction is a flat amount reduced from the gross income and this amount is not subject to federal income tax. I use the standard deduction, and thus do not allow individuals to defer medical expenses as an itemized deduction. The values of standard deductions are obtained from: https://www.taxpolicycenter.org/statistics/standard-deduction.

[32] I obtain the 2015 income tax brackets and marginal tax rates from this website: https://taxfoundation.org/irs-releases-2015-tax-brackets/.

where d takes value \$6,300. Post-tax income for a widow is computed using the 2015 tax brackets and tax rates for "single filing status" as described in Table A.3.[33]

Table B.6: Federal Income Tax Brackets and Marginal Tax Rates for Married Joint Filing Status

Taxable Income (I_t)	Federal Income Tax	Marginal Tax Rate
$0 - 18,450$	$0.1 \times I_t$	10%
$18,451 - 74,900$	$1,845 + 0.15 \times (I_t - 18,450)$	15%
$74,901 - 151,200$	$10,312.5 + 0.25 \times (I_t - 74,900)$	25%
$151,201 - 234,500$	$29,387.5 + 0.28 \times (I_t - 151,200)$	28%
$234,501 - 411,500$	$51,577.5 + 0.33 \times (I_t - 234,500)$	33%
$411,501 - 464,850$	$111,324 + 0.35 \times (I_t - 411,500)$	35%
$464,851+$	$129,996.5 + 0.396 \times (I_t - 464,850)$	39.6%

Notes: All values are in 2015 dollar.

Table B.7: Federal Income Tax Brackets and Marginal Tax Rates for Single Filing Status

Taxable Income (I_t)	Federal Income Tax	Marginal Tax Rate
$0 - 9,225$	$0.1 \times I_t$	10%
$9,226 - 37,450$	$922.5 + 0.15 \times (I_t - 9,225)$	15%
$37,451 - 90,750$	$5,156.25 + 0.25 \times (I_t - 37,450)$	25%
$90,751 - 189,300$	$18,481.25 + 0.28 \times (I_t - 90,750)$	28%
$189,301 - 411,500$	$46,075.25 + 0.33 \times (I_t - 189,300)$	33%
$411,501 - 413,200$	$119,401.25 + 0.35 \times (I_t - 411,500)$	35%
$413,201+$	$119,997.25 + 0.396 \times (I_t - 413,200)$	39.6%

Notes: All values are in 2015 dollar.

C Mathematical Appendix

C.1 Spouses' Income Processes

Log of real wage of spouse $j \in h, w$ at wife's age t can be written as:

$$log(y_t^h) = a_0^h + a_1^h(t+3) + a_2^h(t+3)^2 + Z_t^h$$

[33] According to the IRS, a widow can file taxes using the "qualifying widow status" or two years after the year of her spouse's death as long as she remains unmarried. After the two-year period, if the widow remains unmarried, then she can use the "head of household status" if she has qualifying dependents or the "single filing status", whichever she qualifies for. To keep computation of taxes simple, I assume that widows file taxes using the statutory tax rules for "single filing status".

$$log(y_t^w) = a_0^w + a_1^w x_t + a_2^w x_t^2 + Z_t^w$$

$$Z_t^j = Z_{t-1}^j + \zeta_t^j$$

where the shocks are distributed as follows:

$$\begin{pmatrix} \zeta_t^h \\ \zeta_t^w \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} -\sigma_{\zeta^h}^2/2 \\ -\sigma_{\zeta^w}^2/2 \end{pmatrix}, \begin{pmatrix} \sigma_{\zeta^h}^2 & \rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w} \\ \rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w} & \sigma_{\zeta^w}^2 \end{pmatrix} \right)$$

I assume that each earner's labor income process contains both a permanent component, Z_t^j. Permanent innovations are uncorrelated within persons, but income shocks are correlated across spouses. Variances and covariances of the shocks are constant over the life-cycle.

