

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

Debasmita Das[†]

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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 birth cohort. Utilizing the estimated model, I evaluate the effects of revenue-neutral introduction of the Social Security Caregiver Credits that cover lost earnings during early child-rearing years through change in retirement benefits. The model predicts that introducing the provision of earning credits for child care in the Social Security system would lead to a sizeable reduction in gender gap in average career earnings at the Social Security Early Retirement Age. The findings suggest that instituting caregiver credits 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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[†]Georgia Institute of Technology, Email: `debasmita.das@qcf.gatech.edu`.

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) earnings 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 national 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

¹As 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.

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 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 accu-

mulation, 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 labor supply behavior in the counterfactual scenarios and assess the welfare implications. I conduct counterfactual policy experiments by introducing caregiver credits in the benchmark economy, and I perform the policy experiments in a revenue-neutral set up by adjusting the Social Security tax rate. The policy exercises are implemented in various settings: first, I analyze the effect of the policy at different generosity levels; and second, I introduce the policy in the presence as well as in the absence of the marriage-based noncontributory Social Security benefits (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 any financial risks in the later stage of the life cycle, when 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 62.²

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 counterfactual scenarios. The largest effect is observed under the reform “Generous Caregiver Credit, with Spousal and Survivors Benefits” with 13.17% 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.

Third, the welfare analysis suggests that implementing revenue-neutral Social Security caregiver credit is not welfare improving when the policy is implemented in the presence of spousal and survivors benefits. Households are willing to pay 0.63% to 1.05% of baseline

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

lifetime consumption ex ante to avoid the revenue neutral introduction of caregiver credits as the welfare gain from non-revenue neutral caregiver credits is dominated by the welfare loss from increased Social Security tax rate. On the other hand, in the absence of the spousal and survivor benefits, revenue-neutral implementation of caregiver credits are welfare improving.

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

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

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 United States. 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.

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. It is the largest entitlement program in the United States (Gruber & Wise, 1999). 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 benefits 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 benefits, 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

⁴Benefits 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.

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.

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

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

⁶Although 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.

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.

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 modeled in an exogenous fashion.⁹ To keep the model tractable, I assume that fertility is exogenous and I abstract from modeling the 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 $\in \{t_0, \dots, T\}$, 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

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

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

⁹The 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.

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

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

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 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:

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

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

¹²Note 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.

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:

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

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

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:

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

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:

$$Z_t^j = Z_{t-1}^j + \zeta_t^j \quad (5)$$

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.

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

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

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

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

¹⁴Several 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.

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:

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

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 , $AIM E_t^j$, is computed as spouse j 's average career earnings (measured at age t) divided by 12:

$$AIM E_t^j = \frac{E_t^j}{12}, \text{ for } j \in \{h, w\} \quad (8)$$

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

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

¹⁵For 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>

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:

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

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,

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

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

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

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 the wife's participation status. The household intertemporal budget constraint for this stage can be

written as follows:

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

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:

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

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:

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

¹⁶In 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.

where TR_t is parameterized as:

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

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:

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

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

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

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:

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

For the widowed household, TR_t is parameterized as:

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

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:

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

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:

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

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 func-

tion 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: $D_t = \{(P_t = 1, B_t = 1), (P_t = 1, B_t = 0), (P_t = 0, B_t = 1), \text{ and } (P_t = 0, B_t = 0)\}$, 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.

$$V_t^M(\Omega_t) = \max_{c_t} \left\{ u(c_t, n_t) + \beta \left[\text{surv}_{t+1}^h \text{surv}_{t+1}^w \mathbb{E}_t[V_{t+1}^M(\Omega_{t+1})] \right] \right\}$$

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

$$+(1 - surv_{t+1}^h) surv_{t+1}^w \mathbb{E}_t[V_{t+1}^W(\Omega_{t+1})]\Big]\Big\}$$

$V_{t+1}^M(\cdot)$ 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:

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

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 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 lower average out-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 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.

¹⁸Casanova (2010) adopted similar approach.

¹⁹In 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.

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 married 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

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.

Child Care Cost.— Following Borella et al. (2019), I consider that the per-child child care cost

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

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)
<i>Annual Consumption Floor</i>			
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.

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

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 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

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

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 3: Parameter Estimates of the Wife’s Labor Income Process

	Estimate	Robust S.E.
Panel A: Wage Equation		
<i>Dependent Variable: $\log(y_t^w)$</i>		
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		
<i>Dependent Variable: $Pr(P_t = 1)$</i>		
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.
<i>Dependent Variable: $\log(y_t^h)$</i>			
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 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.

Table 5: Parameter Estimates of the Income Shocks

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

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-

²²In 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 6: Parameter Estimates of the Household Health Expenditure Process

		Estimate	Robust S.E.
Panel A: Married Households			
<i>Dependent Variable: $\log(m_t^{hh})$</i>			
wife's age	π_1^{hh}	-0.0041	0.0031
constant	π_0^{hh}	8.1603	0.2342
s.d. of residual	$\sigma_{\nu^{hh}}$	1.2198	0.0101
observations		10,642	
Panel B: Widowed Households			
<i>Dependent Variable: $\log(m_t^{wd})$</i>			
wife's age	π_1^{wd}	0.0102	0.0035
constant	π_0^{wd}	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.

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).

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 35000 households to compute a vector of simulated moments, $M_s(\theta)$.²³ The MSM estimator, $\hat{\theta}_{MSM}$, is given by:

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

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

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 diagonal 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	0.0026	$0.0242 (\times 10^{-7})$
ψ_o	Disutility from work, old workers	0.0041	$0.4131 (\times 10^{-7})$

The estimated value of ψ_y is 0.0026 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 , 0.0041, is greater than the estimated value of ψ_y . This captures that utility cost of working is higher for older

²⁴Although 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.

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	0.3810
Age 31-40	0.6062	0.5468
Age 41-50	0.6945	0.6050
Age 51-61	0.6580	0.5387
Age 62-70	0.3239	0.3021

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 Policy Analysis: Effects of Instituting Social Security Caregiver Credit

In this section, I analyze the labor supply responses and welfare consequences of introducing Social Security Caregiver Credit using the life cycle model developed and estimated in the previous sections. I perform the policy experiments in various settings. First, I examine the effects of Caregiver Credit in terms of different generosity levels.

