Education, Marriage, and Social Security*

Prasanthi Ramakrishnan†

November 4, 2022
Link to Latest Version

Abstract

The social security system is non-neutral with respect to marriage, with married couples able to receive 150 percent of the primary earner's benefits (spousal benefits). This paper asks how changes in tax and retirement policy affect education and marriage. I first document trends relating to social security and household structure and then build a structural model with endogenous education and marriage, where households are modeled in a collective-household setup as compared to a standard unitary model. Contrary to models where the returns to education are only through the labor market, increasing payroll taxes leads to a marginal increase in those who invest in college, while reducing those who choose to remain single. Removal of spousal benefits or joint income taxation results in reducing the economic benefit of marriage and work. This leads to increased labor force participation by married females; however, removal of spousal benefits leads to higher singlehood rates, higher college investment, and higher male labor force participation, while that of joint income taxation results in lower male labor force participation and marginal change in college investment or singlehood rates. This arises primarily due to the modeling of the collective household, where both spouses' decisions matter. Thus, evaluation of the social security system is sensitive to decisions of education, marriage, and within-household bargaining and will be incomplete without incorporating these decisions.

JEL Codes: H55, J26, D15

*I thank Bart Hamilton, George-Levi Gayle, Limor Golan, Robert Pollak, and Stephen Ryan for their guidance and support throughout the project, and Costas Meghir for conversations that have substantially improved the paper. I also thank Bence Bardóczy, Francisco Buera, Dario Caldara, Chao Fu, Joaquin Garcia-Cabo, Nils Gornemann, Rodolfo Manuelli, Arnaud Maurel, Yongseok Shin, Elie Tamer and Ivan Werning for their helpful comments and seminar participants at the International Finance Workshop at the Federal Reserve Board of Governors, Society of the Economics of the Household 2022, Economics Brownbag at the Olin Business School, 14th Economics Graduate Student Conference and Applied Microeconomics Workshop and Work, Family, Public Policy Seminar at Washington University in St. Louis. I am grateful to Boston College Center for Retirement Research for financial support.

†Department of Economics, Washington University in St. Louis, Campus Box 1208, One Brookings Drive, St. Louis, MO 63130. Email: p.ramakrishnan@wustl.edu.

1 INTRODUCTION

Many policies in the United States are not marriage neutral i.e. vary by the marital status of an individual. Two prime examples of this are the social security system and joint income taxation. Under the social security system, each spouse receives a maximum of either the benefit based on their employment history or 50 percent of the spouse's benefits. In other words, married couples are entitled to at least 150 percent of the primary earner's benefits. Thus, single households and single-earner households pay the same payroll taxes but receive vastly different social security benefits. Further, if spousal benefits are considered an economic benefit of marriage, then it could affect the decision of if and to who to get married to.

This paper seeks to understand the importance of incorporating education, marriage, and intra-household decisions in analyzing changes to the social security system, specifically in terms of payroll taxes and spousal benefits. While there exists a large literature that focusses on education and social security system and there is a growing literature on the effect of education and marriage, there are very few papers that analyze the interplay of education, marriage, and social security system, while explicitly modeling within-household behavior that highlights the individuality of the the household members.

This paper follows a two-step methodology: I first document data trends that are relevant to the social security system and household structure; I then substantiate this by building a structural model to disentangle the mechanisms underlying these trends. I present three key findings: first, through spousal benefits, social security is biased in favor of married households, specifically single-earner households. Second, retirement earnings vary by education and marital status, with low-educated single females being disproportionately represented in the bottom quintile of the income distribution in old age. Third, marital status and within-household decisions affect labor force participation and income. However, the objects being studied here are endogenous.

The question this paper seeks to answer has many selection issues built in and thus, viewing it through the lens of a structural model will help in disentangling the role of education, household structure, and labor force participation in old age outcomes. We develop a life-cycle model with endogenous human capital accumulation, consumption, savings, labor force participation, and marriage. Males and females are initially identical, starting with some initial human capital and assets. Individuals then decide to get low or high education. Based on their education, a female (male) chooses to stay single or get married to a male (female) of low or high education. Once households (single or married) are formed, time allocation of work, home and leisure, and savings decisions are made until they retire. Members of the household earn income, pay taxes and save. Once they retire, they make decisions about home and leisure allocation along with savings. Households then live off their accumulated assets and social security benefits.

In this model, a key aspect is that members within a household are treated as distinct individuals, or in other words, as a collective household setup following **chiappori1992collectiv** where $\boldsymbol{\lambda}$ is the Pareto weight on the female in the household. $\boldsymbol{\lambda}$ can be thought of as a measure of bargaining power within the household, which would determine the time allocation of the spouses. Additionally, I allow for imperfect transferable utility within the households, which ensures that time allocation decisions, taxation, and social security are relevant. This is embedded within an equilibrium marriage market, following **gayle2019optimal**, where the prices that clear the marriage market are the Pareto weights $\boldsymbol{\lambda}$ when the supply of partners equals the demand of partners. Individuals get married for the following economic reasons: public good of home production, joint taxation, social security, and insurance. I allow for a non-economic benefit of marriage, or love shock as in **choo2006marries**.

Incorporating endogenous marriage decisions and equilibrium marriage markets has two key implications. First, the returns to education are two-fold - there are the standard labor-market returns as well as the marriage market returns to education (**chiappori2009investment**). Second, the education and marriage markets are jointly linked - the marriage markets influence education through the change in the returns; however, education influences the marriage market through λ as it affects the availability of individuals of a certain type, and thus, directly impacting supply and demand of individuals. I prove identification for the model. I estimate the model using a two-step Generalized Method of Moments (GMM), with moments from PSID, and HRS data.

The model fits the data well and I find that there are high gains from homogamy in marriage, as well as higher fixed costs of working for females as compared to males. Moreover, while individuals are nearly risk-neutral on home production, they are more risk-average towards consumption and leisure. I conduct three counterfactual exercises: (1) increasing payroll taxes proportionately by 50 percent and decomposing this into 3 effects: when marriage markets are not allowed to adjust (marriage market prices λ are kept fixed), when the education distribution is kept fixed and when both education distribution and marriage markets are kept fixed; (2) increasing payroll taxes and removing spousal benefits; (3) removing marriage non-neutral policy - spousal benefits and joint taxation.

Decomposing the effect of incorporating education and marriage markets, I find that human capital investment would increase by 1.6 percent if payroll taxes are proportionately increased by 50 percent, when households are not allowed to re-bargain ($\boldsymbol{\lambda}$ is held fixed). At the same time, singlehood increases by 3.5 percent, and married males increase their participation in the labor market by 3.1 percent during their work-life. However, when households are allowed to re-bargain, I find that there is a marginal increase in human capital investment of only 0.08 percent. Instead, singlehood rates fall by 1.2 percent. The key reason for the divergence is the incorporation of collective households in an equilibrium marriage market. This allows households to counter the rise in payroll taxes (which makes working costlier, and reduces the labor market returns) by making adjustments within the household by using other margins such as joint income taxation. Thus, incorporating marriage households is important while evaluating marriage non-neutral systems such as the social security system. The estimate of the increase in human capital in the model without bargaining can be comparable to the model of **fan2017understanding**, which incorporates endogenous wage process through human capital accumulation and endogenous retirement, where they find an increase of human capital investment of 2.6 percent and increase in participation by males of 3.1 percent for the same increase in payroll taxes.

Increasing payroll taxes proportionately by 10 percent to 100 percent, I find that increase in payroll taxes still leads to a marginal change in college education, indicating that the above example is common. Moreover, singlehood rates decline by 1.6 percentage points. To put it in perspective, single households have increased from 14 percent to 38 percent, over nearly 60 years, an average of 0.4 percentage points each year. This is also accompanied by a reduction in the bargaining power of females, as well as increased household specialization, with married females working less and married males working more for full-time hours.

Removal of spousal benefits leads to a rise in college education by 1.5 percent and a rise in singlehood by 6.7 percent. This is not surprising as spousal benefits are an economic benefit of marriage in the model and therefore, marriage market benefits of marriage reduce, and thus, singlehood increases. I find a simultaenous rise in part-time employment of married females during older ages by 3.4 percent and full-time employment by 3.8 percent. This is slightly lower compared to **borella2019marriage**; however, in this paper, education, and marriage both react to the change in spousal benefits and singlehood rates itself increase, which might reflect the lower adjustment in labor force participation of women. Allowing for a marriage-neutral system leads to similar findings: a rise in singlehood, and college education, with a reorganization of the division of labor. Thus, the crucial takeaway of the paper is that marriage and household decisions respond to taxation and retirement policy, and therefore, are important to incorporate in the evaluation of marriage non-neutral systems.

The two closest papers to this paper are **borella2019marriage** and **fan2017understanding**, and this paper builds on their body of work. **borella2019marriage** focus on the effect of marriage-related taxes (higher marginal tax rate) and social security (spousal benefits) on female labor supply, with the key mechanism that the social security structure depresses labor market participation. However, human capital accumulation and sorting into the marriage market are taken as exogenous; and thus, any policy prescription will miss any feedback effects from education or marriage. Moreover, they assume a unitary model of household behavior, and thus, miss accounting for within-household inequality. On the other hand, **fan2017understanding** estimate a life cycle model in which individuals make decisions about consumption, human capital investment, and labor supply (Ben-Porath framework). They emphasize that human capital accumulation (education, as well as on-the-job training) along with the endogenous wage process are key to understanding retirement decisions. However, they abstract away from households and estimate a gender-neutral model using data on males. Thus, in this paper, I allow for endogenous education and marriage decisions, in a collective household setup over the lifecycle, thus integrating human capital, marriage, and household decisions, while incorporating gender as well.

As this project focuses on the interplay between education, marriage, within-household, and retirement decisions, this paper contributes to multiple strands of literature. There is a large literature that focuses on labor supply and retirement decisions, with some focus on education (**blundell2016retirement**; **manuelli2012lifetime**; **fan2017understanding**). There is growing literature that explores the link between human capital investment and marital decisions, or the 'marital college premium' (**chiappori2009investment**; **chiappori2018marriage**; **chiappori2017partner**). However, there is scarce literature linking marriage and retirement. While there is descriptive evidence on joint retirement decisions, most papers tend to focus on males; for example, **gustman2009changes** develop a structural retirement model for married males from HRS. Some papers such as **borella2019marriage** focus on the effect of marriage-related taxes (higher marginal tax rate) and social security (spousal benefits) on female labor supply. **goldin2018women** assemble research that shows the importance of incorporating marital status, in addition to education and work experience for women. However, most papers do not focus on the within-household decisions and assume the household acts as a representative agent.

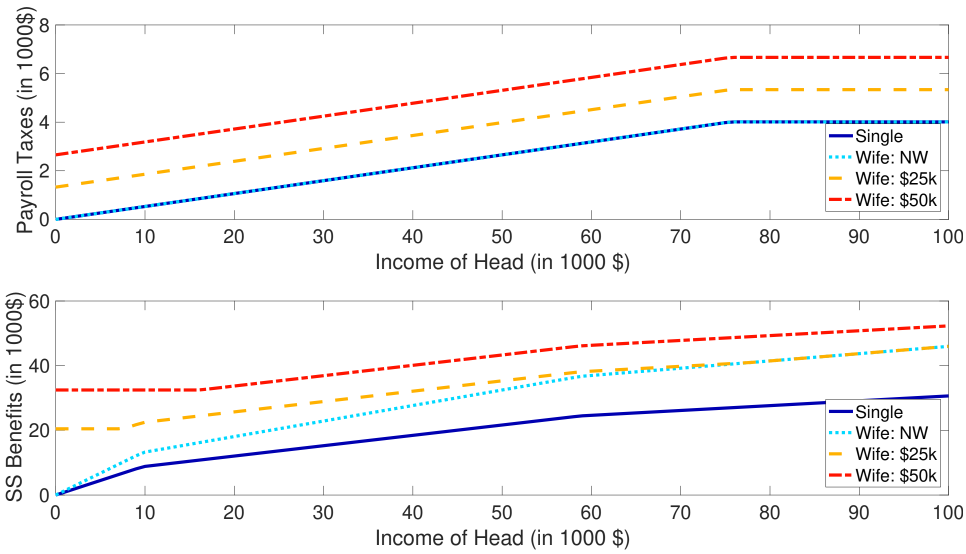
The remainder of the paper is organized as follows. Section 2 presents motivating evidence about the interplay between education, marriage, and retirement earnings. Section 3 describes the model and Section 4 shows the data, specification, estimation, and identification of the model. Section 5 presents the parameter estimates. Section 6 discusses the different counterfactuals. Section 7 concludes.

2 Social Security and Households

2.1 Social Security System in the US

There are three pillars of the retirement system: social security, employment-based-pensions, and own savings. In this paper, we focus on social security. The social secu-

Figure 1: Social Security Favors Married Households



Source: Author's calculations using average payroll tax rates, payroll cap, and AIME cutoffs from Social Security Administration.

rity system was set up in 1935, with social security being an 'earned right' i.e. based on your employment history. The benefits are based on the average of a worker's highest 35 years of earnings (AIME). These benefits are progressive i.e. higher for lower quintiles. While benefits can be claimed early [1], this leads to lower benefits over the lifetime. This system was then expanded to include wives and widows in 1939 - thus, this is a system that is built on the society that existed then of single-earner couples (where only one person in the couple works - this was traditionally the male earner). Under the current setup, spouses receive a maximum of benefits based on their employment history and 50 percent of the husband's benefits, once the husband claims. Although the system is inherently genderless, there is differential treatment built in due to the gender gap in wages.

2.2 Retirements earnings are affected by marital status

Although the social security system has undergone many changes over the last few decades, spousal benefits have persisted. These spousal benefits lead to a system that favors couples over single households. Figure 1 presents payroll taxes and social security benefits for four types of households: a single household, a married household with wife not working (NW), a married household with wife earning an annual income of $25,000, and married household with wife an annual income of $55,000, as the annual income of the head varies. All values are presented at the household level.

First, single and single-earner households (married households where the wife is not working) pay the same level of payroll taxes. Yet, they receive vastly different

1. Early retirement age is 62 years.

benefits, with the benefits received increasing as a function of the head's income. Second, as the wife participates in the labor market and earns an income, payroll taxes increase proportionately, but only up until the payroll cap. At the same time, benefits increase but display a non-linear trend, especially at the lower end of the income distribution. This graph does not take into income taxes or any other transfers that the government gives.

The social security system is biased in favor of married households. At the same time, if social security is an economic benefit for marriage, the existence of spousal benefits directly impacts the decision to marry, at the extensive (whether or not to get married) and at the intensive margin (who to get married to).

2.3 Education and marital status affects retirement earnings

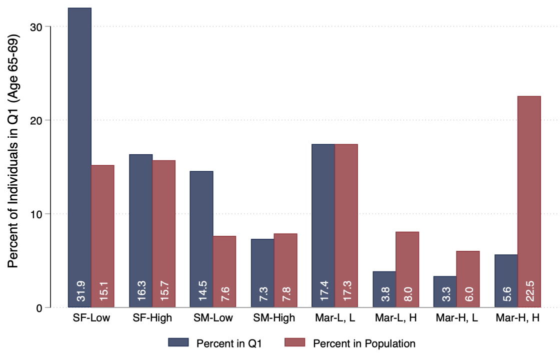
With the current financial situation of the social security system, re-design is an ongoing policy debate. Some of the policies that are often suggested are: increasing payroll taxes, and/or increasing the retirement age. While these will directly help in the solvency of the system, they do impact the individuals who depend on the system the most. To understand the individuals who are the most dependent on the system, I define household income using an equivalent scale [2]. Based on this household equivalent income, we divide the population into 4 quintiles. On average, for those aged 65-69 years, the bottom 25 percent derives 71 percent of their income from social security. The equivalent number for the top 25 percent is 11 percent, which depicts the progressive nature of the social security system.

However, the question that then arises is what is the composition of the bottom quintile, and more importantly, how is it compared to the population? We divide the population into eight groups: single (or currently not married) females of low and high education, single males of low and high education, and married households of low-low, low-high, high-low, and high-education (where the former education category is of the wife and the latter of the husband). Figure 2 presents the comparison between the proportion in the bottom 25 percent and to the entire population for the $1940-49$ generation.

First, while 32 percent of the bottom quintile comprises single females with low education, only 15 percent of them exist in the population. This indicates that there are twice as many single females in the bottom quintile. A similar trend is seen for single males who are low educated as well. Thus, being single and low educated in old age affects retirement security. Second, married households where both spouses are low

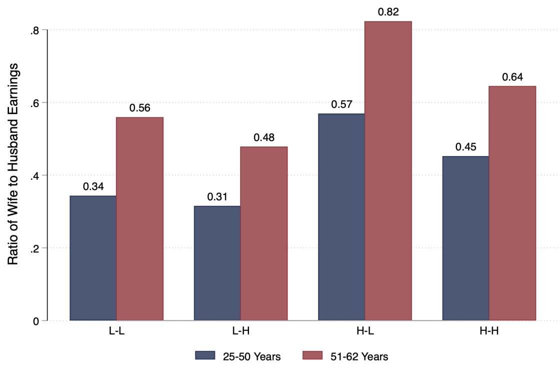
2. The equivalent scale is $\sqrt{\text{Number of Adults + 0.5*Number of Children}}$ as used in **heathcote2005two**.