Since ζ_t^j are normally distributed, $exp(\zeta_t^j)$ are log-normally distributed. For instance,

$$\begin{pmatrix} \zeta_t^h \\ \zeta_t^w \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} -\sigma_{\zeta^h}^2/2 \\ -\sigma_{\zeta^w}^2/2 \end{pmatrix}, \begin{pmatrix} \sigma_{\zeta^h}^2 & \rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w} \\ \rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w} & \sigma_{\zeta^w}^2 \end{pmatrix} \right)$$

$$\implies \begin{pmatrix} exp(\zeta_t^h) \\ exp(\zeta_t^w) \end{pmatrix} \sim log\mathcal{N}\left(\begin{pmatrix} \widetilde{\mu_{\zeta^h}} \\ \widetilde{\mu_{\zeta^w}} \end{pmatrix}, \begin{pmatrix} \widetilde{\sigma_{\zeta^h}^2} & \widetilde{\rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w}} \\ \widetilde{\rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w}} & \widetilde{\sigma_{\zeta^w}^2} \end{pmatrix} \right)$$

where

$$\widetilde{\mu_{\zeta^h}} = exp(-\sigma_{\zeta^h}^2/2 + \sigma_{\zeta^h}^2/2) = 1$$

$$\widetilde{\mu_{\zeta^w}} = exp(-\sigma_{\zeta^w}^2/2 + \sigma_{\zeta^w}^2/2) = 1$$

$$\widetilde{\rho_\zeta^{h,w}} = \frac{[exp(\rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w}) - 1]}{\sqrt{[exp(\sigma_{\zeta^h}^2) - 1][exp(\sigma_{\zeta^w}^2) - 1]}}$$

$$\widetilde{\sigma_{\zeta^h}^2} = exp(2 \times (-\sigma_{\zeta^h}^2/2) + \sigma_{\zeta^h}^2)[exp(\sigma_{\zeta^h}^2) - 1] = exp(\sigma_{\zeta^h}^2) - 1$$

$$\widetilde{\sigma_{\zeta^w}^2} = exp(2 \times (-\sigma_{\zeta^w}^2/2) + \sigma_{\zeta^w}^2)[exp(\sigma_{\zeta^w}^2) - 1] = exp(\sigma_{\zeta^w}^2) - 1$$

C.2 Computation of the Integral using Gauss-Hermite Quadrature

In this section, I describe the steps involved in the computation of the expected value with respect to earnings shocks and health expenditure shocks.

Integration with respect to earnings shocks. The expectation of the value function can be expressed as follows:

$$\mathbb{E}_{\zeta^h,\zeta^w} V_{t+1}(\zeta^h,\zeta^w,X_{t+1},z_{t+1}) = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} V_{t+1}(\zeta^h,\zeta^w,X_{t+1},z_{t+1}) f(\zeta^h,\zeta^w) d\zeta^h d\zeta^w$$

If we have two correlated random variables (say, v_1 and v_2) that follow bivariate normal distribution, the Gauss-Hermite quadrature rule can be used to discretize these shocks into several nodes and to perform the numerical integration.

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \sim N(\mu,\Omega), \text{ with variance-covariance matrix } \Omega = \begin{pmatrix} \tilde{\sigma_1^2} & \tilde{\sigma_{12}} \\ \tilde{\sigma_{12}} & \tilde{\sigma_2^2} \end{pmatrix}$$

We need to transform the variables before approximating the integration. Given Ω is symmetric and positive semi-definite, it has a Cholesky decomposition:

$$\Omega = \begin{bmatrix} \sigma_1 & 0 \\ \rho_{12} & \sigma_2 \end{bmatrix} \begin{bmatrix} \sigma_1 & 0 \\ \rho_{12} & \sigma_2 \end{bmatrix}^T, \text{ where } \Omega \text{ is lower triangular matrix.}$$

Therefore, we can write: $\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \sigma_1 & 0 \\ \rho_{12} & \sigma_2 \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \end{bmatrix}$, $\eta_1, \eta_2 \sim N(0,1)$

If we want to approximate the expected value of function f when it's argument $y \sim N(\mu,\sigma^2)$, $\mathbb{E}[f(y)] = \int_{-\infty}^{+\infty} \frac{1}{\sigma\sqrt{2\pi}} f(y) e^{\left(-\frac{(y-\mu)^2}{2\sigma^2}\right)} dy$, then the general Gauss-Hermite quadrature rule for expectation of x is as follows:

$$\mathbb{E}[f(y)] \approx \sum_{i=1}^{S} \frac{1}{\sqrt{\pi}} \omega_i f(\sqrt{2}\sigma x_i + \mu)$$

where S number of nodes (x_i) and weights (ω_i) can be found in standard references (Judd, 1998). Since the rule is defined for x: $\int_{-\infty}^{+\infty} f(x)e^{-x^2}dx \approx \sum_{i=1}^{S} \omega_i f(x_i)$, we need to transform y: $x^2 = \frac{(y-\mu)^2}{2\sigma^2} \implies y = \sqrt{2}\sigma x + \mu$; $dy = \sqrt{2}\sigma dx$. Therefore, we can write: $\mathbb{E}[f(y)] = \int_{-\infty}^{+\infty} \frac{1}{\sqrt{\pi}} f(\sqrt{2}\sigma x + \mu) e^{(-x^2)} dx$.