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

Table 9: First 5 Years of Child-rearing

Mother's Age	26	27	28	29	30
1 st kid's age	0	1	2	3	4
2 nd kid's age			0	1	2

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:

$$\begin{aligned}
E_{t+1}^w = & \mathbb{I}_{\{t=t_0 \text{ and } x_t \leq 35\}} \left[\min(y_t^w, y_{max}) \times (P_t = 1) \right] \\
& + \mathbb{I}_{\{26 \leq t \leq 30 \text{ and } x_t \leq 35\}} \left[\frac{1}{(t+1-t_0)} [(t-t_0)E_t^w \right. \\
& \left. + \min(y_t^w, y_{max}) \times (P_t = 1) + \textit{Caregiver Credit} \times (P_t = 0)] \right] \\
& + \mathbb{I}_{\{31 \leq t < t_{cl} \text{ and } x_t \leq 35\}} \left[\frac{1}{(t+1-t_0)} [(t-t_0)E_t^w + \min(y_t^w, y_{max}) \times (P_t = 1)] \right] \\
& + \mathbb{I}_{\{t \geq t_{cl} \text{ or } x_t > 35\}} \left[E_t^w \right]
\end{aligned} \tag{20}$$

where *Caregiver Credit* takes value \$24,049.32 under the “Generous Caregiver Credit” and \$15,080 under the “Basic Caregiver Credit”. 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.

The amount of credit for each year of child care would equal one half of the average

²⁵Caregiver 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.

national earnings under the “Generous Caregiver Credit” regime. In 2015 dollar terms, National Average Wage Index (NAWI) takes value \$48,098.63.²⁶ Therefore, annual credit amount under this regime would equal to \$24,049.32. This amount of credit is proposed in the bill for the Social Security Caregiver Act of 2021 (House of Representatives, Congress, 2021) for caregivers with no wages.

Under the “Basic Caregiver Credit” regime, the mother will receive annual equivalent of minimum wage (\$15,080 in 2015 dollar terms) as caregiver earnings credit for each year of child care if she doesn’t have any wage earnings.²⁷ This type of caregiver credit provision is present in other developed countries. For example, in France, a mother caring for a child under age 3, with labor earnings below a specific threshold is credited as if she had received the minimum wage (Jankowski, 2011).

Second, I implement the Social Security caregiver credit in the presence as well as in the absence of the provision of Social Security spousal and survivor benefits. Traditionally, the Social Security system in the US recognizes the care giving 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.

Third, I analyze the effects under a regime where both the Social Security caregiver credit and the auxiliary benefits (spousal and survivor benefits) are not available to the mother.

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

²⁷In 2015, minimum hourly wage is set at \$7.25. To get the annual equivalent of minimum wage, I consider full time work (40 hours per week).

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 pre-retirement labor earnings for lower earners.

Revenue Neutrality. 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.

Table 10 reports adjustment in the Social Security tax rate for each reform. The tax rate is increased when the caregiver credit is introduced as introducing the credit leads to higher public budget deficit. On the other hand, when the spousal and survivors benefits are eliminated, the government runs a budget surplus (or incurs lower budget deficit compared to that under the baseline economy). Under those regimes, the tax rate is decreased to hold constant the deficit.

6.1 Effect on labor supply and earnings over the life cycle

The labor supply implications for married women from the policy reforms are summarized in Table 11. Not surprisingly, the provision of the caregiver credit reduces participation of married women during the child-rearing years. In the presence of auxiliary benefits, I observe positive but small increase in participation in the post-child-rearing period under both “Generous” and “Basic” caregiver credit (as shown in column (1) and column (3) of

Table 10: Adjustment in Social Security Tax Rate for Revenue Neutrality

Policy Reform	Generous Caregiver Credit		Basic Caregiver Credit		No Caregiver Credit
	with Aux. Benefits (1)	without Aux. Benefits (2)	with Aux. Benefits (3)	without Aux. Benefits (4)	without Aux. Benefits (5)
Social Security Tax Rate (%)	13.555	11.78	13.11	11.30	10.59

Notes: Reforms are revenue-neutral by adjusting the Social Security tax rate. At the baseline, the Social Security tax rate is 12.4%. Federal income tax rates and Medicare tax rate are kept the same as in the baseline scenario. “Aux. Benefits” refers to Auxiliary Benefits (Social Security spousal and survivors benefits).

11).²⁸ Under these reforms, disincentive to work during child-rearing years, generated by the caregiver credit, is potentially too large such that it dampens the effect of increment in participation in the later stages of the life cycle. Moreover, the option of claiming retirement benefits depending on husband’s earnings record creates lower attachment to workforce over the life cycle. This results in an overall decline in the employment rate of all married women (aged 25-66) by 2.02% and 1.36% under the “Generous” and the “Basic” caregiver credit respectively.

On the other hand, if the provision of caregiver credit is combined with the removal of spousal and survivors benefits, women come back to the workforce at a faster rate and their attachment to the labor force is higher in the post-motherhood years. When the marriage-based noncontributory benefits are not available, women have more incentive to increase their contributory Social Security benefits by boosting their earnings record. In addition, reward for child care through caregiver credit is realized when women claim retirement benefits based on their own work history. Since the credit covering motherhood earnings penalty is added to her contribution to Social Security benefits, the contributory nature of the credit also creates incentive to work in periods beyond child-rearing. As a result, I find the average employment rate of married women increases over the full working life, except

²⁸The only exception is that participation of women aged 56-61 drops by 0.02% under “Generous” caregiver credit regime.