Figure 2: Single and Low-Educated Poorest in Old Age



Source: Current Population Survey, 1962-2018. *Notes:* These numbers are calculated for the 1940-49 cohort. Low (L) refers to high school and below, while high (H) refers to some college and above. Individuals are currently single, as compared to never married. SF refers to single females and SM refers to single males. For married households, the education of the wife is listed first and then the husband.

Figure 3: Within Household Income Inequality Amongst Married Couples



Source: Current Population Survey, 1962-2018. *Notes:* Low (L) refers to high school and below, while high (H) refers to some college and above. Individuals are currently single, as compared to never married. SF refers to single females and SM refers to single males. For married households, the education of the wife is listed first and then the husband.

educated have no disproportionate representation in the bottom quintile, hinting at the fact that maybe joint production and insurance motives of marriage are playing a role. Third, married households of households where at least one spouse has high education are always underrepresented in the bottom quintile and thus, have less to worry about retirement security. The income security of single individuals is especially crucial with the rise of single households over time (from 14 percent in 1962 to 38 percent in 2018).

2.4 Marriage and within-household decisions affect labor force participation and retirement

While the impact of education and marital status can be seen on retirement earnings and vice versa, it is important to understand the variation of household decisions amongst married couples of different education groups. Taking the ratio of the average income of wife to husband for each of these couples for the 1940 cohort over their early (25-50 years) and later (51-62 years) working life. I make this split to ensure retirement earnings do not feed into the ratio of the early working life. Figure 3 presents these calculations for the 1940-49 cohort.

Firstly, in early work-life, holding the education of the wife fixed, the ratio of wife to husband income is higher when married to a low-educated man. This trend holds in later life as well. Second, when the woman is low educated, then this ratio is much lower than when the woman is high educated. However, this ratio of how income is earned within the household is an endogenous decision and with these numbers, the optimal decisions are seen.

From these facts, changes in marriage and education could interact with the existing retirement system. And thus, it is important to incorporate these while evaluating the social security system.

3 Model of Education, Marriage, and Social Security

This is a life-cycle model, set in discrete time. There are four stages in an individual's life: education (18-25 years), marriage (25 years), work-life (25-62 years), and retirement (62 years till 80 years). Figure 1 presents the timeline.

During the education stage, males and females choose low (High School and below) or high (Some College and above) education. They do not differ by their initial human capital or assets and thus, the difference in the choice for education arises from the present discounted value of future labor market and marriage market returns (**chiappori2018marriage**). Based on their education type, males and females enter into a frictionless marriage market where they choose to remain single or get married to an individual of the opposite sex with low or high education, which depends on an economic component and a non-economic component (or a love shock, as in (**choo2006marries**)). Thus, at the end of the education and marriage stages, there are 6 types of households: single males, single females, low-low couples, low-high couples, high-low couples, and high-high couples (where the education is of the female is first and male is second). Once married, there is no divorce or re-marriage. Households are

Table 1: Timeline in the Model

Period	t=1 Males Females	t=2 Males of type j Females of type i	t=[3, t_w] Single HHs Married HHs	t=[t_r, T] Single HHs Married HHs
State	Human Capital H^f Assets A^f	Education i (j)	$H_t^i, H_t^{k_m}$ Joint A_t^{i,k_m} Weight λ^{i,k_m}	AIME $Y_t^i, Y_t^{k_m}$ Joint A_t^{i,k_m} Weight λ^{i,k_m}
Shocks	HC Shock ϵ_i	Love Shock θ_{i,k_m}^i	Choice Shock $\epsilon_t^{k^{i,k_m}}$	Choice Shock $\epsilon_t^{k^{i,k_m}}$
Choice	Education i (j) $i = 1$ (low) $i = 2$ (high)	Marriage $k_m = 0, j = 1, 2$	Work $M_t^i, M_t^{k_m}$ Home: $Q_t^i, Q_t^{k_m}$ Savings: ρ_t^{i,k_m} Sharing Rule: s_t^{i,k_m}	Home: $Q_t^i, Q_t^{k_m}$ Savings: ρ_t^{i,k_m} Sharing Rule: s_t^{i,k_m}

modeled as formed of distinct individuals, following the collective model literature by **chiappori1992collective** and others. This household is set within an endogenous general equilibrium marriage market where the prices to clear the market are $\boldsymbol{\lambda}$ or the Pareto weights in the household, following **choo2006marries** and **gayle2019optimal**.

During work-life, single and married households make time allocation (work, home production, and leisure) and savings decisions and face health (or preference) shocks every period. Households face joint shocks, as opposed to individual shocks for each member. Income is a function of time spent in work, and human capital (which endogenously accumulates while working), with efficiency in work varying by gender and marital status. There are fixed costs associated with working, which vary by time spent working and by gender. Time spent in home production produces a non-marketable good. In a married household, time spent by both spouses in home production is used to produce this good, which is a public good for the household. Individuals consume and save based on their choice of savings rate, where their total income depends on their labor income along with return on assets less of taxes (payroll, medicare, and income). Assets are assumed to be joint at the household level. Further, individual consumption matters and is split according to an endogenous sharing rule.

During retirement, individuals continue to make time allocations (work, home production, and leisure) and savings decisions and face health (or preference) shocks every period. However, their income is the social security benefits that they earn based on their lifetime income. In married households, spouses are eligible for spousal benefits as well.

In this model, there are four economic benefits from marriage: public good of home production, jointness from income tax, spousal benefits, and insurance.

3.1 Preferences

Each individual derives utility from three components: own consumption C_t^a, home production $C_t^{Q,a}$ and own leisure L_t^a. Thus, for singles, the utility in a household is:

$$u^{S,a}(C_t^a, C_t^{Q,a}, L_t^a, \epsilon_t^a; \mathbf{X^a}) = u(C_t^a, C_t^{Q,a}, L_t^a; \mathbf{X^a}) + \epsilon_t^a$$

We assume additive separability of utility from the error shocks, as is standard in discrete choice models. On the other hand, for households, it is the weighted combination of the individual utilities of the two spouses.

$$\begin{aligned} u^{H,ab}(C_t^{ab}, C_t^{Q,ab}, L_t^{ab}, \epsilon_t^{ab}; \mathbf{X^a}, \mathbf{X^b}) &= \lambda^{ab} u(C_t^a, C_t^{Q,ab}, L_t^a; \mathbf{X^a}, \lambda^{ab}) \\ &\quad + (1-\lambda^{ab}) u(C_t^b, C_t^{Q,ab}, L_t^b; \mathbf{X^b}, \lambda^{ab}) + \epsilon_t^{ab} \end{aligned}$$

As is standard in discrete choice models, each individual (before marriage) and each household (after marriage, whether married or not) experiences preference shocks, which are distributed Type 1 Extreme Value.

3.2 Environment

The model starts with males and females, who do not differ by their initial human capital or assets. Let the initial measure of females and males be $\mathcal{F}$ and $\mathcal{M}$.

At the start of education, individuals observe their human capital and assets, along with their preference shock for education. At the start of the marriage stage, individuals observe their education type and preference for being single or for being married to an individual of low or high type. Along with this, they also observe the Pareto weight $\boldsymbol{\lambda}$ attached to being married. During the work-life period, single households observe their human capital, assets, and their health shocks; married households observe the human capital of each spouse, assets of the household, and joint health shocks. During retirement, single households observe their lifetime income, assets, and health shocks; whereas married households observe the lifetime income of each spouse, joint assets, and joint health shocks.

3.2.1 Time Allocation

The core of the model is a time allocation problem. An individual can spend his time in 4 ways: investing in schooling (I_t), working (M_t), at home (Q_t), and in leisure (L_t). In each period, time allocation sums up to 1; therefore, agents are choosing the proportion of time to invest in each activity. For investing in school, there are two types - low and high. For working and home production, individuals can invest either low,

Table 2: Time Allocation in the Model

Stage	Time Allocation
Education	$I_t, M_t, Q_t = 0, L_t = 0$
Work-Life	$I_t = 0, M_t, Q_t, L_t$
Retirement	$I_t = 0, M_t = 0, Q_t, L_t$
$I_t + M_t + Q_t + L_t = 1$	

medium, or high time. Leisure is considered to be a residual good. Table 2 presents the time allocation available in each stage.

3.2.2 Household Decision-Making

In this paper, married households take decisions in a collective household setup, as compared to a unitary setup. In a unitary setup, married households act as one unit, pooling all household resources and having the same preferences. Several papers have rejected the testable implications of the unitary model, specifically that only total income should matter in consumption decisions or pooling of household resources (**bourguignon1993intra**; **lundberg1997husbands**).

Contrary to that, in a collective household setup, it is assumed that household decisions are always efficient, i.e., no one can be made better off without making someone else worse off (**chiappori1992collective**). It is modeled as a weighted sum of utilities, where this weight is referred to as the Pareto weight or λ^{ij}. However, there is no assumption on the distribution of resources within the household. After making decisions on public goods within the household, there exists a sharing rule s_t^{ij} which will divide the household resources. In our setup, while consumption and leisure are private goods, home production is a public good produced jointly by the two spouses. Further, utility is imperfectly transferable in the model. If utility were perfectly transferable, then time allocation decisions or taxation and social security benefits would be irrelevant (**gayle2019optimal**).

3.2.3 Home Production

Time spent in home production produces a non-marketable public good in the household. It is defined separately for single and married households. For single households, home good is produced as follows:

$$C_t^{Q,a} = \Gamma_a(\mathbf{X^i})Q_t^a$$

where Q_t^a is time spent in home production, $\Gamma^a(\mathbf{X^i})$ is an efficiency scale of home production and $a \in \{i, j\}\ \forall i \in I, j \in J$.

For married households, home production results in a public good, produced as follows:

$$C_t^{Q,ij} = \Gamma_{ij}(\mathbf{X^i}, \mathbf{X^j})(Q^i)^{\alpha}(Q^j)^{1-\alpha}$$

where Q_t^i, Q_t^j are the time spent by wife and husband, respectively, $\Gamma_{ij}(\mathbf{X^i}, \mathbf{X^j})$ is an efficiency scale of home production and α is the returns to scale in home production time spent by the wife.

3.2.4 Human Capital and its Evolution

Individuals are born into a household with initial ability y_1^p, which is drawn from a log-normal distribution with mean μ^p and standard deviation σ_p. This does not vary by gender. After marriage, human capital evolves according to education and gender. During work-life, it then evolves deterministically according to the following learning-by-doing model:

$$H_{t+1}^a = (1-\delta)H_2^a + (M_t^a H_t^a)^{\alpha_2} \tag{1}$$

where δ is the depreciation of human capital over time, α_2 is the returns to human capital from time spent working, and $a \in \{i, j\}\ \forall i \in I, j \in J$. I assume that a significant amount of uncertainty arises in the early years of working in the vein of **topel1992job** and **guvenen2021data**.

3.2.5 Income, Assets, Consumption and Taxes

An individual's total income Y_t^a comprises three components: before-tax labor income, taxes and return on assets. An individual's before-tax income $y_t^a(H_t^a, M_t^a, FC^a)$ depends on his/her own human capital H_t^a, proportion of time spent working M_t^a, less of any fixed cost FC^a. An individual pays taxes $\tau(y_t^a)$ every period that they work. There are three types of taxes: payroll tax τ^p with cap on taxable income for payroll taxes c^p, medicare tax τ^m with no cap, and income tax τ^i with bands $\mathbf{c}^a(\mathbf{X})$ and tax rates $\tau^{i,a}(\mathbf{X})$ that vary by marital status. Taxes at the household level for incomes $\mathbf{y_t} = [y_t^a, y_t^b]$ are:

$$\tau(\mathbf{y_t}, \mathbf{X^\tau}) = \underbrace{\min\{\mathbf{y_t}, c^p\} * \tau^p}_{\text{payroll tax}} + \underbrace{\mathbf{y_t} * \tau^m}_{\text{medicare tax}} + \underbrace{\tau^i(\mathbf{y_t}, \mathbf{c^a}(\mathbf{X}), \tau^{i,a}(\mathbf{X}))}_{\text{income tax}}$$

where $\mathbf{X^\tau} = [c^p, \tau^p, \tau^m, \mathbf{c^a}(\mathbf{X}), \tau^{i,a}(\mathbf{X})]$. While payroll and medicare taxes are at the individual level, income tax is at the household level [3].

3. I assume that all married households file joint taxes.

Individuals have no assets before marriage. After marriage, they're endowed with assets, based on their gender (if unmarried). Each period, an individual maximizes the following budget constraint, if unmarried:

$$C_t^a + A_{t+1}^a = Y_t^a = y_t^a(H_t^a, M_t^a, FC^a) - \tau(y_t^a, \mathbf{X}^\tau) + (1+r)A_t^a \tag{2}$$

where $a \in \{i, j\}\ \forall i \in I, j \in J$, and if married, then:

$$C_t^{ij} + A_{t+1}^{ij} = Y_t^{ij} = y_t^i(H_t^i, M_t^i, FC^i) + y_t^j(H_t^j, M_t^j, FC^j) - \tau(\mathbf{y_t}, \mathbf{X}^\tau) + (1+r)A_t^{ij} \tag{3}$$

$\forall i \in I, j \in J$. Individuals choose how much to save ρ_t^a in each stage. And therefore, $C_t^a = (1-\rho_t^a)Y_t^a$. It is important to note here that married households only have joint assets. Total consumption C_t^{ij} for married households is then divided as:

$$C_t^i + C_t^j = C_t^{ij}; \qquad C_t^i = s_t^{ij} C_t^{ij} \quad \forall i \in I, j \in J \tag{4}$$

Further, once households retire, they will receive social security based on their lifetime income $\mathbf{y_T}$. I take the social security function from the actual policy setup. bp_1, bp_2 are the cutoffs for social security. The social security function for a single individual of type a is as follows:

$$\begin{aligned} F_{ss}^S(y_T^a) = {} & 0.9 * \min\{bp_1, y_T^a\} + 0.32 * \min\{bp_2 - bp_1, \max\{0, y_T^a - bp_1\}\} \\ & + 0.15 * \max\{0, y_T^a - bp_2\} \end{aligned}$$

As noted before, the social security system does not discriminate based on gender. Incorporating spousal benefits, the social security function for a couple is as follows:

$$\begin{aligned} F_{ss}^a(\mathbf{y_T}) &= \min\{F_{ss}^S(y_T^i), 0.5 * F_{ss}^S(y_T^j)\} \\ F_{ss}^C(\mathbf{y_T}) &= F_{ss}^i(\mathbf{y_T}) + F_{ss}^j(\mathbf{y_T}) \end{aligned}$$

3.2.6 Education and Marriage

Males and females choose to get low (High School and below, $i, j = 1$) or high (Some College and Above, $i, j = 2$) education. The contemporaneous utility depends only on the consumption in that period. Income in this period is a function of the time spent working (residual of the time spent in education) and human capital. Once they choose their education, this is their type (i and j) and the only observable on which they will match in the marriage market. Let the measure of females who choose education i be f^i and the measure of males who choose education j be m^j.

Individuals then will choose to either stay single ($k^m = 0$) or get married to an individual of the opposite gender with low or high education ($k^m = j$ if female). In this model, there are three economic benefits from marriage: public good of home production, jointness from income tax, and spousal benefits. They also draw a love shock for each type, following **choo2006marries**. Therefore, while making the education decision, they are evaluating the additional labor market benefits from getting education but also the benefits from getting married to someone of higher education. Further, once they make their marriage decision, they will remain single or married for the rest of their life cycle. Thus, marriage is a one-time decision and there is no re-marriage or divorce in the model.

3.3 INDIVIDUAL'S PROBLEM

The timeline is shown in Figure 1. The initial conditions for an individual are their sex f, m, human capital H_1, and assets A_1. Thus, the state space initially is $z_1 = [H_1, A_1, s]$ where s is for the sex. A female f's decision of education defines their type i (equivalently, m, j for male). Therefore, the state space before marriage is $z_2 = \{a\}$ where a is the choice of education i or j depending on sex s. Their marriage decision $k^m = \{0, j = 1, j = 2\}$ determines the probability of staying single $p^i_{i0}(\mathbf{X})$ and getting married to type $j, p^i_{ij}(\mathbf{X})$. If unmarried, the state space during work-life is their human capital and assets, which follow their evolution process as detailed above; if they are married, then it includes their spouse's human capital as well. Therefore, $z^i_t = \{H^i_t, A^i_t\}$ and if married: $z^{ij}_t = \{H^i_t, H^j_t, A^{ij}_t, \lambda^{ij}\}$. The choices are $k^i_2 = \{M^i_t = \{NW, PT, FT\}, Q^i_t = \{L, M, H\}, \rho^i_t = \{L, H\}\}$, if single and $k^{ij}_2 = \{M^i_t = \{NW, PT, FT\}, Q^i_t = \{L, M, H\}, M^j_t = \{NW, PT, FT\}, Q^j_t = \{L, M, H\}, \rho^{ij}_t = \{L, H\}\}$. In addition, married households need to choose the division of consumption amongst the couple s^{ij}_t.

Once they retire, the state space is their lifetime income and their assets i.e. $z^i_T = \{Y^i_{T-1}, A^i_T\}$ if single and $z^{ij}_T = \{Y^i_{T-1}, Y^j_{T-1}, A^{ij}_T, \lambda^{ij}\}$ if married. The choices are $k^i_T = \{Q^i_T = \{L, M, H\}, \rho^i_T = \{L, H\}\}$, if single and $k^{ij}_T = \{Q^i_T = \{L, M, H\}, Q^j_T = \{L, M, H\}, \rho^{ij}_T = \{L, H\}\}$.