This implies,

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \approx \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \sigma_1 & 0 \\ \rho_{12} & \sigma_2 \end{bmatrix} \begin{bmatrix} \sqrt{2}\eta_{1,i}^{GH} \\ \sqrt{2}\eta_{2,j}^{GH} \end{bmatrix}$$
$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \approx \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \sigma_1\sqrt{2}\eta_{1,i}^{GH} \\ \rho_{12}\sqrt{2}\eta_{1,i}^{GH} + \sigma_2\sqrt{2}\eta_{2,j}^{GH} \end{bmatrix}$$
$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \approx \begin{bmatrix} \sigma_1\sqrt{2}\eta_{1,i}^{GH} + \mu_1 \\ \rho_{12}\sqrt{2}\eta_{1,i}^{GH} + \sigma_2\sqrt{2}\eta_{2,j}^{GH} + \mu_2 \end{bmatrix}$$

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \approx \begin{bmatrix} \sigma_1 \widetilde{\eta_{1,i}^{GH}} + \mu_1 \\ \rho_{12}\widetilde{\eta_{1,i}^{GH}} + \sigma_2 \widetilde{\eta_{2,j}^{GH}} + \mu_2 \end{bmatrix}$$

where $(\eta_{1,i}^{GH}, \omega_{1,i}^{GH})$ and $(\eta_{2,j}^{GH}, \omega_{2,j}^{GH})$ are two sets of Gauss-Hermite nodes and weights. For i, j, $\widetilde{\eta_{1,i}^{GH}} = \sqrt{2}\eta_{1,i}^{GH}$, $\widetilde{\eta_{2,j}^{GH}} = \sqrt{2}\eta_{2,j}^{GH}$, $\widetilde{\omega_{1,i}^{GH}} = \frac{\omega_{1,i}^{GH}}{\sqrt{\pi}}$, $\widetilde{\omega_{2,j}^{GH}} = \frac{\omega_{2,j}^{GH}}{\sqrt{\pi}}$.

Following this approach, I can approximate the expected value as follows:
$\mathbb{E}_{\zeta^h,\zeta^w} V_{t+1}(\zeta^h, \zeta^w, X_{t+1}, z_{t+1})$

$$\approx \sum_{i=1}^{S_1}\sum_{j=1}^{S_2} \pi^{-2}\omega_{i,\zeta}^{h,GH}\omega_{j,\zeta}^{w,GH} V_{t+1}(\sigma_{\zeta^h}\sqrt{2}\zeta_i^{h,GH} + \mu_{\zeta^h}, \rho_\zeta^{h,w}\sqrt{2}\zeta_i^{h,GH} + \sigma_{\zeta^w}\sqrt{2}\zeta_j^{w,GH} + \mu_{\zeta^w})$$

where $(\zeta_i^{h,GH}, \omega_{i,\zeta}^{h,GH})$ and $(\zeta_j^{w,GH}, \omega_{j,\zeta}^{w,GH})$ are two sets of Gauss-Hermite nodes and weights. S_1 and S_2 are number of nodes for the shocks ζ^h and ζ^w respectively.

Integration with respect to medical cost shocks.
For married households, I can approximate the expected value as follows:

$$\begin{aligned} \mathbb{E}_{\nu^{hh}} V_{t+1}^M(\nu^{hh}, X_{t+1}, z_{t+1}) =& (1 - Pr(m_t^{hh} = 0)) \times V_{t+1}^M(m_t^{hh} = 0, X_{t+1}, z_{t+1}) \\ & + Pr(m_t^{hh} > 0) \times \int_{-\infty}^{+\infty} V_{t+1}^M(\nu^{hh}, X_{t+1}, z_{t+1}) f(\nu^{hh}) d\nu^{hh} \\ & \approx (1 - Pr(m_t^{hh} = 0)) \times V_{t+1}^M(m_t^{hh} = 0, X_{t+1}, z_{t+1}) \\ & Pr(m_t^{hh} > 0) \times \frac{\omega_{i,\nu^{hh}}^{GH}}{\sqrt{\pi}} \sum_{i=1}^{S^{hh}} V_{t+1}^M(\sqrt{2}\sigma_{\nu^{hh}} m_{i,\nu^{hh}}^{GH}, X_{t+1}, z_{t+1}) \end{aligned}$$