Table 11: Policy Analysis: Effect on Labor Supply Outcomes over the Life Cycle

Policy Reform	Generous Caregiver Credit		Basic Caregiver Credit		No Caregiver Credit
	with Aux. Benefits (1)	without Aux. Benefits (2)	with Aux. Benefits (3)	without Aux. Benefits (4)	without Aux. Benefits (5)
Employment Rate of Married Women, by age	% Δ	% Δ	% Δ	% Δ	% Δ
25-30	-22.13	-19.15	-15.23	-9.65	12.02
31-35	0.95	11.08	0.89	11.16	9.75
36-40	0.27	5.73	0.24	5.75	5.60
41-45	0.14	5.02	0.06	5.10	5.02
46-50	0.67	6.07	0.44	5.72	5.06
51-55	0.29	5.62	0.23	5.48	5.31
56-61	-0.02	5.69	0.13	5.85	5.56
62-70	1.26	5.52	0.76	4.60	3.57
25-ERA, 62	-2.27	3.36	-1.51	4.44	6.59
25-FRA, 66	-2.02	5.86	-1.36	4.64	6.56

Notes: All effects are percentage changes (%) with respect to the benchmark as marked. 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. “Aux. Benefits” refers to Auxiliary Benefits (Social Security spousal and survivors benefits).

for the child-rearing years. As shown in Table 12, under both the “Generous” and the “Basic” caregiver credit, participation in the workforce increases to 59.11% and 59.09% respectively (compared to 55.59% at baseline) in the post-child-rearing period (that is, in the age group 31-62). Moreover, proportion of women aged 31-62 who never participate in the workforce drops to 12.61% and 12.50% respectively under the “Generous” and the “Basic” caregiver credit compared to 15.67% in the baseline economy.

Under the regime where women can only claim benefits based on their own earnings history and cannot avail the caregiver credit for child care, the average employment rate of married women in the 25 to 66 age group increases by 6.56% (as reported in Column (5) of Table 11) from the status quo value of 0.509 (or equivalently by 3.34 pp. from the status quo

Table 12: Policy Analysis: Effect on Labor Supply in the Post-child-rearing Period

	Baseline	Generous Caregiver		Basic Caregiver		No Caregiver
		Credit		Credit		Credit
		with Aux. Benefits (1)	without Aux. Benefits (2)	with Aux. Benefits (3)	without Aux. Benefits (4)	without Aux. Benefits (5)
Women, 31-62						
% working	55.59	55.78	59.11	55.75	59.09	58.86
% never working	15.67	15.78	12.61	15.67	12.50	12.41
% always working	00.21	00.38	00.46	00.33	00.39	00.32

Notes: All reported effects are at level. 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. “Aux. Benefits” refers to Auxiliary Benefits (Social Security spousal and survivors benefits).

value of 50.09%). 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 (4.67, 4.61, and 3.57 pp. increment at ages 25-30, 31-35, and 36-40), 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 13: Policy Analysis: Effect on Average Career Earnings and Lifetime Labor Earnings

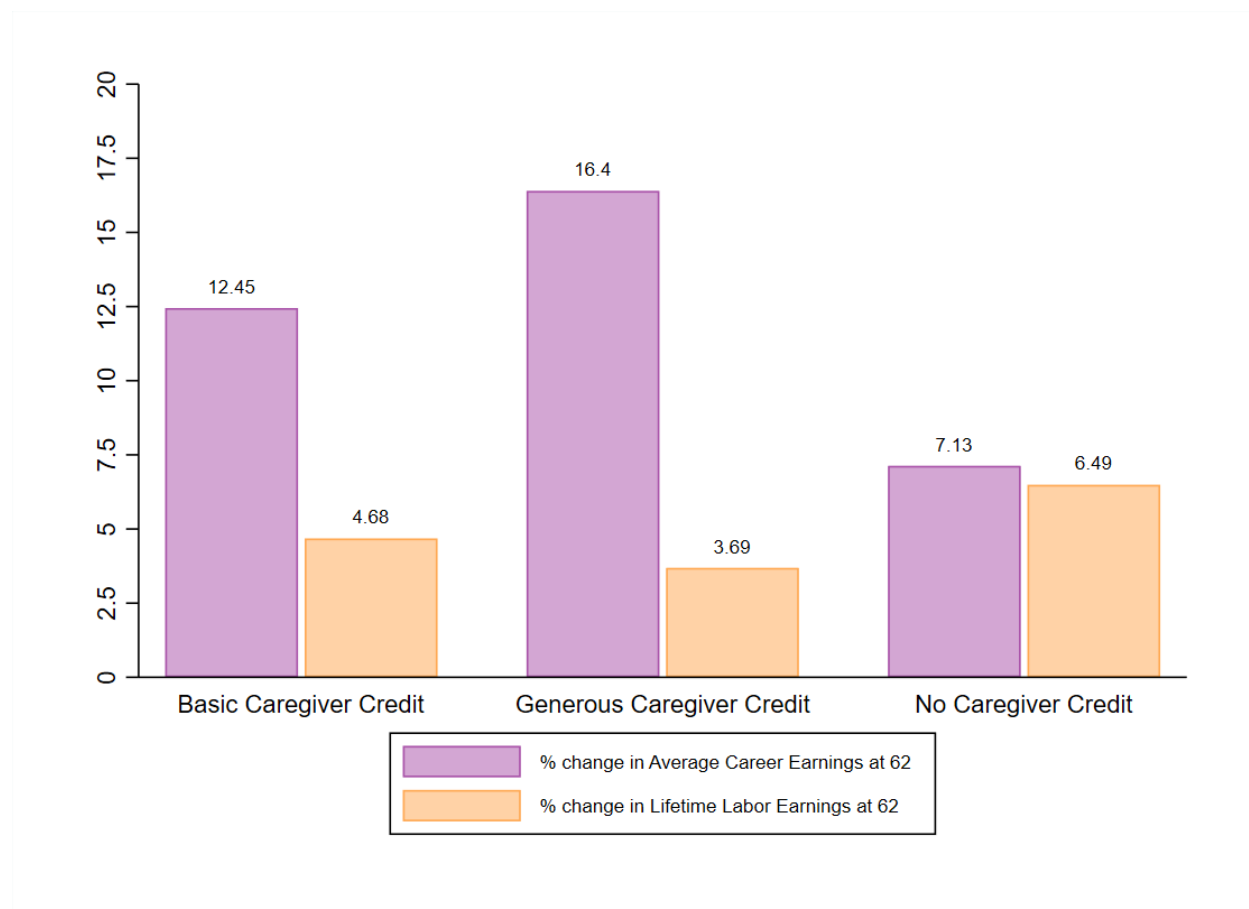
Policy Reform	Generous Caregiver Credit		Basic Caregiver Credit		No Caregiver Credit
	with Aux. Benefits (1)	without Aux. Benefits (2)	with Aux. Benefits (3)	without Aux. Benefits (4)	without Aux. Benefits (5)
	% Δ	% Δ	% Δ	% Δ	% Δ
Work Experience of Married Women at 62	-2.46	3.68	-1.64	4.85	7.19
Lifetime Labor Earnings of Married Women, 25-62	-1.92	3.69	-1.27	4.68	6.49
Average Career Earnings of Married Women at 62	10.50	16.40	6.20	12.45	7.13
Gender gap in Average Career Earnings at 62	-8.43	-13.17	-4.98	-9.99	-5.73

Notes: All effects are percentage changes (%) with respect to the benchmark as marked. 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. “Aux. Benefits” refers to Auxiliary Benefits (Social Security spousal and survivors benefits).