Let d_k be an indicator variable where choice k is chosen. The utility $u(C^a_t, C^{Q,a}_t, L^a_t; \mathbf{X}^a)$ can be rewritten as $u(k^a_t; z^a_t)$ for single households and $u(C^a_t, C^{Q,ab}_t, L^a_t; \mathbf{X}^a)$ as $u(k^{ab}_t, s^{ab}_t; z^{ab}_t)$ for married households.

Therefore, the maximization problem solved by a female at time $t = 0$ is:

$$\max_{\substack{i,k_m,\\ \{k_t^i,k_t^{i,k_m}\}_{t=2}^T}} \mathbb{E}\Bigg\{\sum_{i=1}^{I} \underbrace{d_i}_{\text{education}} \Bigg[u(i;z_1)+\epsilon_i+\beta \underbrace{d_{k_m=0}}_{\text{single}}\Bigg(\mathbb{E}_{h,a}\Bigg\{\sum_{t=2}^{T+1}\sum_{k_t^i}^{K_t^i} d_{k_t^i}\Big[u(k_t^i;z_t^i)+\epsilon_{k_t^i}\Big]\Bigg\}+\theta_{i0}^i\Bigg)$$

$$+\beta\sum_{k_m=1}^{J}\underbrace{d_{k_m}}_{\text{household}}\Bigg(\mathbb{E}_{h_i,h_{k_m},a}\Bigg\{\sum_{t=2}^{T+1}\sum_{k_t^{i,k_m}}^{K_t^{i,k_m}} d_{k_t^{i,k_m}}\Big[u(k_t^{i,k_m},s_t^{i,k_m};z_t^{i,k_m})+\epsilon_{k_t^{i,k_m}}\Big]\Bigg\}+\theta_{i,k_m}^i\Bigg)\Bigg]|z_1\Bigg\} \tag{5}$$

subject to time allocation constraints (as detailed in Table 2), evolution of human capital (1), and budget constraints ((2), (3), (4)). Appendix A presents the detailed solution of the model.

3.3.1 Jointness of Education and Marriage Market

While this is a standard problem during work-life and retirement, it is important to hone in on certain peculiarities regarding the education and marriage markets. Let the probability of choosing education i be $p^f(i|z_1^f,\boldsymbol{\lambda},\boldsymbol{\vartheta}))$ for a female and choosing education j for a male be $p^m(j|z_1^m,\boldsymbol{\lambda},\boldsymbol{\vartheta}))$. Thus, let

$$\mathbf{p}(\boldsymbol{e_1}) = \begin{bmatrix} p^f(i=1|z_1^f,\boldsymbol{\lambda},\boldsymbol{\vartheta})) \\ p^f(i=2|z_1^f,\boldsymbol{\lambda},\boldsymbol{\vartheta})) \\ p^m(j=1|z_1^m,\boldsymbol{\lambda},\boldsymbol{\vartheta})) \\ p^m(j=2|z_1^m,\boldsymbol{\lambda},\boldsymbol{\vartheta}) \end{bmatrix} \qquad \boldsymbol{\lambda} = \begin{bmatrix} \lambda^{i=1,j=1} \\ \lambda^{i=1,j=2} \\ \lambda^{i=2,j=1} \\ \lambda^{i=2,j=2} \end{bmatrix}$$

The dependence on $\boldsymbol{\lambda}$ comes from the fact that while making the education decision, individuals are also analyzing the trade-off of marrying someone with higher education, in addition to labor market advantages.

In (5), we suppress the full notation of λ^{ij} which is: $\lambda^{ij}(\mathbf{p}(\boldsymbol{e_1}),\mathcal{M},\mathcal{F},\boldsymbol{\vartheta})$ where $\boldsymbol{\vartheta}$ refers to all the parameters in the model, including the parameters for the distribution of human capital and assets. Specifically, the measures of males and females of each type are important for marriage market clearing, which are a direct function of the education decisions, as shown below:

$$f^i(p^f(i|z_1^f,\boldsymbol{\lambda}),\mathcal{F}) = p^f(i|z_1^f,\boldsymbol{\lambda})\times\mathcal{F} \tag{6}$$

$$m^j(p^m(j|z_1^m,\boldsymbol{\lambda}),\mathcal{M}) = p^m(j|z_1^m,\boldsymbol{\lambda})\times\mathcal{M} \tag{7}$$

The unique feature here is the dependence of $\boldsymbol{\lambda}$ on $\mathbf{p}(\boldsymbol{e_1})$ and vice versa as this shows that the education and marriage markets are intertwined in this paper. This itself points that a fixed point will be found for the education and marriage markets together.

3.3.2 Marriage Market Clearing

In addition to the above, the standard conditions of marriage market clearing will still need to hold, which are: Let $\mu^d_{ij}(\lambda_{ij})$ be the measure of type i females who want to match with type j males (or 'demand') and $\mu^s_{ij}(\lambda_{ij})$ is the measure of type j males who want to match with type i females (or 'supply'). The marriage market clearing conditions are characterized by an $I \times J$ matrix of Pareto weights $\boldsymbol{\lambda}$ where the demand of type i females by type j males is equal to the supply of type i females to type j males.

$$\mu_{ij}(\boldsymbol{\lambda}) = \mu^d_{ij}(\boldsymbol{\lambda}^i) = \mu^s_{ij}(\boldsymbol{\lambda}^j) \tag{8}$$

Further, the measures of females (males) of type i (j) married to males (females) of all types and the measure of single females (males) of type i (j) is equal to the measure of females of type i (j).

$$\sum_{j \in 2} \mu^s_{ij}(\boldsymbol{\lambda}) + \mu^s_{i0} = f^i(p^f(i|z^f_1, \boldsymbol{\lambda}), \mathcal{F}) \quad \forall i \in I \tag{9}$$

$$\sum_{i \in 2} \mu^d_{ij}(\boldsymbol{\lambda}) + \mu^d_{0j} = m^j(p^m(j = 1|z^m_1, \boldsymbol{\lambda}), \mathcal{M}) \quad \forall j \in J \tag{10}$$

3.3.3 Definition of Equilibrium

Theorem 3.1. *A stationary equilibrium consists of (i) conditional choice probabilities for single women* $p(k^i_t, z^i_t)$*, single men* $p(k^j_t, z^j_t)$ *and married couples* $p(k^{ij}_t, z^{ij}_t, \lambda_{ij})$ *for work-life and retirement* $(t \in T)$*, respectively; (ii) conditional choice probabilities of marriage for females* $p^i_{ij}(\mathbf{X})$ *and males* $p^j_{ij}(\mathbf{X})$ *(iii) conditional choice probability of education for males and females* $p(\boldsymbol{e_1})$*; (iii) an optimal rule for the Pareto weight* $\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}), \mathcal{M}, \mathcal{F}, \boldsymbol{\vartheta})$ *and a sharing rule* $s^{ij,*}_t(\lambda_{ij})$ *such that*

1. *Males and Females solve* (5)

2. *Pareto weights satisfy* (6)-(10).

Further solution of the value functions are detailed in Appendix A. A sketch of the proof of existence is detailed in Appendix B.

4 Data and Estimation

4.1 Data

We use data from the Panel Study of Income Dynamics (PSID) and Health and Retirement Survey (specifically, RAND-HRS Longitudinal File 2018). There are five sets of variables: (1) Demographics (Education, Marital Status, Age); (2) Income (Own, Spouse if Married, Father's); (3) Assets (Joint); (4) Time Allocation (Work, Housework, and Leisure); (5) Consumption. We condense the life cycle into the following age groups: Age 18-25 (Education), Age 25 (Marriage), Work Life (25-50 years and 51-61 years), and Retirement (62+ years).

One of the key variables in this paper is marital status. Using the data from the Marital History file (1985-2019) as well as Family File (for those whose data is missing in the Marital History file) from PSID, we construct the marital status as the following. If the individual is married by age 46 and is in a marriage that lasts for at least 10 years, then they are considered married. This is from the social security rules that only individuals who have been married for 10 years will be able to claim security from their spouse's work profile. If two marriages last longer than 10 years, then we take the longest marriage. For the HRS, we only have information on the current spouse. Therefore, to ensure we preserve most observations, we focus on the current marriage and whether this marriage has a length of more than 10 years.

For the HRS, time allocation is taken from the Consumption and Activities Mail Survey 2001-2019 (CAMS-HRS). This is a sub-survey sent out to respondents of HRS. Measures of hours spent in work, home production, and leisure are constructed from this survey. PSID collects information on annual work hours and weekly housework hours. Leisure is taken as a residual in the PSID and the model as well. In the PSID, data on food consumption is available from 1968. To construct total consumption, we use estimates from **guo2010superior** [4]. For the HRS, consumption is taken from RAND CAMS Spending Data File 2001-2019 (V1). We use data on the reported age from PSID and HRS, along with data on their birth year. As retirement age is an important cutoff for this paper, we plot retirement age by type of household in Figure C.2. Although 62 years is the early retirement age, a significant proportion of individuals retire then. Labor income is used from the PSID and HRS as the input for income.

All nominal variables are converted into real 2015 \$. Appendix C details the imputation process followed for missing values. We restrict the sample for the birth cohort of 1940 to 1949 for the rest of the analysis. While for single individuals, this is straightforward; for married couples, we keep the couple if the husband was born in the birth cohort of 1940 to 1949. We refer to this as the birth year, as defined by the male head

4. For a more careful analysis, we are in the process of using CEX data and then inverting the estimates to get total consumption

of the household.

4.1.1 Specification

UTILITY FUNCTION The utility function is defined as follows:

$$u(C_t^i, C_t^{Q,i}, L_t^i) = \frac{(C_t^i)^{1-\eta_C} - 1}{1-\eta_C} + \beta_Q \frac{(C_t^{Q,i})^{1-\eta_Q} - 1}{1-\eta_Q} + \beta_L \frac{(L_t^i)^{1-\eta_L} - 1}{1-\eta_L} \tag{11}$$

Preferences are unchanged by marital status or by gender or education type i.e. $u^{S,i} = u^{S,j} = u^{H,i} = u^{H,j}$. Moreover, in the education stage, we assume that $\beta_Q = \beta_L = 0$ as we only allow for time allocation between schooling and market work.

Moreover, we define the bequest function as in **de2004wealth**:

$$V_5^{H,ij}(A_5^{ij}) = b_1[(b_2 + A_5^{ij})^{1-\eta_C} - 1] \tag{12}$$

b_1 captures the relative weight of the bequest motive and b_2 determines its curvature. We impose that the bequest function is the same across singles and couples.

HOME PRODUCTION Home production will differ by the type of household (married or single). We allow for the efficiency scale of women to vary by type. We further impose that the single men of lowest education level have efficiency scale of 1 i.e. $\Gamma_j(\mathbf{X^{j=1}}) = 1$. We also impose that efficiency scale of a household of any type is a function of a homophily parameter $\Gamma_{i=j}$ and women's education type i.e. $\Gamma_{ij}(\mathbf{X^i}, \mathbf{X^j}) = \Gamma_{i=j} \times \tilde{\Gamma}_i$.

INCOME FUNCTION We assume the labor market is perfectly competitive as in **fan2017understanding**. Therefore, the income function is defined as:

$$y_t^a(H_t^a, M_t^a, FC_t^a) = H_t^a * M_t^a - FC^a * M_t^a \tag{13}$$

We assume that the income function does not vary across married or single individuals nor by type.

Thus, we have the following parameters, collectively referred to as ϑ:

$$\vartheta = \{\eta_Q, \eta_L, \beta_Q, \beta_L, \alpha, \eta_C, \tau_f^1, \tau_f^2, \tau_m^1, \tau_m^2, \tau_c^1, \tau_c^2, \tau_c^h, \sigma_n, fc_{pt}^f, fc_{pt}^m, fc_{ft}^f, fc_{ft}^m\}$$

In addition, for each ϑ, there exists an optimal $\boldsymbol{\lambda}(\vartheta)$.

4.1.2 Mapping to Model

Low education is mapped into the data as those with high school education or below ($\leqslant$ 12 years) and high education is those with some college education ($>$ 12 years). For work hours, anyone working less than 400 hours in a year is considered not working

(NW). Those working between 400 and 1400 hours are considered part-time (PT) and those working beyond 1400 hours are considered full-time (FT). Housework hours vary significantly by marital status and gender, and therefore, the cutoffs vary as well. Table D.4 presents these cutoffs.

4.2 IDENTIFICATION

The estimation is of a fully specified parametric model. For identifying the Pareto weights $\boldsymbol{\lambda}$, **blundell2005collective** and **browning2013estimating** prove that if there exists a distribution factor, then both model primitives and Pareto weights are identified for a collective household model with public and private goods. **gayle2019optimal** show that sufficient variation in population vectors (along with some minimal conditions) will pin down the Pareto weights. Their identification strategy follows here; additionally, the variation of spousal benefits across households due to their income level provides us with a distribution factor as well. Once the Pareto weights $\boldsymbol{\lambda}$ are identified, the identification of the utility parameters, home production technology and fixed costs follows from standard semi-parametric identification results for discrete-choice models from **matzkin1992nonparametric** and **matzkin1993nonparametric**.

Further, we formally show how the variation in the choices across individuals and households helps us pin down the parameters using **arcidiacono2011conditional**. The utility parameter on consumption (η_C) is identified from the retirement stage of singles by varying the saving rates chosen while keeping the home production and leisure decisions fixed. The utility parameters on home production and leisure ($\beta_L, \beta_Q, \eta_L, \eta_Q$) are jointly identified by varying the home production choices while keeping leisure fixed and vice versa during the work-life of singles.

Home production parameters of single individuals are identified from the variation in home production choices and education by gender ($\tau_f^1, \tau_f^2, \tau_m^1, \tau_m^2$); for married couples, by varying within the types of couples ($\tau_c^1, \tau_c^2, \tau_c^h, \alpha$). Fixed costs ($fc_{pt}^f, fc_{pt}^m, fc_{ft}^f, fc_{ft}^m$) are identified from the variation in choice of work across couples. The variance of love shock σ_n is identified from the comparison of the model generated singles with the data. Appendix E gives details on the equations that identify each of these parameters.

4.3 ESTIMATION

The estimation strategy followed is that of a nested fixed point. For each set of parameters ϑ, the Pareto weights that clear the marriage market need to be found $\boldsymbol{\lambda}(\vartheta)$. Therefore, the model is solved iteratively solved till a solution is found which clears the marriage market. The optimal set of parameters is used to construct the conditional choice probabilities, which form the objective function. This process is repeated till a minimum is found for ϑ, and with it, $\lambda(\vartheta)$.

4.3.1 Parameters Set Outside the Model

The following parameters are set outside the model. Appendix F details the values of the set parameters. Payroll tax parameters are calculated using Payroll Tax and Cap data from the Social Security Administration, for the years as they match the age profile of the 1940s cohort. The income tax parameters as well as social security bend points are calculated, following a similar process, using historic Income Tax Rates and Brackets data. The distribution of the father's income is condensed to a 2-point distribution[5]. Mapping into the education is a deterministic human capital in $T = 2$, as opposed to a distribution[6]. Returns to human capital are calculated using a non-linear regression from the merged PSID-HRS dataset.

5 Results

5.1 Parameter Estimates

Table F.9 presents the estimated parameters and Figure 4 presents the model fit with the data. Focusing on the home production parameters, there is high gains from homogamy in marriage. Moreover, there is a high weight on the time spent by a woman in home production in a married household ($\alpha \sim 0.8$)[7]. This implies that return of time spent by a woman in home production in a married household is significantly much higher than that of a man, which feeds back to a discussion of household specialization. For single females, there is a marginal difference in returns to home production, and is much higher than of females. As children are not modelled, the efficiency scale is essentially an average for those with and without children.

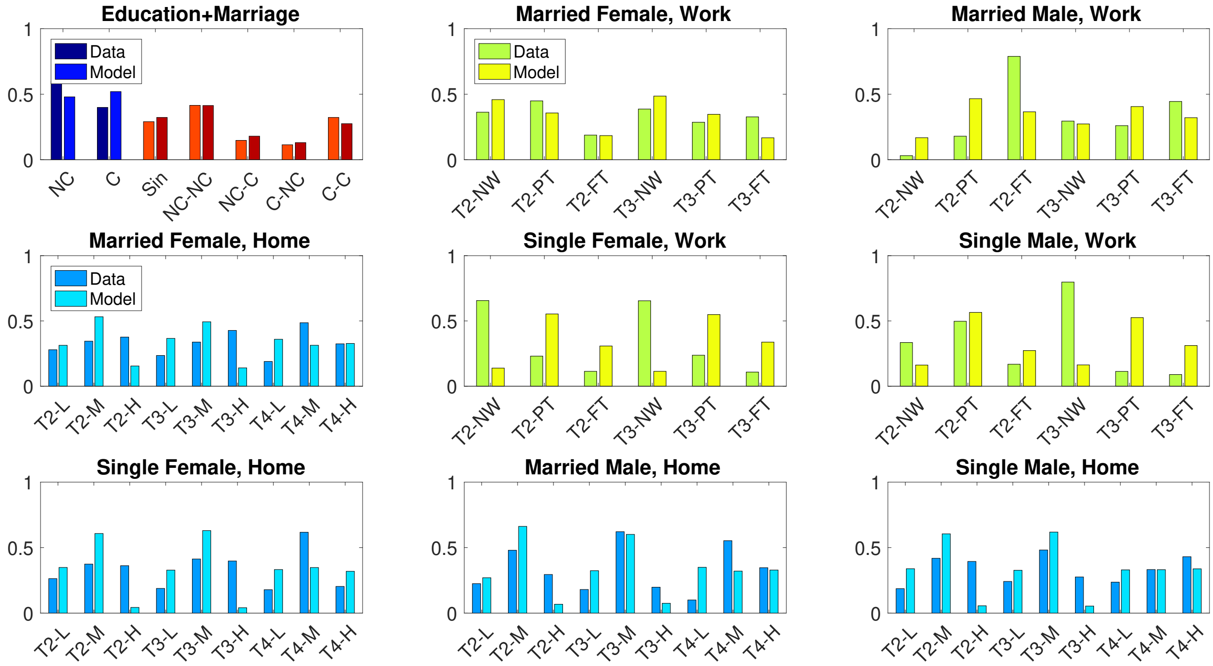
In terms of fixed costs associated with working, the fixed cost with part-time work is lower than that of full-time work for both males and females. However, there is a non-linear trend, indicating that the incentives for part-time and full-time work are significantly different. Moreover, the fixed cost of part-time work for females is nearly 6 times that of males, and for full-time work, this number falls to approximately 4 times. This is not surprising given the labor force participation of the women of the 1940s cohort.