Similarly, for widowed households, the expected value is approximated as follows.

$$\begin{aligned} \mathbb{E}_{\nu^{wd}} V_{t+1}^W(\nu^{wd}, X_{t+1}, z_{t+1}) =& (1 - Pr(m_t^{wd} = 0)) \times V_{t+1}^W(m_t^{wd} = 0, X_{t+1}, z_{t+1}) + \\ & Pr(m_t^{wd} > 0) \times \int_{-\infty}^{+\infty} V_{t+1}^W(\nu^{wd}, X_{t+1}, z_{t+1}) f(\nu^{wd}) d\nu^{wd} \\ & \approx (1 - Pr(m_t^{wd} = 0)) \times V_{t+1}^W(m_t^{wd} = 0, X_{t+1}, z_{t+1}) \\ & Pr(m_t^{wd} > 0) \times \frac{\omega_{i,\nu^{wd}}^{GH}}{\sqrt{\pi}} \sum_{i=1}^{S^{wd}} V_{t+1}^W(\sqrt{2}\sigma_{\nu^{wd}} m_{i,\nu^{wd}}^{GH}, X_{t+1}, z_{t+1}) \end{aligned}$$

$(m_{i,\nu^{hh}}^{GH}, \omega_{i,\nu^{hh}}^{GH})$ and $(m_{i,\nu^{wd}}^{GH}, \omega_{i,\nu^{wd}}^{GH})$ are two sets of Gauss-Hermite nodes and weights. S_{hh} and S_{wd} are number of nodes for the shocks ν^{hh} and ν^{wd} respectively.

D Estimation Appendix

D.1 Identification of Parameters Associated with Spouses' Income Processes

Log of real wage of spouse $j \in h, w$ at age t can be written as:

$$log(y_t^h) = a_0^h + a_1^h(t+3) + a_2^h(t+3)^2 + Z_t^h$$

$$log(y_t^w) = a_0^w + a_1^w x_t + a_2^w x_t^2 + Z_t^w$$

$$Z_t^j = Z_{t-1}^j + \zeta_t^j$$

where the shocks are distributed as follows:

$$\begin{pmatrix} \zeta_t^h \\ \zeta_t^w \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} -\sigma_{\zeta^h}^2/2 \\ -\sigma_{\zeta^w}^2/2 \end{pmatrix}, \begin{pmatrix} \sigma_{\zeta^h}^2 & \rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w} \\ \rho_\zeta^{h,w}\sigma_{\zeta^h}\sigma_{\zeta^w} & \sigma_{\zeta^w}^2 \end{pmatrix}\right)$$

D.1.1 Husband's Income Process

Parameters associated with husband's income process are estimated under the assumption that husbands always participate in the labor force and that there is no selection bias. The growth in residual log wages can be written as:

$$\Delta u_t^h = \zeta_t^h$$

In other words, Δu_t^h is the log change in hourly wages of husband net of observables (husband's age, square of husband's age). Following Blundell et al. (2008) and Meghir and Pistaferri (2004), the variance of the husband's permanent income shocks can be identified by the moment:

$$\mathbb{E}(\Delta u_t^h(\Delta u_{t-1}^h + \Delta u_t^h + \Delta u_{t+1}^h)) = \sigma_{\zeta^h}^2 \tag{D.1}$$

D.1.2 Wife's Income Process, Selection into Work, and Correlation of Spouses' Income Shocks

Since we cannot observe earnings for those women who do not participate in the labor force, identification of parameters associated with labor income process requires correction for endogenous selection of married women into employment. Let the participation decision

$P_t = 1$ of the wife depend on some latent variable, P_t^*, which can be written as:

$$P_t^* = I_t'\iota + K_t'\kappa + \mu_t \tag{D.2}$$

$$P_t = \begin{cases} 1 & \text{if } P_t^* > 0 \\ 0 & \text{otherwise} \end{cases}$$

where P_t^* is a latent variable, P_t is the observed choice, I_t are exogeneous variables that affect the wife's probability of working but are excluded from the wage equation and K_t are variables in the wage equation (experience and square of experience). I use wife's age, number of children in the household, age of the youngest child, real hourly wage of husband as exclusion restrictions.