We now turn to the impact of the policy changes on work experience, pre-tax lifetime labor earnings and average career earnings. As shown in Table 13, the introduction of caregiver credit leads to a reduction in the accumulated work experience at the ERA by 2.46% and 1.64% under the “Generous” and the “Basic” regimes, respectively, in the presence of spousal and survivor benefits. The reforms also reduce aggregate lifetime labor earnings of married women. 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 10.50% and 6.20%, and consequently the difference between the average career earnings of married men and married women at their ERA drops by 8.43% and 4.98%, under the “Generous” and the “Basic” regimes, respectively.

In contrast, with no auxiliary benefits, increased attachment to the workforce leads to increment in accumulated work experience at the Social Security Early Retirement Age (ERA) of age 62 by 3.68% and 4.85% under the “Generous” and the “Basic” caregiver credit, respectively.²⁹ 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. Increased participation and substantial returns to labor-market experience boost their lifetime earnings by 3.69% and 4.68%, under the “Generous” and the “Basic” regimes, respectively.

Figure 1: Effect on Average Career Earnings and Lifetime Labor Earnings, under No Auxiliary Benefits

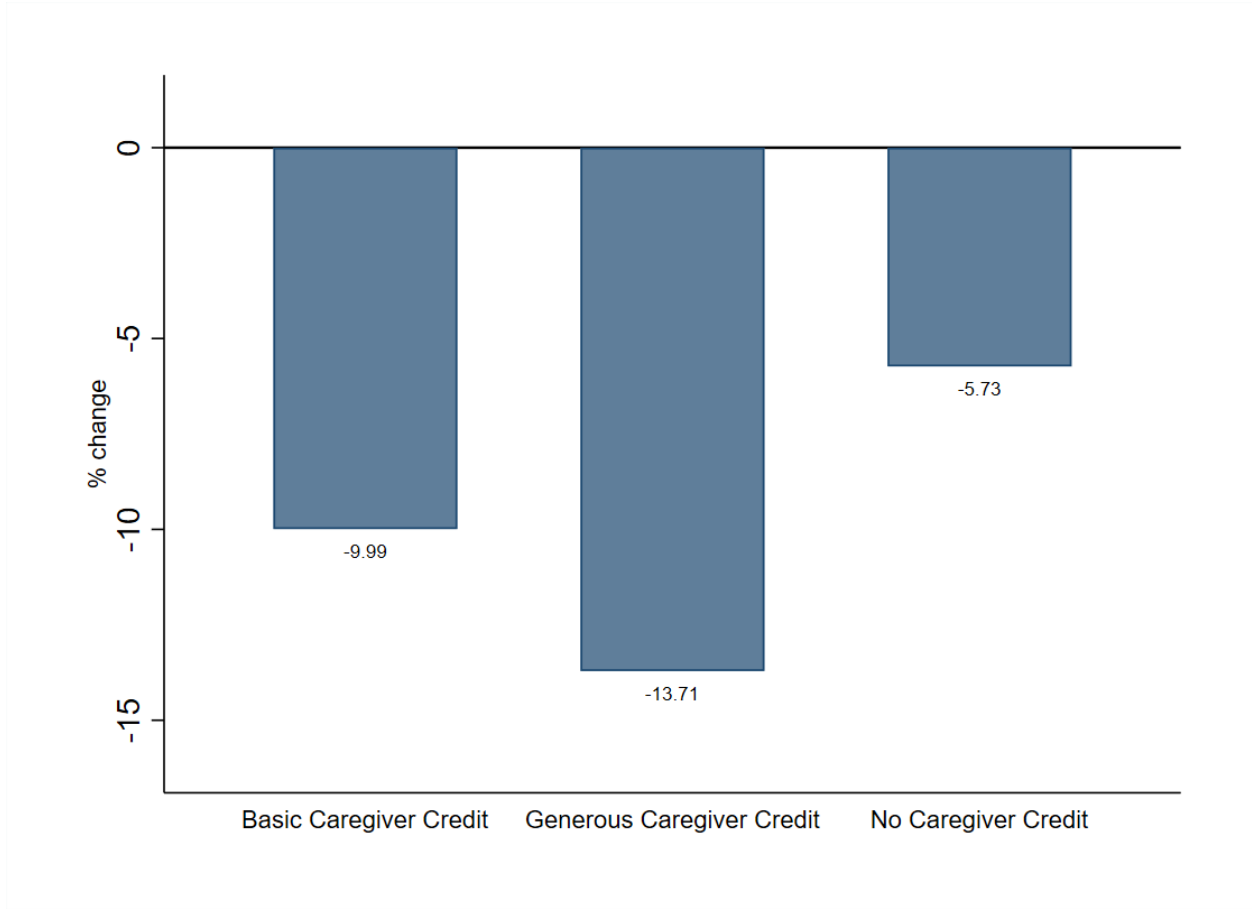


²⁹The Social Security Early Retirement Age (ERA) refers to the minimum age at which a worker can start claiming Social Security retirement benefits.

In case of the “Generous Caregiver Credit”, I observe a considerably large effect (16.40% 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 16.4% extra Social Security retirement benefits under the reform “Generous Caregiver Credit, No Auxiliary Benefits” compared to the baseline scenario. This implies that if married women get Social Security benefits solely on their own earnings record, the provision of “Generous 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. The reform 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 13.17% compared to the status quo. I obtain similar but smaller effects under the “Basic Caregiver Credit, No Auxiliary Benefits” reform.