In terms of the utility parameters, the weight on leisure and home production are nearly the same; although individuals are nearly risk-neutral on home production,

5. This is being converted to a log-normal distribution.
6. This is being converted to a log-normal distribution.
7. In **gayle2019optimal**, α is 0.832.

they are more risk averse towards consumption and leisure. This is similar to the estimates from **gayle2019optimal**.

Figure 4: Model Fit



Notes: NC refers to Not-College and C refers to College. NW refers to Not Working; PT is Part-Time and FT is Full-Time. L refers to Low, M refers to Medium and H refers to High. Please refer to Section 4 for details referring to definition of NW, PT and FT as well as L, M and H.

5.2 Discussion

Focusing on the fit, the model does a good job of fitting the education and marriage trends, central to this paper. Male and female home production trends are fairly well-matched. Although married female fit of their work decisions is fairly close, the fit on the married male work decisions, especially for full-time work, leaves more to be desired. Similarly for single male and female work decisions. Due to this, we focus primarily on education and marriage decisions as the model fits that well.

6 Effect on Education and Marriage

The key focus of this paper is to understand how does including endogenous education and marriage lead to different outcomes when we make changes to retirement and taxation policy.

6.1 DECOMPOSITION OF EDUCATION AND HOUSEHOLD DECISIONS

Before I explore the counterfactuals in further detail, I focus on two counterfactuals: increasing payroll taxes proportionally by 50 percent and removing spousal benefits. I then compare these estimates with 4 other sets of models: (a) models where education can vary but fixed in their household bargaining (λ); (b) models where education is fixed but households can re-bargain; (c) models where both education and household bargaining is fixed; (d) models where education and singlehood rates are fixed.

When payroll taxes are increased by 50 percent, for the model when λ is fixed (M1), college education increases by 1.6 percent, as compared to this paper where the education increases marginally by 0.08 percent. More importantly, while singlehood increases by 3.5 percent in M1, singlehood rates fall by 1.2 percent when within-household bargaining is incorporated. This depicts the adjustment within the marriage markets when it is costlier to work. The increasing cost of work is adjusted by education and marriage markets - higher education implies higher wages which can ensure the post-tax income of the household is similar to before the policy change. Moreover, through joint income taxation, there is an additional margin to adjust for married couples.

A rise in married male LFPR of 3.1 percent and a fall in married female LFPR by 0.8 percent is seen. Similar but smaller levels are seen for this paper as well. M1 is similar to models where human capital accumulation and retirement are endogenous, but within household decisions are not taken into consideration. **fan2017understanding** have a rich model of endogenous human capital accumulation along with endogenous wage process and retirement; however, they focus only on males. Comparing their results for the same policy change, they find a 2.6 percent increase in college education and a 3.1 percent increase in labor force participation rate, which are similar in magnitude to M1. Thus, not incorporating within household decisions would lead to a larger adjustment in labor supply and education, than in a model where households are accounted for. When education is held fixed (M2, M3), then the substitution effect dominates for married couples and participation falls. However, when $\boldsymbol{\lambda}$ is allowed to vary (M2), a fall in singlehood similar to this paper is seen; whereas if is held fixed (M3), then a rise in singlehood is seen to accommodate for the higher cost of working.

Lastly, keeping education and singlehood fixed, then household specialization reduces, and married female LFPR rises by 5 percent while that of married males falls by 12.8 percent. These are significant changes, indicating that not allowing for adjustment on the margins of human capital accumulation and marriage can overstate the adjustment by labor force participation. Using the same model to remove spousal benefits, married males and females both reduce their labor force participation rate, while marginal change for single males and females. A comparison of M4 with this

Table 3: Decomposition of Education and Household Decisions

Model	College	Single	Married LFPR		Single LFPR	
			Female	Male	Female	Male
Baseline	0.52	0.32	0.54	0.78	0.87	0.84
Increasing Payroll Taxes by 50 percent						
M1	1.65	3.47	-0.85	3.10	0.52	0.35
M2		-1.98	-4.68	-2.26	1.18	-0.33
M3		1.67	-4.85	-1.73	1.18	-0.42
M4			5.33	-12.79	1.10	-0.30
This Paper	0.08	-1.18	-0.54	0.99	0.52	0.65
Removing Spousal Benefits						
M4			-17.05	-17.27	0.78	-0.93
This Paper	1.50	6.45	48.84	2.74	0.35	-0.36

Notes: Baseline is the estimated model. Each line denotes the percent change from the baseline. M1: Pareto weights λ are held fixed. M2: Education is held fixed. M3: Education and Pareto weights λ are held fixed. M4: Education and single is held fixed. LFPR is the labor force participation of individuals over the ages of 25-62 years. Please refer to Section 3 for further details regarding the model setup.

paper shows a completely different scenario: removal of spousal benefits leads to a rise in education by 1.5 percent, a rise in singlehood by 6.5 percent, and a rise in married labor force participation by 48 percent, with relatively small increases for married males, single males, and females. While M4 is comparable to **borella2019marriage**, they find a 5-10 percentage point increase in married LFPR, varying by age. However, their paper would miss the adjustment by education and singlehood, which leads to an even more dramatic rise when spousal benefits are removed.

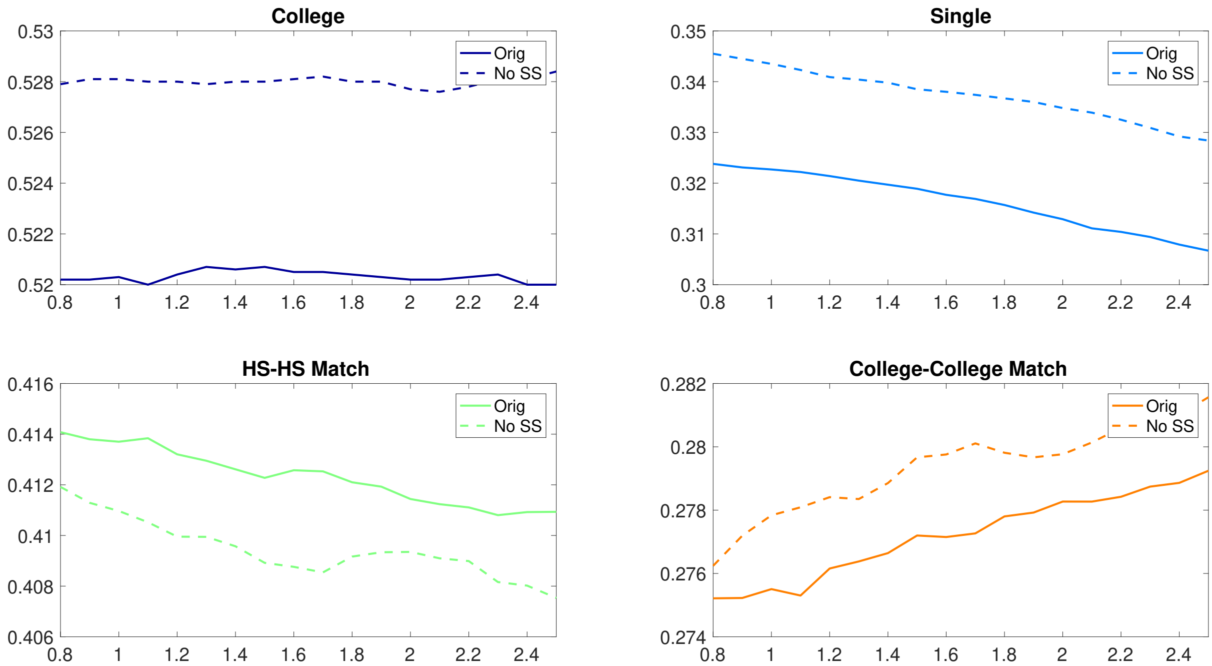
6.2 Payroll Taxes and Spousal Benefits

Given the payroll taxes, we vary the payroll taxes by increasing it by a fraction - from 0.8 to 2 times. Further, we do the same exercise when we remove spousal benefits as well. Figure 5 and 6 presents the variation of payroll taxes and spousal benefits on education and marriage as well as labor force participation.

A surprising finding is that the rise in payroll taxes leads to a marginal change in college education. The mechanism behind the no change in education is that the marriage market adjusts to absorb the negative push on college education by adjusting the bargaining power and pushing for household specialization. Thus, married households can reap economies of scale, and thus, the proportion of people single falls as payroll taxes increase. Thus, this implies that we would overestimate the effect of taxes and retirement policy when marriage markets are not included. Further, this change in bargaining power leads to a fall in the matches where the male is of high school education and a rise in the matches where the male is of a college education. This is also seen in the fall of bargaining power for the female, across all matches.

At the same time, eliminating spousal benefits and varying payroll taxes shows similar trends but with level shifts. Specifically, individuals marginally invest more in college education, since the higher wage benefits will help to save for more during retirement. As one of the benefits of marriage disappears, there is a rise in singlehood. However, assuming payroll taxes stay the same, only the removal of spousal benefits would imply that the types of marriages are different. The bargaining power of a female falls as the pecuniary benefit from marrying a female has fallen; however, college-educated females still enjoy higher bargaining power. Therefore, a rise in marriage is seen amongst those with a college education.

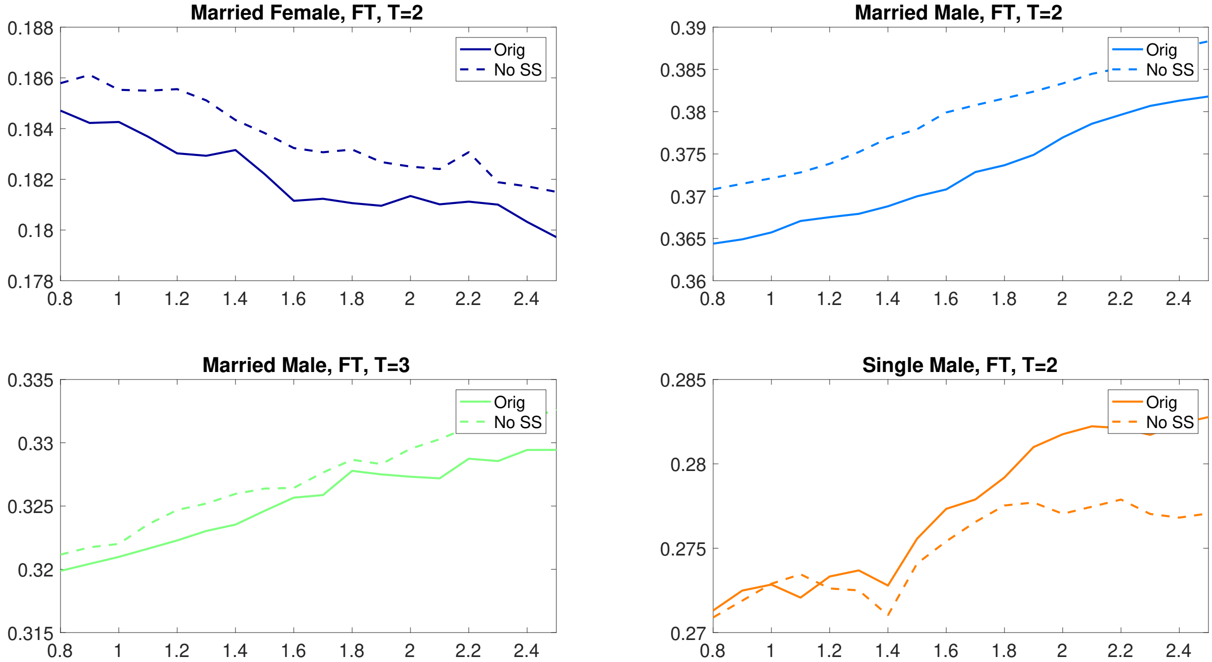
Figure 5: Variation of Payroll Taxes and Spousal Benefits



Notes: Please refer to Section 4 for details.

Focusing on work participation, an increase in payroll taxes with or without spousal benefits leads to household specialization, with the married male working more. The rise in full-time work is stronger during early work-life, as compared to late work-life for married males. There is a rise in single male full-time work as well, as payroll taxes increase; however, the rise is lower when there are no spousal benefits as there is a change in the composition of who is single as well.

Figure 6: Variation of Payroll Taxes and Spousal Benefits



Notes: NC refers to Not-College and C refers to College. NW refers to Not Working; PT is Part-Time and FT is Full-Time. L refers to Low, M refers to Medium and H refers to High. Please refer to Section 4 for details referring to the definition of NW, PT, and FT as well as L, M, and H.

6.3 Decomposition

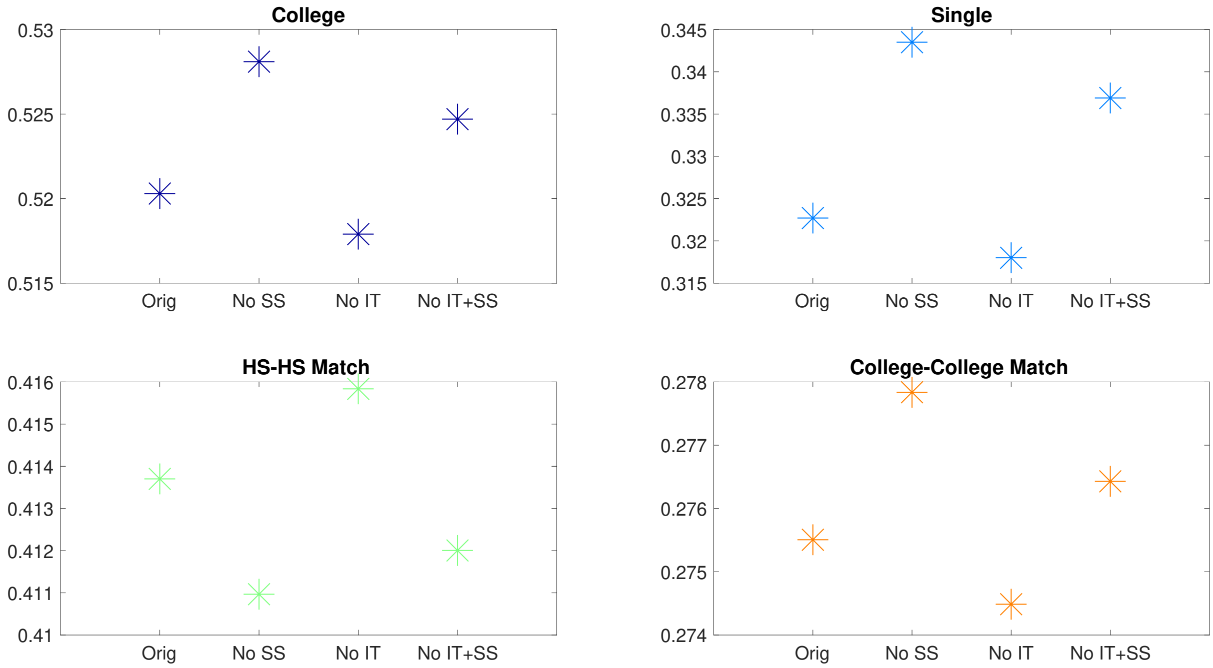
6.4 Marriage-Neutral

In this counterfactual, we remove joint income taxation (and only allow for individual income taxation) and then remove both spousal benefits and joint income taxation - essentially, allowing for a marriage-neutral system. Figure 7 and 8 present the four different scenarios: baseline, removing spousal benefits, removing joint income taxation, and a marriage-neutral system for education, marriage, and work participation.

As mentioned earlier, removing spousal benefits leads to a fall in the value-added from marrying an individual. With the removal of joint income taxation, married males will reduce their full-time work, as they will pay higher taxes as the gains from jointness have been removed. Therefore, married females will engage in more full-time work as due to the gender gap, they will pay fewer taxes. This leads to a re-shuffle in the division of labor within the household. With spousal benefits, it influences both spouses to work more, relative to the baseline. Therefore, although removing spousal benefits and jointness of income taxation are removing benefits from marriage, their impact within the household is very different - a factor we will not see if we do not include a collective household setup.

Thus, the impact on singlehood as well as college education is dramatically different as well - removing spousal benefits leads to a rise in singlehood and a rise in college education, whereas removing jointness of income taxation leads to a fall in singlehood and a fall in college education. Further, removing spousal benefits leads to an increase in matches where both spouses have a college education as well as a fall in the bargaining power of females across all types of matches; whereas removing the jointness of income taxation results in a rise of matches where both spouses are high-school educated and overall bargaining power of women increases.