To identify the parameters associated with the wife's income process, I follow the two-step procedure à la Heckman (1979). In the first stage, I use a probit to estimate the probability of wife's labor force participation as

$$Pr(P_t = 1) = Pr(P_t^* > 0) = Pr(\mu_t > -I_t'\iota - K_t'\kappa) = Pr(\mu_t > -\alpha_t) \tag{D.3}$$

where $\alpha_t = I_t'\iota + K_t'\kappa$. Since wage growth is only observed for women working in both t and $t-1$, we can write:

$$\mathbb{E}[\Delta log(y_t^w)|P_t = 1, P_{t-1} = 1] = \Delta X_t^{w'}\beta + \mathbb{E}(\zeta_t^w|P_t = 1, P_{t-1} = 1) \tag{D.4}$$

$$\mathbb{E}[\Delta log(y_t^w)|P_t = 1, P_{t-1} = 1] = \Delta X_t^{w'}\beta + \mathbb{E}(\zeta_t^w|\mu_t > -\alpha_t, \mu_{t-1} > -\alpha_{t-1}) \tag{D.5}$$

As in Low, Meghir, and Pistaferri (2010), I assume $(\mu_t, \mu_{t-1}) \sim N(0, \mathbb{I})$. This implies:

$$\mathbb{E}[\Delta log(y_t^w)|P_t = 1, P_{t-1} = 1] = \Delta X_t^{w'}\beta + \sigma_{\zeta^w}\rho_{\zeta_t^w\mu_t}\Lambda_t + \sigma_{\zeta^w}\rho_{\zeta_t^w\mu_{t-1}}\Lambda_{t-1} \tag{D.6}$$

where $X_t^{w'}\beta = a_0^w + a_1^w x_t + a_2^w x_t^2$; $\sigma_{\zeta^w}^2 = Var(\zeta_t^w)$; $\rho_{\zeta_t^w\mu_t} = Corr(\zeta_t^w, \mu_t)$; $\Lambda_t = \frac{\phi(\alpha_t)}{\Phi(\alpha_t)}$ is the inverse Mills ratio (with ϕ and Φ being the standard normal density and distribution functions, respectively). With $\hat{\alpha}_t$ derived from the probit estimate of the first stage, I estimate the inverse Mills ratio from the sample of married women, $\widehat{\Lambda}_t = \frac{\phi(\hat{\alpha}_t)}{\Phi(\hat{\alpha}_t)}$.

In the second stage, I use only the sample of married women participating in both periods t and $t-1$, and regress wage growth against $\Delta X_t^{w'}$ and the inverse Mills ratios for the two periods in order to obtain consistent estimates of the wage growth parameters. To identify the parameters, the moment conditions are corrected for sample selection in the spirit of Blundell, Pistaferri, and Saporta-Eksten (2016) and Low et al. (2010). The moment conditions are based on conditional covariance restrictions rather than unconditional covariance restrictions.[34] I use the following four moment conditions in a Generalized Method of Moments (GMM) framework to identify $\sigma^2_{\zeta^w}$ and σ_{ζ^h,ζ^w} :

$$\mathbb{E}[\Delta u^w_t | P_t = 1, P_{t-1} = 1] = \sigma_{\zeta^w,\mu}\Lambda_t \tag{D.7}$$

$$\mathbb{E}[\Delta u^w_t(\Delta u^w_{t-1} + \Delta u^w_t + \Delta u^w_{t+1}) | P_t = 1, P_{t-1} = 1, P_{t+1} = 1, P_{t-2} = 1] = \sigma^2_{\zeta^w} - \sigma^2_{\zeta^w,\mu}\Lambda_t\alpha_t \tag{D.8}$$

$$\mathbb{E}[\Delta u^h_t | P_t = 1, P_{t-1} = 1] = \sigma_{\zeta^h,\mu}\Lambda_t \tag{D.9}$$

$$\mathbb{E}[\Delta u^w_t \Delta u^h_t | P_t = 1, P_{t-1} = 1] = \sigma_{\zeta^h,\zeta^w} - \sigma_{\zeta^h,\mu}\sigma_{\zeta^w,\mu}\Lambda_t\alpha_t \tag{D.10}$$

where $\sigma_{\zeta^h,\zeta^w} = \rho^{h,w}_{\zeta}\sigma_{\zeta^h}\sigma_{\zeta^w}$; and $\sigma_{\zeta^j,\mu} = \sigma_{\zeta^j}\rho_{\zeta^j\mu}$, $j = h, w$.

[34]The moment conditions are corrected for sample selection using formulae for the moments of the conditional truncated normal distribution (see Tallis (1961)).