It is worth noting that, in the absence of auxiliary benefits, increment in lifetime labor earnings under “No Caregiver Credit” is slightly higher than that under “Generous” and “Basic” caregiver credit. However, the importance of caregiver credit in rewarding child care as well as offsetting motherhood earnings penalty is highlighted by the changes observed for average career earnings with respect to the policy reforms. As shown in Figure 1, under “No Caregiver Credit”, increment in average career earnings at the ERA (7.13%) is not significantly different from increment in lifetime labor earnings (6.49%). With caregiver credit, increment in average career earnings at the ERA is not only driven by higher lifetime earnings due to higher participation but it also accounts for the earnings credit for child-rearing. This results in greater reduction in gender gap in average career earnings (or equivalently, gender gap in Social Security benefit entitlement) when the caregiver credit is rewarded for child care compared to the absence of caregiver credit (see Figure 2).

Figure 2: Effect on Gender Gap in Average Career Earnings, under No Auxiliary Benefits



6.2 Effect on Government Budget

Table 14 reports the impact of each revenue-neutral reform on income tax revenue and on Social Security expenditure. Under all policy reforms, Social Security expenditure increases. While instituting the caregiver credit is expected to increase government expenditure, the elimination of spousal and survivors benefits is expected to reduce government expenditure to some extent. Moreover, labor supply responses of women affect their average career earnings which in turn impacts Social Security expenditure depending on her benefit claiming decision.

Since the Social Security tax rate has been increased under regimes with the caregiver credit as well the auxiliary marriage-based Social Security benefits, payroll taxes paid by the households have increased significantly with the highest increment of 6.74% under “Generous

Table 14: Policy Analysis: Effect on Public Expenditure and Public Revenue

Policy Reform	Generous Caregiver Credit		Basic Caregiver Credit		No Caregiver Credit
	with Aux. Benefits (1)	without Aux. Benefits (2)	with Aux. Benefits (3)	without Aux. Benefits (4)	without Aux. Benefits (5)
	% Δ	% Δ	% Δ	% Δ	% Δ
Total Payroll Taxes paid by Married Women	5.57	-0.25	3.39	-2.65	-6.02
Total Payroll Taxes paid by Married Men	7.36	-3.95	4.52	-7.01	-11.53
Total Payroll Taxes paid by Households	6.74	-2.67	4.13	-5.49	-9.61
Total Federal Income Taxes paid by Households	-0.54	2.24	-0.35	2.56	3.07
Total Tax Revenue	2.89	-0.07	1.76	-1.24	-2.91
Total Social Security Benefits	3.27	-0.09	1.99	-1.39	-3.29
Social Security Tax Rate (%)	13.555	11.78	13.11	11.30	10.59

Notes: All effects are percentage changes (%) with respect to the benchmark as marked. Reforms are revenue-neutral by adjusting the Social Security tax rate. At the baseline, the Social Security tax rate is 12.4%. Federal income tax rates and Medicare tax rate are kept the same as in the baseline scenario. “Aux. Benefits” refers to Auxiliary Benefits (Social Security spousal and survivors benefits).

Caregiver Credit” with auxiliary benefits. On the other hand, under regimes where caregiver credit is implemented in the absence of the auxiliary benefits, Social Security tax rate is reduced. This leads to fall in payroll taxes paid by the households. 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 response to the policy reforms and change in the tax rate for revenue-neutrality.

When caregiver credit is implemented in the presence of spousal and survivors benefits,

revenue from federal income taxes decreases by 0.54% under the “Generous Credit” and 0.35% under the “Basic Credit”. However, federal income tax revenue increases from 2.24% to 2.56% when the caregiver credit is introduced in the absence of spousal and survivors benefits. This result is partly driven by the fact that women’s labor force attachment and earnings are higher in the post-child-rearing periods when they receive the reward for child care through caregiver credit and do not have the option to claim Social Security retirement benefits on the basis of their husband’s earnings history.

6.3 Welfare Analysis

In this section, I summarize the welfare implications of policy changes. To measure the welfare effects of 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:

$$\begin{aligned}
\mathbb{E}_0 U(\text{baseline}, \tau_{\text{baseline}}^{ss})|_{\pi} = & \\
\mathbb{I}_{\{t \leq T^{FR}\}} \left[\sum_{i=1}^N \sum_{t=0}^{T^{FR}} \beta^t \left(\frac{((1-\pi)\frac{c_t}{n_t})^{(1-\gamma)}}{1-\gamma} - \psi_t P_t \right) \right] & \\
+ \mathbb{I}_{\{t > T^{FR}\}} \left[\sum_{i=1}^N \sum_{t=T^{FR}+1}^T \left\{ \beta^t \text{surv}_{t+1}^h \text{surv}_{t+1}^w \left(\frac{((1-\pi)\frac{c_t}{n_t})^{(1-\gamma)}}{1-\gamma} \right) \right. \right. & \\
\left. \left. + \beta^t (1 - \text{surv}_{t+1}^h) \text{surv}_{t+1}^w \left(\frac{((1-\pi)c_t)^{(1-\gamma)}}{1-\gamma} \right) \right\} \right] & \quad (21)
\end{aligned}$$

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:

$$\begin{aligned}
\mathbb{E}_0 U(\text{reform}, \tau_{\text{reform}}^{ss}) = & \\
\mathbb{I}_{\{t \leq T^{FR}\}} \left[\sum_{i=1}^N \sum_{t=0}^{T^{FR}} \beta^t \left(\frac{\left(\frac{c_t}{n_t}\right)^{(1-\gamma)}}{1-\gamma} - \psi_t P_t \right) \right] & \\
+ \mathbb{I}_{\{t > T^{FR}\}} \left[\sum_{i=1}^N \sum_{t=T^{FR}+1}^T \left\{ \beta^t \text{surv}_{t+1}^h \text{surv}_{t+1}^w \left(\frac{\left(\frac{c_t}{n_t}\right)^{(1-\gamma)}}{1-\gamma} \right) \right. \right. & \\
\left. \left. + \beta^t (1 - \text{surv}_{t+1}^h) \text{surv}_{t+1}^w \left(\frac{(c_t)^{(1-\gamma)}}{1-\gamma} \right) \right\} \right] & \quad (22)
\end{aligned}$$

where $\tau_{\text{reform}}^{ss} = \tau_{\text{baseline}}^{ss} = 6.2\%$ without revenue-neutrality, and with revenue-neutrality $\tau_{\text{reform}}^{ss}$ takes value for each reform based on values reported in Table ?? .