Figure 7: Effect of a Marriage Neutral System



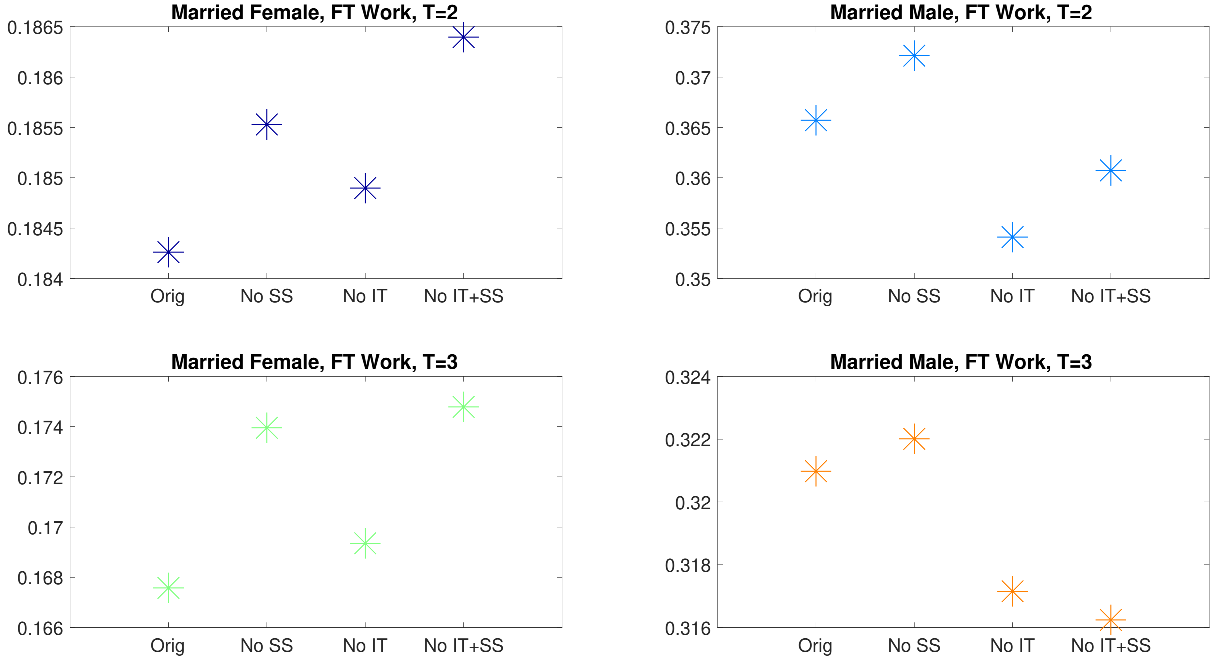
Notes: NC refers to Not-College and C refers to College. NW refers to Not Working; PT is Part-Time and FT is Full-Time. L refers to Low, M refers to Medium and H refers to High. Please refer to Section 4 for details referring to the definition of NW, PT, and FT as well as L, M, and H.

7 Conclusion

The social security system and joint income taxation in the US are examples of marriage non-neutral systems i.e. systems where the treatment varies by marital status. Under the social security system, married couples are entitled to at least 150 percent of the benefits based on the primary earner's work profile. This paper seeks to answer as to how do changes in tax and retirement policy affect education and marriage. This paper follows a two-step methodology: I first document data trends that are relevant to the social security system and household structure. Specifically, education and marital status affects retirement earnings, with low-educated and single individuals the most dependent on the social security system - the bottom quintile of the population at ages 65-69 years derives 71 percent of their income from social security.

I then substantiate this by building a structural model to disentangle the mechanisms underlying these trends. I develop a life-cycle model with endogenous human

Figure 8: Effect of a Marriage Neutral System



Notes: NC refers to Not-College and C refers to College. NW refers to Not Working; PT is Part-Time and FT is Full-Time. L refers to Low, M refers to Medium and H refers to High. Please refer to Section 4 for details referring to the definition of NW, PT, and FT as well as L, M, and H.

capital accumulation, consumption, savings, labor force participation, and marriage. Specifically, households are modeled in a collective household setup (as compared to the unitary model) and thus, effects on intra-household bargaining can be analyzed as well.

Focusing on the effects on education and marriage, increasing payroll taxes has no effect on education and leads to fall in single-hood. This implies that individuals adjusted to the higher taxes by getting married more often to enjoy gains from economies of scale in marriage. Moreover, higher household specialization is seen as well. Comparing with models where household decision making is not considered, a 1.6 percent rise in education would be seen, as compared to 0.08 percent rise in this paper.

Removal of spousal benefits in the social security system leads to higher college education and more people choosing to remain single, which is not surprising as, in the model, social security benefits are an added advantage of being married. However, despite the rise in singlehood, there is a rise in the proportion of people who get married who are both with a college education; yet, there is a fall in intra-household bargaining power for the female in such matches.

The implications of this research are particularly relevant where there are talks of reform to the social security system due to the concern about the current financial state of the Social Security system - after the year 2033, the full level of scheduled benefits cannot be paid out. However, most retirement models and papers still focus on either only males, or if they do take into accounts males and females, they focus on modeling the household as a setup with a unitary decision maker, whose testable implications have been debunked by many different papers. Thus, this paper brings into light the importance of including females and collective households in retirement analysis.

A SOLVING THE MODEL

We will describe the model for singles and couples separately first, and then describe the marriage and education markets.

We will also describe the solution at each stage. Given we assume Type 1 Extreme Value errors, the ex-ante value function, conditional on the states, has a closed form solution, as noted by **rust1987optimal**. Moreover, the ex-ante value function can be written as the sum of the conditional value function for an arbitrary choice k with a correction term, which adjusts for the fact that k may not be the optimal choice (**arcidiacono2011conditional**) i.e.

$$V(x_t) = \int V(x_t, \epsilon_t) df(\epsilon_t) = \nu(k_t, x_t) + \gamma - \sigma_\epsilon \log[p(k_t|x_t)]$$

where $\nu(x_t, k_t)$ is the conditional value function, γ is the mean of Type 1 extreme value distribution and $\log[p(k_t|x_t)]$ is the adjustment term. Therefore, we can write out the ex-ante value function of singlehood using this equation.

A.1 SINGLES

Retirement Single females with lifetime income Y^i_{T-1}, assets A^i_T and demographic characteristics $\mathbf{X}^i$ choose k^i_T comprising of a time allocation component and a savings component i.e. $k^i_T = [Q^i_T = \{L, M, H\}, \rho^i_T = \{L, H\}]$ where Q^i_T is time spent in home production and ρ^i_T is the savings rate. Their income Y^i_T comprises of the social security (as calculated from their lifetime income Y^i_T) as well as their savings with its return $(1+r)A^i_T$. Individuals consume $1-\rho^i_T$ of their income. The remaining amount A^i_{T+1} is saved to leave bequests on their assets, which is defined by $V^{S,i}_{T+1}(A_{T+1}; \mathbf{X})$. Let the feasible set of allocations be K^i_T. With each discrete allocation, an additive state specific error $\epsilon_{k^i_T}$ is associated. In addition, we define the state space as $z^i_T = [Y^i_{T-1}, A^i_T, \mathbf{X}^i]$ and $z^i_{T+1} = [A^i_{T+1}, \mathbf{X}^i]$. The single female's utility maximization problem is as follows:

$$\begin{aligned}
&\max_{k^i_T \in K^i_T} u^{S,i}(C^i_T, C^{Q,i}_T, L^i_T; \mathbf{X}^i) + \beta V^{S,i}_{T+1}(z^i_{T+1}) + \epsilon_{k^i_T} \\
&\text{subject to: } Q^i_T + L^i_T = 1 \\
&\qquad\qquad C^i_T + A^i_{T+1} = Y^i_T = F^S_{ss}(Y^i_{T-1}) + (1+r)A^i_T \\
&\qquad\qquad C^i_T = (1-\rho^i_T)Y^i_T \\
&\qquad\qquad C^{Q,i}_T = \Gamma_i(\mathbf{X}^i)Q^i_T
\end{aligned}$$

$\Gamma_i(\mathbf{X}^i)$ is the efficiency scale of home production which depends on their type i as well as on demographics X^i. This stage can be written analogously for males of type j. The utility $u^{S,i}(C^i_T, C^{Q,i}_T, L^i_T; \mathbf{X}^i)$ can be rewritten as $u^{S,i}(k^i_T; z^i_T)$.

Therefore, the conditional value function is:

$$v^{S,i}(k_T^i, z_T^i) = u^{S,i}(k_T^i, z_T^i) + \beta \sum_{z' \in z_{T+1}^i} V_5^{S,i}(z')F(z'|z_T^i, k_T^i = 1)$$

where $F(z'|z_T^i, k_T^i = 1)$ is the transition function for state variables, conditional on choice k_T^i. Therefore, the Bellman is then:

$$V_T^{S,i}(z_T^i, \boldsymbol{\epsilon}_{\mathbf{k_T}}) = \max_{k_T^i}\{v^{S,i}(k_T^i, z_T^i) + \epsilon_{k_T^i}\}$$

and the solution to the problem is given by:

$$k_T^{i,*}(z_T^i, \boldsymbol{\epsilon}_{\mathbf{k_T}}) = \arg\max_{k_T^i}\{v^{S,i}(k_T^i, z_T^i) + \epsilon_{k_T^i}\}$$

As $\boldsymbol{\epsilon}_{\mathbf{k_4}}$ is unobserved to the econometrician, therefore, we can define the ex-ante valuation function for single females $V_4^{S,i}(z_4^i)$, as the continuation value of being in state z_4^i before $\epsilon_{k_4^i}$ is revealed:

$$V_T^{S,i}(z_T^i) = \int_{\epsilon} V_T^{S,i}(z_T^i, \boldsymbol{\epsilon}_{\mathbf{k_T}})\, d f \boldsymbol{\epsilon}_{\mathbf{k_T}}$$

where $f\boldsymbol{\epsilon}_{\mathbf{k_T}}$ is the continuously differentiable density of $F_\epsilon(\boldsymbol{\epsilon}_{\mathbf{k_T}})$.

Assuming Type 1 Extreme Value errors with a zero location parameter and scale parameter σ_ϵ, we have:

$$V_T^{S,i}(z_T^i) = \sigma_\epsilon \gamma + \sigma_\epsilon \log\left\{\sum_{k_T^i \in K_T^i} \exp[v^{S,i}(k_T^i, z_T^i)/\sigma_\epsilon]\right\}$$

$$p^{S,i}(k_T^i|z_T^i) = \frac{\exp[v^{S,i}(k_T^i, z_T^i)/\sigma_\epsilon]}{\sum_{k' \in K_T^i} \exp[v^{S,i}(k', z_T^i)/\sigma_\epsilon]}$$

$$\log\left[\frac{p^{S,i}(k_T^i = k_2|z_T^i)}{p^{S,i}(k_T^i = k_1|z_T^i)}\right] = \frac{1}{\sigma_\epsilon}\left[v^{S,i}(k_T^i = k_2, z_T^i) - v^{S,i}(k_T^i = k_1, z_T^i)\right]$$

where γ is the Euler's constant.

Work-Life For work-life stage t, single females of type i with human capital investment H_t^i, assets A_t^i and demographic characteristics $\mathbf{X^i}$ choose k_t^i comprising of a time allocation component and a saving component i.e. $k_t^i = [Q_t^i = \{L, M, H\}, M_t^i = \{NW, PT, FT\}, \rho_t^i = \{L, M, H\}]$. In this period, income $y_t^i(H_t^i, M_t^i, FC^i)$ is a function of time spent working M_t^i, and human capital accumulated thus far H_t^i. Taxes are paid on income $\tau(y_t^i, \mathbf{X}^\tau)$. We also allow for a fixed cost of working FC^i, which is positive only if she works and varies by their type. However, time spent working not only generates more income today but also leads to higher human capital accumulation tomorrow (learning-by-doing).

The maximization problem is as follows:

$$\max_{k_t^i \in K_t^i} u^{S,i}(C_t^i, C_t^{Q,i}, L_t^i; \mathbf{X^i}) + \epsilon_{k_t^i} + \beta \sum_{z' \in z_{t+1}^i} \left[\int V_{t+1}^{S,i}(z', \epsilon_{k_{t+1}}) df(\boldsymbol{\epsilon}_{\mathbf{k_{t+1}}}) \right] F(z'|z_t^i, k_t^i = 1)$$

$$\begin{aligned}
\text{subject to: } & M_t^i + Q_t^i + L_t^i = 1 \\
& C_t^i + A_{t+1}^i = Y_t^i = y_t^i(H_t^i, M_t^i, FC^i) - \tau(y_t^i + (1+r)A_t^i \\
& C_t^i = (1-\rho_t^i)Y_t^i \\
& H_{t+1}^i = (1-\delta)H_t^i + (M_t^i H_t^i)^{\alpha_2} \\
& C_t^{Q,i} = \Gamma_i(\mathbf{X^i})Q_t^i
\end{aligned}$$

where δ is the depreciation of human capital over time, while α_2 is the returns to human capital from time spent working. This stage can be analogously written for males of type j.

Rewriting the utility as before, the conditional value function is:

$$\nu^{S,i}(k_t^i, z_t^i) = u^{S,i}(k_t^i, z_t^i) + \beta \sum_{z' \in z_{t+1}^i} V_{t+1}^{S,i}(z') F(z'|z_t^i, k_t^i = 1) \tag{14}$$

where $F(z'|z_t^i, k_t^i = 1)$ is the transition function for state variables, conditional on choice k_t^i. Therefore, the Bellman is then:

$$V_t^{S,i}(z_t^i, \boldsymbol{\epsilon}_{\mathbf{k_t}}) = \max_{k_t^i} \{\nu^{S,i}(k_t^i, z_t^i) + \epsilon_{k_t^i}\}$$

and the solution to the problem is given by:

$$k_t^{i,*}(z_t^i, \boldsymbol{\epsilon}_{\mathbf{k_t}}) = \arg\max_{k_t^i} \{\nu^{S,i}(k_t^i, z_t^i) + \epsilon_{k_t^i}\}$$

As $\boldsymbol{\epsilon}_{\mathbf{k_t}}$ is unobserved to the econometrician, therefore, we can define the ex-ante valuation function for single females $V_t^{S,i}(z_2^i)$, as the continuation value of being in state z_2^i before $\epsilon_{k_2^i}$ is revealed:

$$V_2^{S,i}(z_2^i) = \int_\epsilon V_2^{S,i}(z_2^i, \boldsymbol{\epsilon}_{\mathbf{k_2}}) df \boldsymbol{\epsilon}_{\mathbf{k_2}}$$

where $f\boldsymbol{\epsilon}_{\mathbf{k_2}}$ is the continuously differentiable density of $F_\epsilon(\boldsymbol{\epsilon}_{\mathbf{k_2}})$.

Assuming Type 1 Extreme Value errors with a zero location parameter and scale parameter σ_ϵ, we have:

$$V_t^{S,i}(z_t^i) = \sigma_\epsilon \gamma + \sigma_\epsilon \log \left\{ \sum_{k_t^i \in K_t^i} \exp[\nu^{S,i}(k_t^i, z_t^i)/\sigma_\epsilon] \right\}$$

$$p^{S,i}(k_t^i | z_t^i) = \frac{\exp[\nu^{S,i}(k_t^i, z_t^i)/\sigma_\epsilon]}{\sum_{k' \in K_t^i} \exp[\nu^{S,i}(k', z_t^i)/\sigma_\epsilon]}$$

where γ is the Euler's constant.

In addition, applying **arcidiacono2011conditional**, we can write for an arbitrary choice k_2^o:

$$V_2^{S,i}(z_2^i) = \nu^{S,i}(k_2^o, z_2^i) + \sigma_\epsilon \gamma - \sigma_\epsilon \log[p_2^{S,i}(k_2^o | z_2^i)]$$

At the start of work-life, at $t = 2$, individuals draw human capital and assets from a distribution. Therefore, we further define:

$$\bar{V}_2^{S,i} = \int_{z_2} V_2^{S,i}(z_2^i) \mathrm{d}f \mathbf{z_2}$$

A.2 COUPLES

Married households take decisions in a collective household setup that assumes efficient allocation of intra-household resources (**chiappori1992collective**). We will describe the maximization problems for a couple with a female of type i married to a male of type j. Let $\lambda_{ij} \in [0, 1]$ be the Pareto weight on the female's share of utility; therefore, the share on male utility is $1 - \lambda_{ij}$. As this is a collective household setup, the household chooses a time allocation vector, savings rate and division of consumption amongst spouses by maximizing household utility. Moreover, the preference shocks at the household level are assume to be additively separable – this will be explained clearly below.

Retirement Couples of type ij with wife's lifetime income Y_{T-1}^i and husband's lifetime income Y_{T-1}^j, joint assets A_T^{ij} and demographic characteristics $\mathbf{X}^i$ and $\mathbf{X}^j$ choose k_T^{ij} comprising of a time allocation component for both husband and wife, and a savings component i.e. $k_T^{ij} = [Q_T^i = \{L, M, H\}, Q_T^j = \{L, M, H\}, \rho_T^{ij} = \{L, H\}]$ where Q_T^i, Q_T^j is time spent in home production by wife and husband respectively and ρ_T^{ij} is the savings rate of the household. Their income Y_T^{ij} comprises of the social security for the household (as calculated from their lifetime income Y_{T-1}^i and Y_{T-1}^j) as well as their joint savings and its return $(1 + r)A_T^{ij}$. We assume savings to be joint as in **chiappori2018marriage**. Households consume $1 - \rho_T^{ij}$ of their income, of which s_T^{ij} is the share consumed by the wife. The remaining amount A^{ij}_{T+1} is saved to leave bequests on their assets, which is defined by $V^{H,ij}_{T+1}(A^{ij}_{T+1}; \mathbf{X^i}, \mathbf{X^j})$. Let the feasible set of allocations be K^{ij}_T. With each discrete allocation, an additive state specific error $\epsilon^C_{k^{ij}_T}$ is associated with the household, which is assumed to be additively separable. In addition, we define the state space as $z^{ij}_T = [Y^i_{T-1}, Y^j_{T-1}, A^{ij}_T, \mathbf{X^i}, \mathbf{X^j}]$ and $z^{ij}_{T+1} = [A^{ij}_{T+1}, \mathbf{X^i}, \mathbf{X^j}]$. The household's utility maximization problem is as follows:

$$
\begin{aligned}
\max_{k^{ij}_T \in K^{ij}_T, s^{ij}_T \in [0,1]} \quad & \lambda_{ij} u^{H,i}(C^i_T, C^{Q,ij}_T, L^i_T; \mathbf{X^i}) + (1-\lambda_{ij}) u^{H,j}(C^j_T, C^{Q,ij}_T, L^j_T; \mathbf{X^j}) \\
& + \epsilon^H_{k^{ij}_T} + \beta V^{H,ij}_{T+1}(z^{ij}_{T+1}) \\
\text{subject to: } & Q^i_T + L^i_T = 1; \qquad Q^j_T + L^j_T = 1 \\
& C^{ij}_T + A^{ij}_{T+1} = Y^{ij}_T = F^C_{ss}(Y^i_{T-1}, Y^j_{T-1}) + (1+r)A^{ij}_T \\
& C^{ij}_T = (1-\rho^{ij}_T) Y^{ij}_T \\
& C^i_T + C^j_T = C^{ij}_T; \qquad C^i_T = s^{ij}_T C^{ij}_T \\
& C^{Q,ij}_T = \zeta_{ij}(\mathbf{X^i}, \mathbf{X^j}) f_Q(Q^i_T, Q^j_T)
\end{aligned}
$$

It is important to note that the social security function varies from that in the single setup to incorporate that both husband and wife's lifetime income matter to the social security received by the household. In addition, $\Gamma_{ij}(\mathbf{X^i}, \mathbf{X^j})$ is the efficiency scale of home production which depends on both the wife's type and the husband's type. The utility $u^{H,i}(C^i_T, C^{Q,ij}_T, L^i_T; \mathbf{X^i})$ can be rewritten as $u^{H,i}(k^{ij}_T, s^{ij}_T; z^{ij}_T)$.

Therefore, the conditional value function is:

$$
\begin{aligned}
v^{H,i}(k^{ij}_T, s^{ij}_T, z^{ij}_T, \lambda_{ij}) &= u^{H,i}(k^{ij}_T, s^{ij}_T, z^{ij}_T) + \beta \sum_{z' \in z^{ij}_{T+1}} V^{H,ij}_{T+1}(z') F(z' | z^{ij}_T, \lambda_{ij}, k^{ij}_T = 1) \\
v^{H,j}(k^{ij}_T, s^{ij}_T, z^{ij}_T, \lambda_{ij}) &= u^{H,j}(k^{ij}_T, s^{ij}_T, z^{ij}_T) + \beta \sum_{z' \in z^{ij}_{T+1}} V^{H,ij}_T(z') F(z' | z^{ij}_T, \lambda_{ij}, k^{ij}_T = 1) \\
v^{H,ij}(k^{ij}_T, s^{ij}_T, z^{ij}_T, \lambda_{ij}) &= \lambda_{ij} v^{H,i}(k^{ij}_T, s^{ij}_T, z^{ij}_T, \lambda_{ij}) + (1-\lambda_{ij}) v^{H,j}(k^{ij}_T, s^{ij}_T, z^{ij}_T, \lambda_{ij})
\end{aligned}
$$

where $F(z' | z^{ij}_T, , \lambda_{ij}, k^{ij}_T = 1)$ is the transition function for state variables, conditional on choice k^{ij}_T and λ_{ij}. It is important to note here that this does not depend on s^{ij}_T. The key argument is that we assume assets to be joint in the households (community property). Therefore, s^{ij}_T only affects the share of consumption by each spouse, and is not affected by the level of consumption - if consumption changes, the share consumed by each couple will change in the same ratio. Therefore, the Bellman is then:

$$
V^{H,ij}_T(z^{ij}_T, \lambda_{ij}, \boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_T}}) = \max_{k^{ij}_T, s^{ij}_T} \{ v^{H,ij}(k^{ij}_T, s^{ij}_T, z^{ij}_T, \lambda_{ij}) + \epsilon^H_{k^{ij}_T} \}
$$

As $\epsilon^{\mathbf{H}}_{\mathbf{k_T}}$ is unobserved to the econometrician, therefore, we can define the ex-ante valuation function for households $V^{H,ij}_T(z^{ij}_T, \lambda_{ij})$, as the continuation value of being in state z^{ij}_T before $\epsilon^{H}_{k^{ij}_T 4}$ is revealed:

$$V^{H,ij}_4(z^{ij}_T, \lambda_{ij}) = \int_{\epsilon} V^{H,i}_T(z^{ij}_T, \lambda_{ij}, \epsilon^{\mathbf{H}}_{\mathbf{k_T}}) d f \epsilon^{\mathbf{H}}_{\mathbf{k_T}}$$

where $f\epsilon^{\mathbf{H}}_{\mathbf{k_T}}$ is the continuously differentiable density of $F_{\epsilon}(\epsilon_{\mathbf{k^H_T}})$.

Further, we assume that the utility function is additively separable in consumption and has a CRRA form. This is particularly useful as it gives us that the consumption will depend only on relative Pareto weights and not on the income level itself Therefore, to solve for s^{ij}_T, we have:

$$\frac{\partial v^{H,ij}(k^{ij}_T, s^{ij}_T, z^{ij}_T, \lambda_{ij})}{\partial s^{ij}_T} = 0 \implies \lambda_{ij} \frac{\partial v^{H,i}(k^{ij}_T, s^{ij}_T, z^{ij}_T, \lambda_{ij})}{\partial s^{ij}_T} + (1 - \lambda_{ij}) \frac{\partial v^{H,j}(k^{ij}_T, s^{ij}_T, z^{ij}_T, \lambda_{ij})}{\partial s^{ij}_T} = 0$$

Given the additive separability and the independence of the future utility from s^{ij}_T, therefore, the optimal $s^{ij,*}_T$ is:

$$\frac{\lambda_{ij}}{1 - \lambda_{ij}} = \left(\frac{(1 - s^{ij}_T) C^{ij}_T}{s^{ij}_T C^{ij}_T} \right)^{-\eta_C} \implies s^{ij,*}_T(\lambda_{ij}) = \left[\left(\frac{\lambda_{ij}}{1 - \lambda_{ij}} \right)^{-1/\eta_C} + 1 \right]^{-1}$$

Thus, we can rewrite the Bellman as:

$$V^{H,ij}_T(z^{ij}_T, \lambda_{ij}, \epsilon^{\mathbf{H}}_{\mathbf{k_T}}) = \max_{k^{ij}_T} \{ v^{H,ij}(k^{ij}_T, s^{ij,*}_T, z^{ij}_T, \lambda_{ij}) + \epsilon^{H}_{k^{ij}_T} \}$$

and the solution to the problem is:

$$k^{ij,*}_T(z^{ij}_T, \lambda_{ij}, \epsilon^{\mathbf{H}}_{\mathbf{k_T}}) = \arg\max_{k^{ij}_T} \{ v^{H,ij}(k^{ij}_T, s^{ij,*}_T, z^{ij}_T, \lambda_{ij}) + \epsilon^{H}_{k^{ij}_T} \}$$

Assuming Type 1 Extreme Value errors with a zero location parameter and scale parameter σ_{ϵ}, we have:

$$V^{H,ij}_T(z^{ij}_T, \lambda_{ij}) = \sigma_{\epsilon} \gamma + \sigma_{\epsilon} \log \left\{ \sum_{k^{ij}_T \in K^{ij}_T} \exp[v^{H,ij}(k^{ij}_T, s^{ij,*}_T, z^{ij}_T, \lambda_{ij}) / \sigma_{\epsilon}] \right\}$$

$$p^{H,ij}(k^{ij}_T | z^{ij}_T, \lambda_{ij}) = \frac{\exp[v^{H,ij}(k^{ij}_T, s^{ij,*}_T, z^{ij}_T, \lambda_{ij}) / \sigma_{\epsilon}]}{\sum_{k' \in K^{ij}_T} \exp[v^{H,ij}(k', s^{ij,*}_T, z^{ij}_T, \lambda_{ij}) / \sigma_{\epsilon}]}$$

$$\log \left[\frac{p^{H,ij}(k^{ij}_T = k_2 | z^{ij}_T, \lambda_{ij})}{p^{H,ij}(k^{ij}_T = k_1 | z^{ij}_T, \lambda_{ij})} \right] = \frac{1}{\sigma_{\epsilon}} \left[v^{H,ij}(k^{ij}_T = k_2, s^{ij,*}_T, z^{ij}_T, \lambda_{ij}) - v^{H,ij}(k^{ij}_T = k_1, s^{ij,*}_T, z^{ij}_T, \lambda_{ij}) \right]$$

Let us also define the married male and female valuation functions:

$$V_T^{H,i}(z_T^{ij},\lambda_{ij},\boldsymbol{\epsilon}_{\mathbf{k_T}}^{\mathbf{H}}) = \{\nu^{H,i}(k_T^{ij,*},s_T^{ij,*},z_T^{ij},\lambda_{ij}) + \epsilon^H_{k_T^{ij,*}}\}$$
$$V_T^{H,j}(z_T^{ij},,\lambda_{ij},\boldsymbol{\epsilon}_{\mathbf{k_T}}^{\mathbf{H}}) = \{\nu^{H,j}(k_T^{ij,*},s_T^{ij,*},z_T^{ij},\lambda_{ij}) + \epsilon^H_{k_T^{ij,*}}\}$$

where $k^{ij,*}(z_T^{ij},\lambda_{ij}), s^{ij,*}(\lambda_{ij})$ are the solution to the household optimization problem.

Therefore, as $\boldsymbol{\epsilon}_{\mathbf{k_T}}^{\mathbf{H}}$ is unobserved to the econometrician, therefore, we can define the ex-ante valuation function for married female $V_T^{H,i}(z_T^{ij},\lambda_{ij})$ and married male $V_T^{H,j}(z_T^{ij},\lambda_{ij})$, as the continuation value of being in state z_T^{ij} before $\epsilon^H_{k_T^{ij}}$ is revealed.

$$\begin{aligned}
V_T^{H,i}(z_T^{ij},\lambda_{ij}) &= \int \{\nu^{H,i}(k_T^{ij,*},s_T^{ij,*},z_T^{ij},\lambda_{ij}) + \epsilon^H_{k_T^{ij,*}}\} df \boldsymbol{\epsilon}_{\mathbf{k_T}}^{\mathbf{H}} \\
&= \int \sum_{k_T^{ij}\in K_T^{ij}} \mathbb{1}[k_T^{ij} = k_T^{ij,*}]\{\nu^{H,i}(k_T^{ij},s_T^{ij,*},z_T^{ij},\lambda_{ij}) + \epsilon^H_{k_T^{ij}}\} df \boldsymbol{\epsilon}_{\mathbf{k_T}}^{\mathbf{H}} \\
&= \sum_{k_T^{ij}\in K_T^{ij}} p^{H,ij}(k_T^{ij}|z_T^{ij},\lambda_{ij})\nu^{H,i}(k_T^{ij},s_T^{ij,*},z_T^{ij},\lambda_{ij}) \\
&+ \sum_{k_T^{ij}\in K_T^{ij}} p^{H,ij}(k_T^{ij}|z_T^{ij},\lambda_{ij})[\sigma_\epsilon(\gamma - \log p^{H,ij}(k_T^{ij}|z^{ij}T,\lambda_{ij}))] \\
&= \sigma_\epsilon\gamma + \sum_{k_T^{ij}\in K_T^{ij}} p^{H,ij}(k_T^{ij}|z_T^{ij},\lambda_{ij})\left[\nu^{H,i}(k_T^{ij},s_T^{ij,*},z_T^{ij},\lambda_{ij}) - \sigma_\epsilon \log p^{H,ij}(k_T^{ij}|z_T^{ij},\lambda_{ij}))\right]
\end{aligned}$$

Similarly, for the married male:

$$V_T^{H,j}(z_T^{ij}) = \sigma_\epsilon\gamma + \sum_{k_T^{ij}\in K_T^{ij}} p^{H,ij}(k_T^{ij}|z_T^{ij},\lambda_{ij})\left[\nu^{H,j}(k_T^{ij},s_T^{ij,*},z_T^{ij},\lambda_{ij}) - \sigma_\epsilon \log p^{H,ij}(k_T^{ij}|z_T^{ij},\lambda_{ij}))\right]$$

Work-Life For work-life stage t, households of type ij with human capital investment H_t^i, H_t^j, assets A_t^{ij} and demographic characteristics $\mathbf{X^i}, \mathbf{X^j}$ choose k_t^{ij} comprising of a time allocation component for both husband and wife, and a saving component i.e. $k_t^{ij} = [Q_t^i = \{L, M, H\}, M_t^i = \{NW, PT, FT\}, Q_t^j = \{L, M, H\}, M_t^j = \{NW, PT, FT\}, \rho_t^{ij} = \{L, H\}]$. We also define the state space as $z_t^{ij} = [H_t^i, H_t^j, A_t^{ij}, \lambda_{ij}]$. The maximization problem is as follows:

$$\max_{k_t^{ij} \in K_t^{ij}} \lambda_{ij} u^{H,i}(C_t^i, C_t^{Q,ij}, L_t^i; \mathbf{X^i}) + (1-\lambda_{ij}) u^{H,j}(C_t^j, C_t^{Q,ij}, L_t^j; \mathbf{X^j}) + \epsilon^H_{k_t^{ij}}$$
$$+ \beta \sum_{z' \in z_{t+1}^{ij}} \left[\int V_{t+1}^{H,ij}(z', \lambda_{ij}, \boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_{t+1}}}) df(\boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_{t+1}}}) \right] F(z'|z_t^{ij}, \lambda_{ij}, k_t^{ij} = 1)$$

subject to: $M_t^i + Q_t^i + L_t^i = 1; \qquad M_t^j + Q_t^j + L_t^j = 1$

$$H_{t+1}^i = (1-\sigma)H_t^i + (M_t^i H_t^i)^\alpha$$
$$H_{t+1}^j = (1-\sigma)H^j t + (M_t^j H_t^j)^\alpha$$
$$C_t^{ij} + A_{t+1}^{ij} = Y_t^{ij} = y_t^i(H_t^i, M_t^i, FC^i) + y_t^j(H_t^j, M_t^j, FC^j) - \tau(\mathbf{y_t}, \mathbf{X^\tau}) + (1+r)A_t^{ij}$$
$$C_t^{ij} = (1-\rho_t^{ij})Y_t^{ij}$$
$$C_t^i + C_t^j = C_t^{ij}; \qquad C_t^i = s_t^{ij} C_t^{ij}$$
$$C_t^{Q,ij} = \Gamma_{ij}(\mathbf{X^i}, \mathbf{X^j}) f_Q(Q_t^i, Q_t^j)$$

Rewriting the utility function as before, the conditional value function is:

$$\nu^{H,i}(k_t^{ij}, s_t^{ij}, z_t^{ij}, \lambda_{ij}) = u^{H,i}(k_t^{ij}, s_t^{ij}, z_t^{ij}) + \beta \sum_{z' \in z_3^{ij}} V_3^{H,ij}(z') F(z'|z_t^{ij}, \lambda_{ij}, k_t^{ij} = 1)$$
$$\nu^{H,j}(k_t^{ij}, s_t^{ij}, z_t^{ij}, \lambda_{ij}) = u^{H,j}(k_t^{ij}, s_t^{ij}, z_t^{ij}) + \beta \sum_{z' \in z_3^{ij}} V_3^{H,ij}(z') F(z'|z_t^{ij}, \lambda_{ij}, k_t^{ij} = 1)$$
$$\nu^{H,ij}(k_t^{ij}, s_t^{ij}, z_t^{ij}, \lambda_{ij}) = \lambda_{ij} \nu^{H,i}(k_t^{ij}, s_t^{ij}, z_t^{ij}, \lambda_{ij}) + (1-\lambda_{ij}) \nu^{H,j}(k_t^{ij}, s_t^{ij}, z_t^{ij}, \lambda_{ij})$$

where $F(z'|z_t^{ij}, \lambda_{ij}, k_t^{ij} = 1)$ is the transition function for state variables, conditional on choice k_3^{ij}, as before.