I solve for π such that

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

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 15 reports value of π in terms of percentage change in lifetime consumption of going from the baseline to each policy regime with revenue-neutrality. To better understand the mechanisms behind the welfare effects of policy changes, I also show the decomposition by reporting welfare measures under non-revenue neutrality (where the reforms are performed without adjusting the Social Security tax rate) as well as under the scenario where Social Security tax rates are adjusted but the policy reforms are not conducted. This helps to decompose the welfare effect of the policy reforms from the welfare effect of payroll tax changes.

Considering revenue-neutral policy reforms, I find that the welfare benefits of caregiver

Table 15: Welfare Analysis

Welfare cost of going from baseline to reform	Generous Caregiver Credit		Basic Caregiver Credit		No Caregiver Credit
	with Aux. Benefits (1)	without Aux. Benefits (2)	with Aux. Benefits (3)	without Aux. Benefits (4)	without Aux. Benefits (5)
with revenue neutrality	-1.05%	0.83%	-0.63%	1.29%	1.88%
<i>Decomposition</i>					
without revenue neutrality	0.31%	0.11%	0.21%	-0.01%	-0.24%
only changing social security tax rate	-1.34%	0.73%	-0.83%	1.31%	2.14%

Notes: Reforms are revenue-neutral by adjusting the Social Security tax rate. At the baseline, the Social Security tax rate is 12.4%. Federal income tax rates and Medicare tax rate are kept the same as in the baseline scenario. “Aux. Benefits” refers to Auxiliary Benefits (Social Security spousal and survivors benefits).

credit would be considerably smaller under the regimes with spousal and survivor benefits compared to the baseline scenario. Households are willing to pay 1.05% and 0.63% of baseline lifetime consumption ex ante to avoid the “Generous Caregiver Credit” and the “Basic Caregiver Credit”, respectively, and remain in the baseline regime. The welfare decomposition indicates that the welfare loss under revenue-neutral caregiver credit policy is driven by the mechanism that the welfare gain from non-revenue neutral caregiver credit leads to welfare gain of 0.31%, while the increment in Social Security tax rate generates large welfare loss (1.34% of baseline lifetime consumption).

In contrast, in the absence of the spousal and survivor benefits, revenue-neutral implementation of “Generous” and “Basic” caregiver credits are welfare improving. While households appear to gain under “Generous Credit” from both the non-revenue neutral introduction of the caregiver credit and reduction in Social Security tax rate, welfare gain under “Basic Credit” is primarily generating from lower Social Security tax rate. Along similar lines, I find that although welfare benefits under the revenue-neutral “No Caregiver Credit, No

Auxiliary benefits” reform would be considerably higher compared to the baseline economy, significant reduction in Social Security tax rate induces the gain whereas non-revenue neutral implementation of the reform is welfare negative.

7 Conclusion

There are large international differences in how the public pension system compensates for the lifetime earnings cost of child-rearing. While many developed countries, such as France, Germany, and Sweden, provide caregiver public pension credit for time spent away from the labor force while taking care of young children, the Social Security system in the United States addresses the concern of motherhood earnings penalty primarily by providing spousal and survivor benefits for married women. Recently, due to growing concern that the lifetime economic consequence of child-rearing (or caregiving, in general) should be recognized, many policymakers have proposed a bill to amend the Social Security Caregiver Credit Act of 2021 ([House of Representatives, Congress, 2021](#)). In this paper, I analyze the labor supply implications and welfare consequences of reforming the Social Security system in the United States in a way that compensates for the earnings penalty for child-rearing through 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 quantify the impact of implementing Social Security caregiver credits in reducing motherhood earnings penalty over the life cycle.

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 in the absence of auxiliary benefits, as the incentive to return to the workforce following childbirth is stronger when the option to claim marriage-based benefits are not available. A key substantive result is that: lifetime labor earnings of married women increases in response to higher attachment to workforce in the post-motherhood years, and there is sizeable reduction in gender gap in average career earnings at the Social Security Early Retirement Age. 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. Combination of public pension policy design with dynamic lifecycle models of the sort presented in this paper may therefore be an avenue that helps exploring the effects of policy interventions that may help reduce motherhood earnings penalty over the lifecycle and improve retirement adequacy of women with career gaps due to motherhood.

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.

References

- Adda, J., Dustmann, C., & Stevens, K. (2017). The career costs of children. *Journal of Political Economy*, 125(2), 293–337.

- Albanesi, S., & Kim, J. (2021). Effects of the COVID-19 recession on the US labor market: Occupation, family, and gender. *Journal of Economic Perspectives*, 35(3), 3–24.
- Altonji, J. G., Hynsjo, D. M., & Vidangos, I. (2021). *Marriage dynamics, earnings dynamics, and lifetime family income*. National Bureau of Economic Research, Cambridge, MA.
- Altonji, J. G., & Segal, L. M. (1996). Small-sample bias in GMM estimation of covariance structures. *Journal of Business & Economic Statistics*, 14(3), 353–366.
- Attanasio, O., Low, H., & Sánchez-Marcos, V. (2008). Explaining changes in female labor supply in a life-cycle model. *American Economic Review*, 98(4), 1517–52.
- Attanasio, O., & Weber, G. (1995). Is consumption growth consistent with intertemporal optimization? Evidence from the consumer expenditure survey. *Journal of political Economy*, 103(6), 1121–1157.
- Bell, F. C., & Miller, M. L. (2005). *Life tables for the United States social security area, 1900-2100* (No. 120). Social Security Administration, Office of the Chief Actuary.
- Blundell, R., Costa-Dias, M., Goll, D., & Meghir, C. (2021). Wages, experience, and training of women over the life cycle. *Journal of Labor Economics*, 39(S1), S275–S315.
- Blundell, R., Costa Dias, M., Meghir, C., & Shaw, J. (2016). Female labor supply, human capital, and welfare reform. *Econometrica*, 84(5), 1705–1753.
- Blundell, R., Pistaferri, L., & Preston, I. (2008). Consumption inequality and partial insurance. *American Economic Review*, 98(5), 1887–1921.
- Blundell, R., Pistaferri, L., & Saporta-Eksten, I. (2016). Consumption inequality and family labor supply. *American Economic Review*, 106(2), 387–435.
- Blundell, R., Pistaferri, L., & Saporta-Eksten, I. (2018). Children, time allocation, and

- consumption insurance. *Journal of Political Economy*, 126(S1), S73–S115.
- Borella, M., De Nardi, M., & Yang, F. (2019). *Are marriage-related taxes and Social Security benefits holding back female labor supply?* National Bureau of Economic Research, Cambridge, MA.
- Butrica, B. A., & Smith, K. E. (2012). The impact of changes in couples’ earnings on married women’s Social Security benefits. *Social Security Bulletin*, 72, 1.
- Casanova, M. (2010). *Happy together: A structural model of couples’ joint retirement choices*. Unpublished Manuscript, Department of Economics, UCLA.
- Cortes, P., & Pan, J. (2020). *Children and the remaining gender gaps in the labor market*. National Bureau of Economic Research, Cambridge, MA.
- Eckstein, Z., Keane, M., & Lifshitz, O. (2019). Career and family decisions: Cohorts born 1935–1975. *Econometrica*, 87(1), 217–253.
- Eckstein, Z., & Lifshitz, O. (2011). Dynamic female labor supply. *Econometrica*, 79(6), 1675–1726.
- Favreault, M., & Sammartino, F. J. (2002). The impact of Social Security reform on low-income and older women.
- Favreault, M., & Steuerle, C. E. (2007). Social Security spouse and survivor benefits for the modern family. *Available at SSRN 1299202*.
- French, E. (2005). The effects of health, wealth, and wages on labour supply and retirement behaviour. *The Review of Economic Studies*, 72(2), 395–427.
- French, E., & Jones, J. B. (2011). The effects of health insurance and self-insurance on retirement behavior. *Econometrica*, 79(3), 693–732.

- Gallen, Y. (2018). Motherhood and the gender productivity gap. *Becker Friedman Institute for Research in Economics Working Paper*(2018-41).
- Goldin, C. (2014). A grand gender convergence: Its last chapter. *American Economic Review*, 104(4), 1091–1119.
- Goldin, C., & Katz, L. F. (2017). Women working longer: Facts and some explanations. In *Women working longer: Increased employment at older ages* (pp. 11–53). University of Chicago Press.
- Goldin, C., & Mitchell, J. (2017). The new life cycle of women’s employment: Disappearing humps, sagging middles, expanding tops. *Journal of Economic Perspectives*, 31(1), 161–82.
- Gourinchas, P.-O., & Parker, J. A. (2002). Consumption over the life cycle. *Econometrica*, 70(1), 47–89.
- Groneck, M., & Wallenius, J. (2021). It sucks to be single! Marital status and redistribution of social security. *The Economic Journal*, 131(633), 327–371.
- Gruber, J., & Wise, D. A. (1999). *Social security and retirement around the world*. University of Chicago Press Chicago.
- Guner, N., Kaygusuz, R., & Ventura, G. (2020). Child-related transfers, household labour supply, and welfare. *The Review of Economic Studies*, 87(5), 2290–2321.
- Haan, P., & Prowse, V. L. (2017). Optimal social assistance and unemployment insurance in a life-cycle model of family labor supply and savings. *Available at SSRN 2692616*.
- Hannusch, A. (2019). Taxing families: The impact of child-related transfers on maternal labor supply. *Unpublished Manuscript, Mannheim University*.

- Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica: Journal of the Econometric Society*, 153–161.
- Herd, P. (2006). Crediting care or marriage? reforming Social Security family benefits. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 61(1), S24–S34.
- House of Representatives, Congress. (2021). *H.R. 3632 (IH) - Social Security Caregiver Credit Act of 2021*. U.S. Government Publishing Office.
- Hubbard, R. G., Skinner, J., & Zeldes, S. P. (1995). Precautionary saving and social insurance. *Journal of Political Economy*, 103(2), 360–399.
- Hyslop, D. R. (2001). Rising US earnings inequality and family labor supply: The covariance structure of intrafamily earnings. *American Economic Review*, 91(4), 755–777.
- Iams, H. M. (2016). Married women’s projected retirement benefits: An update. *Social Security Bulletin*, 76, 17.
- Jankowski, J. (2011). Caregiver credits in france, germany, and sweden: lessons for the United States. *Social Security Bulletin*, 71, 61.
- Judd, K. L. (1998). *Numerical methods in economics*. MIT press.
- Kaygusuz, R. (2015). Social Security and two-earner households. *Journal of Economic Dynamics and Control*, 59, 163–178.
- Knapp, D. (2013). *The effect of Social Security auxiliary spouse and survivor’s benefits on the household retirement decision*. Unpublished manuscript.
- Lee, S. (2020). *Spousal labor supply, caregiving, and the value of disability insurance*. McMaster University Department of Economics Working Paper Series.

- Low, H., Meghir, C., & Pistaferri, L. (2010). Wage risk and employment risk over the life cycle. *American Economic Review*, 100(4), 1432–67.
- Maestas, N. (2017). The return to work and women’s employment decisions. In *Women working longer: Increased employment at older ages* (pp. 55–83). University of Chicago Press.
- McFadden, D. (1989). A method of simulated moments for estimation of discrete response models without numerical integration. *Econometrica: Journal of the Econometric Society*, 995–1026.
- Meghir, C., & Pistaferri, L. (2004). Income variance dynamics and heterogeneity. *Econometrica*, 72(1), 1–32.
- Munnell, A. H., & Eschtruth, A. D. (2018). Modernizing Social Security: Caregiver credits. *Issue in Brief*, 18–15.
- Nishiyama, S. (2019). The joint labor supply decision of married couples and the US Social Security pension system. *Review of Economic Dynamics*, 31, 277–304.
- Olivetti, C. (2006). Changes in women’s hours of market work: The role of returns to experience. *Review of Economic Dynamics*, 9(4), 557–587.
- Pakes, A., & Pollard, D. (1989). Simulation and the asymptotics of optimization estimators. *Econometrica: Journal of the Econometric Society*, 1027–1057.
- Rutledge, M. S., Zulkarnain, A., & King, S. E. (2017). *How much does motherhood cost women in Social Security benefits?* (Vol. 14). Center for Retirement research at Boston College Working Paper.
- Rutledge, M. S., Zulkarnain, A., & King, S. E. (2021). How much does Social Security offset the motherhood penalty? *Center for Retirement research at Boston College*.