Therefore, the Bellman is then:

$$V_t^{H,ij}(z_t^{ij}, \boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_t}}) = \max_{k_t^{ij}, s_t^{ij}} \{\nu^{H,ij}(k_t^{ij}, s_t^{ij}, z_t^{ij}) + \epsilon^H_{k_t^{ij}}\}$$

As $\boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_t}}$ is unobserved to the econometrician, therefore, we can define the ex-ante valuation function for households $V_t^{H,ij}(z_t^{ij}, \lambda_{ij})$, as the continuation value of being in state z_t^{ij} before $\epsilon^H_{k_t^{ij}}$ is revealed:

$$V_t^{H,ij}(z_t^{ij}, \lambda_{ij}) = \int_\epsilon V_t^{H,i}(z_t^{ij}, \lambda_{ij}, \boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_t}}) d f \boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_t}}$$

where $f\boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_t}}$ is the continuously differentiable density of $F_\epsilon(\boldsymbol{\epsilon}_{\mathbf{k_t^H}})$.

Further, as mentioned earlier, we assume that the utility function is additively separable in consumption and has a CRRA form. Thus, s_t^{ij} only depends on λ_{ij}. It can be written as s^{ij} due to this, although we do not do so.

Thus, we can rewrite the Bellman as:

$$V_t^{H,ij}(z_t^{ij}, \lambda_{ij}, \boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_t}}) = \max_{k_t^{ij}} \{ \nu^{H,ij}(k_t^{ij}, s_t^{ij,*}, z_t^{ij}, \lambda_{ij}) + \epsilon^H_{k_t^{ij}} \}$$

and the solution to the problem is:

$$k_t^{ij,*}(z_t^{ij}, \lambda_{ij}, \boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_t}}) = \arg\max_{k_t^{ij}} \{ \nu^{H,ij}(k_t^{ij}, s_t^{ij,*}, z_t^{ij}, \lambda_{ij}) + \epsilon^H_{k_t^{ij}} \}$$

Assuming Type 1 Extreme Value errors with a zero location parameter and scale parameter σ_ϵ, we have:

$$V_t^{H,ij}(z_t^{ij}) = \sigma_\epsilon \gamma + \sigma_\epsilon \log \left\{ \sum_{k_t^{ij} \in K_t^{ij}} \exp[\nu^{H,ij}(k_t^{ij}, s_t^{ij,*}, z_t^{ij}, \lambda_{ij})/\sigma_\epsilon] \right\}$$

$$p^{H,ij}(k_t^{ij}|z_t^{ij}, \lambda_{ij}) = \frac{\exp[\nu^{H,ij}(k_t^{ij}, s_t^{ij,*}, z_t^{ij}, \lambda_{ij})/\sigma_\epsilon]}{\sum_{k' \in K_t^{ij}} \exp[\nu^{H,ij}(k', s_t^{ij,*}, z_t^{ij}, \lambda_{ij})/\sigma_\epsilon]}$$

$$\log\left[\frac{p^{H,ij}(k_t^{ij} = k_2|z_t^{ij}, \lambda_{ij})}{p^{H,ij}(k_t^{ij} = k_1|z_t^{ij}, \lambda_{ij})}\right] = \frac{1}{\sigma_\epsilon}\left[\nu^{H,ij}(k_t^{ij} = k_2, s_t^{ij,*}, z_t^{ij}, \lambda_{ij}) - \nu^{H,ij}(k_t^{ij} = k_1, s_t^{ij,*}, z_t^{ij}, \lambda_{ij})\right]$$

Let us also define the married male and female valuation functions, following the same procedure as before:

$$V_t^{H,i}(z_t^{ij}, \lambda_{ij}, \boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_t}}) = \{ \nu^{H,i}(k_t^{ij,*}, s_t^{ij,*}, z_t^{ij}, \lambda_{ij}) + \epsilon^H_{k_t^{ij,*}} \}$$
$$V_t^{H,j}(z_t^{ij}, \lambda_{ij}, \boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_t}}) = \{ \nu^{H,j}(k_t^{ij,*}, s_t^{ij,*}, z_t^{ij}, \lambda_{ij}) + \epsilon^H_{k_t^{ij,*}} \}$$

where $k^{ij,*}(z_t^{ij})$, $s^{ij,*}(\lambda_{ij})$ are the solution to the household optimization problem.

Therefore, as $\boldsymbol{\epsilon}^{\mathbf{H}}_{\mathbf{k_t}}$ is unobserved to the econometrician, therefore, we can define the ex-ante valuation function for married female $V_t^{H,i}(z_t^{ij})$ and married male $V_t^{H,j}(z_t^{ij})$, as the continuation value of being in state z_t^{ij} before $\epsilon^H_{k_t^{ij}}$ is revealed. Following the same procedure as before:

$$V_t^{H,i}(z_t^{ij}, \lambda_{ij}) = \sigma_\epsilon \gamma + \sum_{k_t^{ij} \in K_t^{ij}} p^{H,ij}(k_t^{ij}|z_t^{ij}, \lambda_{ij}) \left[\nu^{H,i}(k_t^{ij}, s_t^{ij,*}, z_t^{ij}, \lambda_{ij}) - \sigma_\epsilon \log p^{H,ij}(k_t^{ij}|z_t^{ij}, \lambda_{ij}))\right]$$
$$V_t^{H,j}(z_t^{ij}, \lambda_{ij}) = \sigma_\epsilon \gamma + \sum_{k_t^{ij} \in K_t^{ij}} p^{H,ij}(k_t^{ij}|z_t^{ij}, \lambda_{ij}) \left[\nu^{H,j}(k_t^{ij}, s_t^{ij,*}, z_t^{ij}, \lambda_{ij}) - \sigma_\epsilon \log p^{H,ij}(k_t^{ij}|z_t^{ij}, \lambda_{ij}))\right]$$

Further, at the start of work-life, at $t = 2$, individuals draw human capital and assets from a distribution. Therefore, we further define:

$$\bar{V}_t^{H,ij}(\lambda_{ij}) = \int_{z_2} V_t^{H,i}(z_t^{ij}, \lambda_{ij}) df \boldsymbol{z_2}$$

A.3 Marriage

Following **gayle2019optimal**, we embed our model into a frictionless empirical marriage matching model. As in **choo2006marries**, each individual will draw a type-specific preference shock for the opposite sex before making their marriage decision i.e. for a female g of type i, who can match with $j \in J$ types of men, she will draw $\vartheta_{ij}^{i,g}$. The choice set will be the $k_m^i = \{0, 1, 2\}$ where choice 0 refers to that of remaining single.

$$V_2^{f,2}(\boldsymbol{\lambda^i}, \boldsymbol{\vartheta^{i,g}}) = \max_{k_m^i} \left\{ \bar{V}_2^{S,i} + \vartheta_{i0}^{i,g}, \bar{V}_2^{H,i}(\lambda_{i1}) + \vartheta_{i1}^{i,g}, \bar{V}_2^{H,i}(\lambda_{i2}) + \vartheta_{i2}^{i,g} \right\}$$

Compared to existing literature, the gains from marriage are two-fold: first, the publicness of home production; second, the spousal benefit from retirement.

Let the measure of males and females be $\mathcal{M}$ and $\mathcal{F}$, respectively. Further, $\mathcal{M} = \sum_{j \in J} m^j$ and $\mathcal{F} = \sum_{i \in I} f^i$ where i and j are types of women and men, as determined in the education stage. Let the probability of choosing a specific education or type be $p^a(i|z_1^a) \quad \forall a = m, f$. Then,

$$f^i(p^f(i|z_f^1), \mathcal{F}) = p^f(i|z_1^f) \times \mathcal{F}$$
$$m^j(p^m(j|z_1^m), \mathcal{M}) = p^m(j|z_1^m) \times \mathcal{M}$$

Let $\boldsymbol{\lambda^i} = [\lambda_{i1}, ..., \lambda_{iJ}]$ be the $J \times 1$ vector of Pareto weights associated with different spouses for female of type i. Similarly, $\boldsymbol{\lambda^j} = [\lambda_{1j}, ..., \lambda_{Ij}]$ is $I \times 1$ vector of Pareto weights associated with different spouses for male of type j. Let $\mu_{ij}^d(\lambda_{ij})$ be the measure of type i females who want to match with type j males (or 'demand') and $\mu_{ij}^s(\lambda_{ij})$ is the measure of type j males who want to match with type i females (or 'supply'). The marriage market clearing conditions are characterized by an $I \times J$ matrix of Pareto weights $\boldsymbol{\lambda}$ where the demand of type i females by type j males is equal to the supply of type i females to type j males.

$$\mu_{ij}(\boldsymbol{\lambda}) = \mu_{ij}^d(\boldsymbol{\lambda^i}) = \mu_{ij}^s(\boldsymbol{\lambda^j}) \tag{15}$$

Further, the measures of females (males) of type i (j) married to males (females) of all types and the measure of single females (males) of type i (j) is equal to the measure of females of type i (j).

$$\sum_{j \in J} \mu_{ij}^{s}(\boldsymbol{\lambda}) + \mu_{i0}^{s} = f^{i} \quad \forall i \in I \tag{16}$$

$$\sum_{i \in I} \mu_{ij}^{d}(\boldsymbol{\lambda}) + \mu_{0j}^{d} = m^{j} \quad \forall j \in J \tag{17}$$

From the above equations, it is clear that the Pareto weights depend on: distribution of economic gains from alternative marriage pairings, the distribution of idiosyncratic marital payoffs, and the relative scarcity of spouses of different types. Therefore, when we write $\boldsymbol{\lambda}$, we suppress the notation: $\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}), \mathcal{F}, \mathcal{M}, \boldsymbol{\theta})$ where $\mathbf{p}(\boldsymbol{e_1}) = \{p^{f}(i|z_1^{f}), p^{m}(j|z_1^{m})\} \forall i \in I, j \in J$, and the parameter vector $\boldsymbol{\theta}$.

A.4 Education Stage

Females choose education $i \in I$, which determines time invested in education and time worked. Each individual draws a father's income y_1^{p} from a distribution. An individual can earn a function of the father's income and time spent working. Time spent in schooling will lead to higher human capital tomorrow (**ben1967production**), although there is foregone consumption today. The state space is defined as $z_1 = [y_1^{p}, s]$ where s is gender. Therefore, the maximization problem for a female is:

$$\max_{i \in I} u^{f}(C_1^{f}; z_1) + \epsilon_i^{f} + \beta \left[\int_{\theta} V_2^{f,2}(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}), \mathcal{F}, \mathcal{M}, \boldsymbol{\theta}), \vartheta^{i,g}) df(\vartheta^{i,g}) \right]$$

$$\text{subject to: } M_1^{f} + I_1^{f}(i) = 1$$

$$C_1^{f} = y_1^{f}(M_1^{f}, y_1^{p})$$

This can be analogously written for males.

Rewriting the utility function as before, the conditional value function is:

$$v^{f}(i, z_1, \boldsymbol{\lambda}) = u^{f}(i, z_1) + \beta \int_{\theta} V_2^{f,2}(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}), \mathcal{F}, \mathcal{M}, \boldsymbol{\theta}), \vartheta^{i,g}) df(\vartheta^{i,g})$$

Further, this emphasizes that the women's choice today does not affect the man's choice directly; however, it indirectly affects it through the equilibrium marriage market. Therefore, the Bellman is then:

$$V_1^{f}(z_1, \boldsymbol{\lambda}, \boldsymbol{\epsilon_i}) = \max_{i} \{v^{f}(i, z_1, \boldsymbol{\lambda}) + \epsilon_i^{f}\}$$

and the solution to the problem is:

$$i_1^*(z_1, \boldsymbol{\lambda}, \boldsymbol{\epsilon_i}) = \arg\max_i \{v^f(i, z_1, \boldsymbol{\lambda}) + \epsilon_i\}$$

Assuming Type 1 Extreme Value errors with a zero location parameter and scale parameter σ_ϵ, we have [8] :

$$V_1^f(z_1, \boldsymbol{\lambda}) = \sigma_\epsilon \gamma + \sigma_\epsilon \log\left\{\sum_{i\in I} \exp[v^f(i, z_1, \boldsymbol{\lambda})/\sigma_\epsilon]\right\}$$

$$p^f(i|z_1, \boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}), \mathcal{F}, \mathcal{M}, \boldsymbol{\theta})) = \frac{\exp[v^f(i, z_1, \boldsymbol{\lambda})/\sigma_\epsilon]}{\sum_{i'\in I} \exp[v^f(i', z_1, \boldsymbol{\lambda}))/\sigma_\epsilon]} = \frac{f_i(p^f(i|z_1^f, \boldsymbol{\lambda}))}{\mathcal{F}}$$

where γ is the Euler's constant. From the above equation, it is clear the dependency of education and marriage markets on each other.

Adding the male's choice of education, we have a system of educations, where we have $p(e_1)$ on the left and right hand side.

$$\mathbf{p}(\boldsymbol{e_1}) = \begin{bmatrix} p^f(i=1|z_1, \boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}), \mathcal{F}, \mathcal{M}, \boldsymbol{\theta})) & = \frac{\exp[v^f(i=1, z_1, \boldsymbol{\lambda})/\sigma_\epsilon]}{\sum_{i'\in I} \exp[v^f(i', z_1, \boldsymbol{\lambda}))/\sigma_\epsilon]} \\ p^f(i=2|z_1, \boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}), \mathcal{F}, \mathcal{M}, \boldsymbol{\theta})) & = \frac{\exp[v^f(i=2, z_1, \boldsymbol{\lambda})/\sigma_\epsilon]}{\sum_{i'\in I} \exp[v^f(i', z_1, \boldsymbol{\lambda}))/\sigma_\epsilon]} \\ p^m(j=1|z_1, \boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}), \mathcal{F}, \mathcal{M}, \boldsymbol{\theta})) & = \frac{\exp[v^m(j=1, z_1, \boldsymbol{\lambda})/\sigma_\epsilon]}{\sum_{j'\in J} \exp[v^f(j', z_1, \boldsymbol{\lambda}))/\sigma_\epsilon]} \\ p^m(j=2|z_1, \boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}), \mathcal{F}, \mathcal{M}, \boldsymbol{\theta})) & = \frac{\exp[v^m(j=2, z_1, \boldsymbol{\lambda})/\sigma_\epsilon]}{\sum_{j'\in J} \exp[v^f(j', z_1, \boldsymbol{\lambda}))/\sigma_\epsilon]} \end{bmatrix}$$

B Sketch of Existence

The individual utility functions $u^i(C^i, Q, L^i; \mathbf{X^i})$ and $u^j(C^j, Q, L^j; \mathbf{X^j})$ are assumed to be increasing and concave in C, Q, L and with $\lim_{C^i \to 0} u^i(C^i, Q, L^i; \mathbf{X^i}) = \lim_{C^j \to 0} u^j(C^j, Q, L^j; \mathbf{X^j}) = -\infty$ [9]

We will define the excess demand functions as:

$$ED_{ij}(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}))) = \mu_{ij}^d(\boldsymbol{\lambda^j}(\mathbf{p}(\boldsymbol{e_1}))) - \mu_{ij}^s(\boldsymbol{\lambda^i}(\mathbf{p}(\boldsymbol{e_1})))$$

The above equation will need to hold for a given $\mathbf{p}(\boldsymbol{e_1})$. Properties of ED: (i) $\frac{\partial ED_{ij}(\boldsymbol{\lambda})}{\partial \lambda_{ij}} < 0$ (ii) $\frac{\partial ED_{ik}(\boldsymbol{\lambda})}{\partial \lambda_{ij}} < 0$ if $k \neq j$ (ii) $\frac{\partial ED_{kj}(\boldsymbol{\lambda})}{\partial \lambda_{ij}} < 0$ if $i \neq k$ (iv) $\frac{\partial ED_{kl}(\boldsymbol{\lambda})}{\partial \lambda_{ij}} = 0$ if $i \neq k, l \neq j$

To prove existence, we follow **gayle2019optimal**. For $\psi > 0$, define:

$$\kappa(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}))) = \psi \mathbf{ED}(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}))) + \boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1}))$$

8. Link 1, Link 2

9. This holds by the additive separability and CRRA form of the utilities, along with imposing $\eta_C > 1$.

We appeal to Brouwer's Fixed Point Theorem. We know that the domain of $\boldsymbol{\kappa}$ is $[0,1]^{I\times J}$ We need to prove:

1. Continuity: We assume that $V_2^{H,i}(z_2^{ij},\lambda_{ij})$ and $V_2^{H,j}(z_2^{ij},\lambda_{ij})$ are continuously differentiable in λ_{ij} [10]

2. Range of $\boldsymbol{\kappa}$ to be $[0,1]^{I\times J}$:

   - First, we can show that $\mathbf{ED}(\mathbf{0}_{I\times J}) \geqslant \mathbf{0}_{i\times J}$ and $\mathbf{ED}(\mathbf{1}_{I\times J}) \leqslant \mathbf{0}_{i\times J}$. This comes from assuming $\lim_{\lambda_{ij}\to 0} \mathsf{ED}_{ij}(\lambda_{ij},\boldsymbol{\lambda}_{-ij}) > 0$ and $\lim_{\lambda_{ij}\to 1} \mathsf{ED}_{ij}(\lambda_{ij},\boldsymbol{\lambda}_{-ij}) < 0$ and from the properties of ED.
   - Now, we want to show that this function is an increasing function i.e. $\frac{\partial\boldsymbol{\kappa}(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1})))}{\partial\boldsymbol{\lambda}} > 0$, or $\psi\frac{\partial\mathbf{ED}(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1})))}{\partial\lambda_{ij}} + 1 \geqslant 0$. We know that from the properties of ED, that $\frac{\partial\mathbf{ED}_{kl}(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1})))}{\partial\lambda_{ij}} > 0$ where $k \neq i$ and/or $l \neq j$, therefore, as long as $\psi > 0$, the equation holds. For $\frac{\partial\mathbf{ED}_{ij}(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1})))}{\partial\lambda_{ij}}$, we know this sign is negative from our properties, therefore, we will impose that ψ is small enough that the overall term is positive. In other words, as long as $\psi < |\frac{\partial\mathbf{ED}_{ij}(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1})))}{\partial\lambda_{ij}}|^{-1}$, we can show that $\frac{\partial\boldsymbol{\kappa}(\boldsymbol{\lambda}(\mathbf{p}(\boldsymbol{e_1})))}{\partial\boldsymbol{\lambda}} > 0$. This gives us that $\boldsymbol{\kappa}(\mathbf{0}_{I\times J}) < \boldsymbol{\kappa}(\boldsymbol{\lambda})) < \boldsymbol{\kappa}(\mathbf{1}_{I\times J})$. Then from the continuity argument, we can show $\mathbf{0}_{I\times J} \leqslant \boldsymbol{\kappa}(\mathbf{0}_{I\times J})$ and $\boldsymbol{\kappa}(\mathbf{0}_{I\times J}) \leqslant \mathbf{1}_{I\times J}$

However, all of this is conditional on $\mathbf{p}(\boldsymbol{e_1})$. For $\mathbf{p}(\boldsymbol{e_1})$ to be a fixed point, we need to show:

$$\begin{aligned} \mathbf{f}(\mathbf{p}(\boldsymbol{e_1})) &= \mathbf{p}(\boldsymbol{e_1}) \\ \text{where } \mathbf{f}(\mathbf{p}(\boldsymbol{e_1})) &= \frac{\exp[\nu^f(e_1^f, z_1^f, \mathbf{p}(\boldsymbol{e_1}), \boldsymbol{\mathcal{X}^c},)/\sigma_\epsilon]}{\sum_{e'\in E_1^f}\exp[\nu^f(e', z_1^f, \mathbf{p}(\boldsymbol{e_1}), \boldsymbol{\mathcal{X}^c}))/\sigma_\epsilon]} \end{aligned}$$

We will appeal to Brouwer's Fixed Point Theorem again. We need to prove:

1. Continuity: We assume that $\nu^f(e_1^f, z_1^f, p(e_1), \mathcal{X}^J)$ are continuous. This follows from the utility functions being concave and increasing.