- Sánchez-Marcos, V., & Bethencourt, C. (2018). The effect of public pensions on women's labor market participation over a full life cycle. *Quantitative Economics*, 9(2), 707–733.
- Tallis, G. M. (1961). The moment generating function of the truncated multi-normal distribution. *Journal of the Royal Statistical Society: Series B (Methodological)*, 23(1), 223–229.
- Toossi, M., & Morisi, T. L. (2017). *Women in the workforce before, during, and after the Great Recession*. Spotlight on Statistics, U.S. Bureau of Labor Statistics.
- Van der Klaauw, W., & Wolpin, K. I. (2008). Social Security and the retirement and savings behavior of low-income households. *Journal of econometrics*, 145(1-2), 21–42.
- Voena, A. (2015). Yours, mine, and ours: Do divorce laws affect the intertemporal behavior of married couples? *American Economic Review*, 105(8), 2295–2332.
- Wu, A. Y., Karamcheva, N. S., Munnell, A. H., & Purcell, P. J. (2013). How do trends in women's labor force activity and marriage patterns affect Social Security replacement rates. *Social Security Bulletin*, 73, 1.

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:

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

where b_1 and b_2 are the bend points at which the progressive replacement rates (90%, 32% and 15%) change.³⁰ 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.

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.

³⁰Bend points are scaled each year by average nominal wage growth in the economy.

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.

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:

$$PIA_{fmax}^j = 1.5 \times \min\{PIA^j, b_1^f\} + 2.72 \times \min\{\max\{PIA^j - b_1^f, 0\}, b_2^f - b_1^f\} \\ + 1.34 \times \min\{\max\{PIA^j - b_2^f, 0\}, b_3^f - b_2^f\} + 1.75 \times \max\{PIA^j - b_3^f, 0\}, \text{ for } j \in \{h, w\}$$

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_1^f	first bend point for Maximum Family Benefit	\$1056
b_2^f	second bend point for Maximum Family Benefit	\$1524
b_3^f	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:

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

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.³¹ 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.

³¹If 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.

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).³² 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.³³ Therefore, each spouse’s payroll tax contribution is specified as 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

³²The 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>.

³³Social 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. For more details, see <https://www.ssa.gov/pubs/EN-05-10024.pdf>.

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.³⁴ I use $d = \$12,600$ based on the standard deductions for married couples filing jointly in 2015.³⁵ 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 B.6 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.³⁶

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

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

³⁴While 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>.

³⁵In this paper, I am not considering personal exemptions for families with kids and child tax credit. The 2017 Tax Cuts and Jobs Act (TCJA) increased the standard deduction, eliminated personal exemptions, doubled the maximum child tax credit from \$1000 to \$2000 per child under age 17. Before TCJA, taxpayers could claim a personal exemption for themselves and each of their dependents. The tax benefit from personal exemptions depends on a taxpayer's marginal tax rate. Therefore, under a progressive income tax, exemptions are worth more to high-income taxpayers than to low-income taxpayers.

³⁶I 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 B.7.³⁷

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:

³⁷According 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”.

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

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

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

where the shocks are distributed as follows:

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

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,

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

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 $y \sim N(\mu, \sigma^2)$, $\mathbb{E}[f(y)] = \int_{-\infty}^{+\infty} \frac{1}{\sigma\sqrt{2\pi}} f(y) e^{-\frac{(y-\mu)^2}{2\sigma^2}} dy$, 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,

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

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:

$$\mathbb{E}_{\zeta^h, \zeta^w} V_{t+1}(\zeta^h, \zeta^w, X_{t+1}, z_{t+1})$$

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

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:

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

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

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

$(m_{i,\nu^{hh}}^{GH}, \omega_{i,\nu^{hh}}^{GH})$ 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:

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

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:

$$P_t^* = I_t' \iota + K_t' \kappa + \mu_t \quad (\text{D.2})$$

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

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

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

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:

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

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

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

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

where $X_t^{w'} \beta = a_0^w + a_1^w x_t + a_2^w x_t^2$; $\sigma_{\zeta^w}^2 = \text{Var}(\zeta_t^w)$; $\rho_{\zeta_t^w \mu_t} = \text{Corr}(\zeta_t^w, \mu_t)$; $\Lambda_t = \frac{\phi(\alpha_t)}{\Phi(\alpha_t)}$ 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, $\hat{\Lambda}_t = \frac{\phi(\hat{\alpha}_t)}{\Phi(\hat{\alpha}_t)}$.

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.³⁸ I use the following four moment conditions in a Generalized Method of Moments (GMM) framework to identify $\sigma_{\zeta^w}^2$ and $\sigma_{\zeta^h, \zeta^w}$:

$$\mathbb{E}[\Delta u_t^w | P_t = 1, P_{t-1} = 1] = \sigma_{\zeta^w, \mu} \Lambda_t \quad (\text{D.7})$$

$$\mathbb{E}[\Delta u_t^w (\Delta u_{t-1}^w + \Delta u_t^w + \Delta u_{t+1}^w) | P_t = 1, P_{t-1} = 1, P_{t+1} = 1, P_{t-2} = 1] = \sigma_{\zeta^w}^2 - \sigma_{\zeta^w, \mu}^2 \Lambda_t \alpha_t \quad (\text{D.8})$$

$$\mathbb{E}[\Delta u_t^h | P_t = 1, P_{t-1} = 1] = \sigma_{\zeta^h, \mu} \Lambda_t \quad (\text{D.9})$$

$$\mathbb{E}[\Delta u_t^w \Delta u_t^h | P_t = 1, P_{t-1} = 1] = \sigma_{\zeta^h, \zeta^w} - \sigma_{\zeta^h, \mu} \sigma_{\zeta^w, \mu} \Lambda_t \alpha_t \quad (\text{D.10})$$

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

³⁸The moment conditions are corrected for sample selection using formulae for the moments of the conditional truncated normal distribution (see [Tallis \(1961\)](#)).