2. Range of $\mathbf{f}$ to be $[0,1]^{2\times E}$: By construction, as it is a logit function, range of $\mathbf{f}$ to be $[0,1]^{2\times E}$.

C Data Construction

We use data from the Panel Study of Income Dynamics (PSID) and Health and Retirement Survey (specifically, RAND-HRS Longitudinal File 2018). There are five sets

10. This follows from the utility functions being concave and increasing.

of variables: (1) Demographics (Education, Marital Status, Age, Ability); (2) Income (Own, Spouse if Married); (3) Assets (Joint); (4) Time Allocation (Work, Housework and Leisure); (5) Consumption.

C.1 Data Sources

C.1.1 Demographics

Education: Using data on completed education from PSID, [11], we construct the completed education as the highest grade completed over their life-cycle. For HRS, we use the completed years of education as given.
Age: We use data on the reported age from PSID, along with data on their birth year. For the birth year, we take the birth year that is the mode over their life-cycle and if birth year is missing, we impute it from the reported age. Then, we calculate the age from the year and birth year. For HRS, we use the age as given and is filled in for any missing years. As retirement age is an important cutoff for this paper, we plot retirement age by type of household in Figure C.2. Although 62 years is the early retirement age, significant proportion of individuals retire then.
Marital Status: Using the data from the Marital History file (1985-2019) as well as Family File (for those whom data is missing in the Marital History file) from PSID, we construct the marital status as the following. If the individual is married by age 46 and is in a marriage that lasts for at least 10 years, then they are considered married. Age at first marriage from both the Family File and Marital History is primarily in the 30s for the 1940-49 cohort. Moreover, most marriages last more than 10 years. We further show this by understanding the division of those married by the length of marriage and age at marriage (Figure C.1) . If there are two marriages which last longer than 10 years, then we take the longest marriage. There are many discrepancies in the Marital History file between spouses and care is taken to clean this.

For the HRS, we only have information on the current spouse. Therefore, to ensure we preserve most observations, we focus on the current marriage and whether this marriage has a length of more than 10 years. We only focus on marriages where there are married (irrespective of whether spouse is present). Therefore, an individual is considered to be married if they're currently married and the marriage had lasted for 10 years for the survey years.

C.1.2 Income

In the PSID, income is composed of three components: labor income, labor portion of business income and labor portion of asset income. From 1968 to 1993, the income of

11. The question used is: 'What is the highest grade (he/she) finished?'

the head and wife of the household already included these 3 components. From 1994 onwards, these 3 components were given separately and therefore, were summed to have comparable incomes to before 1994. Farming income was provided as a joint income of the head and wife and it was divided in half to construct individual incomes. We also use data on individual money income and taxable income to construct a variable on taxable income. All nominal variables are converted into real 2015 $. In the HRS, prior to retirement age, we assume it to be the labor income. After retirement age, this is set to social security income only. Therefore, even if someone is earning labor income, we do not consider that after retirement.

C.1.3 Assets

For the PSID, three variables are used: house value (1968-2019), wealth without home equity (1984, 1989, 1994, 1999-2013) and wealth with home equity (1984, 1989, 1994, 1999-2013). All variables were converted into real 2015 $.

For the HRS, assets are the sum of all assets less of debt. This includes value of primary residence, net value of other real estate, net value of vehicles, net value of business, net value of IRA, Keogh accounts, net value of stocks, mutual funds, and investment funds, value of checking, savings, or money market accounts, value of CD, government savings bonds, and T-bills, net value of bonds and bond funds, net value of all other savings, less of value of all mortgages/land contracts (primary residence), value of other home loans (primary residence) and value of other debt.

C.1.4 Time Allocation

For the HRS, time allocation is taken from the Consumption and Activities Mail Survey 2001-2019 (CAMS-HRS). This is a sub-survey sent out to respondents of HRS. Measures of hours spent in work, home production and leisure are constructed from this survey. In this survey, individuals can double count activities - if an individual walked to the store, they might report it as walking and shopping. Further, any activity is adjusted to be capped at 112 hours for weekly reporting and 480 hours for monthly reporting. Lastly, due to the double counting, we sum the total time spent at the monthly level (weekly hours are multiplied by 4.3), and then normalize the categories of time allocation.

<u>Work Hours:</u> For the PSID, work hours is collected from 3 different variables: annual hours worked by the head of the household for money (1968-2019), annual hours worked by the wife of the household for money, (1968-2019), and annual hours worked by an individual (1968-1993). In the CAMS-HRS, working for pay is considered as hours spent working.

<u>Housework Hours:</u> In the PSID, housework hours is collected from 5 different sources:

annual housework hours by the head of the household (1969-1974, 1976-1993), weekly (or other unit) housework hours by the head of the household (1976-2019), annual housework hours by the wife of the household (1969-1974, 1976-1993), weekly (or other unit) housework hours by the wife of the household (1976-2019), weekly hours by the individual (1969-1974, 1976-1986). We construct a harmonious variable for annual housework hours by the individual by using annual housework hours wherever available, and then for missing values, using the annualized weekly (or other reported unit) hours.

In the CAMS-HRS, the following activities are classified as home production: (weekly) house cleaning, washing, ironing, or mending clothes, yard work or gardening, shopping or running errands, preparing meals and cleaning up afterwards, caring for pets, (annual) taking care of finances or investments, such as banking, paying bills, balancing the checkbook, doing taxes, etc., doing home improvements, including painting, redecorating, or making home repairs, and working on, maintaining, or cleaning your car(s) or vehicle(s).

Leisure Hours: In the PSID, leisure hours are a residual i.e. the total hours spent in leisure are total time available to an individual ($16 \times 365 = 5840$ hours) less of work and housework hours.

In the CAMS-HRS, the following activities are classified as leisure: (weekly) watching programs or movies/videos on TV, computers, etc., reading newspapers or magazines, reading books, listening to music, walking, participating in sports or other exercise activities, visiting in-person with friends, neighbors or relatives, communicating by telephone, letters, e-mail, Facebook, Skype, or other media with friends, neighbors, or relatives, using the computer, praying or meditating, personal grooming and hygiene, such as bathing and dressing, physically showing affection for others through hugging, kissing, etc, (annual) helping friends, neighbors, or relatives who did not live with you and did not pay you for the help, taking care of grandchildren, doing volunteer work for religious, educational, health-related, or other charitable organizations, attending religious services, attending meetings of clubs or religious groups, treating or managing an existing medical condition of your own, playing cards or games, or solving puzzles, attending concerts, movies, or lectures, or visiting museums, singing or playing a musical instrument, doing arts and crafts projects, including knitting, embroidery, or painting, and dining or eating outside the home (not related to business or work).

C.1.5 Consumption

In the PSID, data on food consumption is available from 1968. Three components of food consumption are recorded - food at home, food outside and food delivery.

All three are summed to construct total food consumption. This is adjusted to 2015 $ to convert to real terms. To construct total consumption, we use estimates from **guo2010superior**. For a more careful analysis, we are in the process of using CEX data and then inverting the estimates to get total consumption. For the HRS, consumption is taken from RAND CAMS Spending Data File 2001-2019 (V1). This is the sum of all of the consumption in the household, including durable consumption, housing consumption, transportation consumption and nondurable spending.

C.2 Merging and Cleaning Data

For each dataset, we merge all the variables from the above subcategories using the unique ID. Further, we also merge the same variables using Spouse ID to get the same variables at the spouse level as well.

C.2.1 Sample Selection

We restrict the sample for the birth cohort of 1940 to 1949 for the rest of the analysis. While for single individuals, this is straightforward; for married couples, we keep the couple if the husband was born in the birth cohort of 1940 to 1949. We refer to this as the birth year, as defined by the male head of household.

C.2.2 Imputing Labor Income

For the PSID, we run individual regressions for males and females and by marital status for the ages 25 to 58 to impute these values. Further, we restrict the regressions to values of income that are below the 99th percentile, as well as for positive values of income. We use these regressions to predict labor income for those whom labor income is missing or negative. If work hours are known, then we substitute labor income as 0 for those individuals for whom zero hours are worked. For the HRS, we follow the same procedure - however, we run separate regressions when the individual is working and retired. For when the individual is retired, we include average pre-retirement own and spousal income as that contributes to social security income.

C.2.3 Imputing Time Allocation

In the PSID and HRS, for imputing hours, we first interpolate hours by running a regression of hours on age for each individual. Then, for the missing values, we construct hourly wage rate by taking a ratio of the imputed income and existing hours. We then run a regression of wage on age, education and its interaction for the ages of 25 to 58 years in the PSID and for working individuals in the HRS, for values less than the 99th percentile. We then use the regressions to impute wage for the missing values. Hours are then constructed by taking the ratio of imputed income and the hourly wage rate. Hours are capped at 5840 hours (16 hours a day * 365 days in the year). For housework hours, we follow a similar methodology. In the PSID, we first interpolate housework hours by running a regression of hours on age for each individual. Then, for the missing values, we run a regression of housework hours on age, education and its interaction for values less than the 99th percentile. Predicted hours from these regressions are used to impute housework hours. In the HRS, we run a similar regression, however we allow variation by retirement and work hours and spousal variables (if married). As we have leisure data in the HRS, we do run similar regressions for leisure hours too (more as an exercise to understand the hours.

C.2.4 Imputing Assets

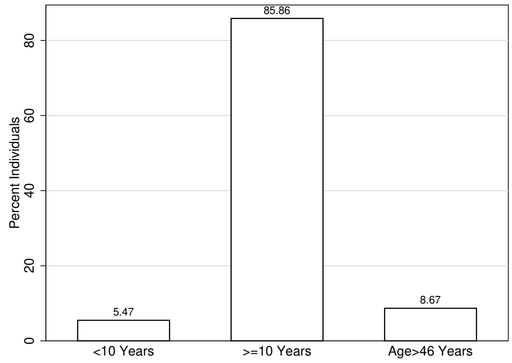
In the PSID, we have two relevant variables for assets - value of house which is available from 1968 to 2019 and real wealth with home equity from 1984 onwards but at sparse intervals. Therefore, since there is sparse data, we first run regressions of asset on value of house, age, education and its interaction for single individuals by sex. For married couples, we include the spouse education, spouse age, interaction of spouse age and education, as well as an interaction of both spouses' education. In case house value is missing, we run the same regressions but using income and spouse income (if married) instead. We first replace missing values by running an interpolation over age by individual and then fill in the missing remaining values with the predicted values from the regression from Model 1 and if there are still missing values, then from Model 2.

In the HRS, we run regressions of assets on age, education, its interaction, and own income for single individuals. For married individuals, in addition to these variables, we add spousal income, age, education and its interaction, alongwith interaction of education of spouses. We first replace missing values by running an interpolation over age by individual and then fill in the missing remaining values with the predicted values from this regression.

C.2.5 Imputing Consumption

For both HRS and PSID, we run regressions of constructed consumption on age, education, interaction of age and education, own income and spouse income (if married). We first replace missing values by running an interpolation over age by individual and then fill in the missing remaining values with the predicted values from the regression.

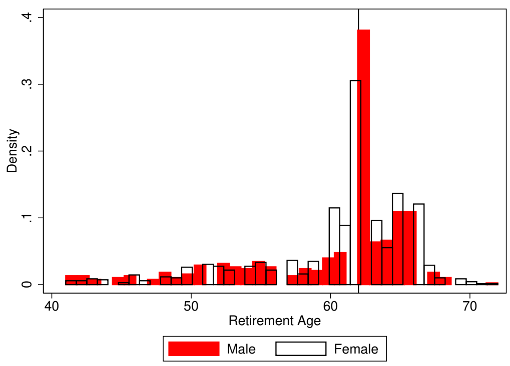
Figure C.1: Proportion Married - 1940-49 Cohort



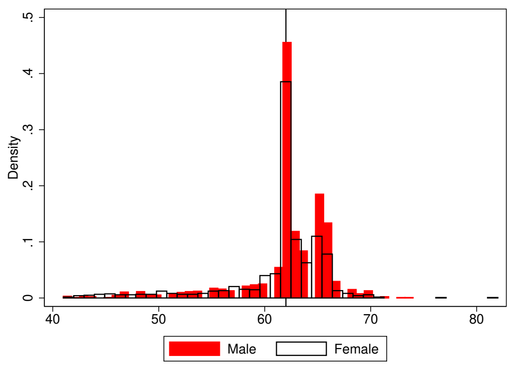
Source: Author's calculations using the file from PSID.

Figure C.2: Retirement Age for 1940-49 Cohort

(a) Single Households



(b) Married Households



Source: RAND Health and Retirement Survey, 1992-2018

C.2.6 Father's Income

For father's income, we impute it by running a regression of father's income on income of the individual in the ages of 18 to 25.

D Combining HRS and PSID

After the imputation, we convert the existing data to map into our model. We model $T = 2$ as the ages 25 to 50 and $T = 3$ as the ages 51 to 61 and $T = 4$ is 62+.

D.1 Mapping to Model

D.1.1 Education

As we use a discrete choice model, a key consideration will be that we have enough individuals in each category space. Thus, we settle with 2 education categories - HS or

Table D.4: Cutoffs for Housework Hours

Period	Household	Low	Medium	High
T=2	Single Male	$\leqslant 50$	$(50, 100)$	$\geqslant 100$
T=3	Single Male	$\leqslant 250$	$(250, 300)$	$\geqslant 300$
T=4	Single Male	$\leqslant 830$	$(830, 870)$	$\geqslant 870$
T=2	Single Female	$\leqslant 200$	$(200, 400)$	$\geqslant 400$
T=3	Single Female	$\leqslant 600$	$(600, 700)$	$\geqslant 700$
T=4	Single Female	$\leqslant 1050$	$(1050, 1200)$	$\geqslant 1200$
T=2	Married Female	$\leqslant 500$	$(500, 1000)$	$\geqslant 1000$
T=3	Married Female	$\leqslant 800$	$(800, 1000)$	$\geqslant 1000$
T=4	Married Female	$\leqslant 1000$	$(1000, 1200)$	$\geqslant 1200$
T=2	Married Male	$\leqslant 100$	$(100, 300)$	$\geqslant 300$
T=3	Married Male	$\leqslant 250$	$(250, 400)$	$\geqslant 400$
T=4	Married Male	$\leqslant 800$	$(800, 900)$	$\geqslant 900$

below ($\leqslant$ 12 years of education) and College ($>$ 12 years of education). Allowing for three categories (HS, SC, College or LHS, HS, College) leads to some sets of married couples with less than 5 percent.

D.1.2 Time Allocation

The cutoffs for work hours are taken to be 400 and 1400 hours. The cutoffs for housework hours are given in Table D.4. There is a significant difference between the housework hours for the ages that overlap between the PSID and HRS - this probably stems from the way the time diary is collected (**hurd2007time**).

E IDENTIFICATION

At this point, we normalize σ_ϵ to 1.

E.0.1 Identifying η_C

If we set b_1, b_2 from outside the model, then the following equation from the retirement stage of singles is a function of η_C. As the CCP is identified from data, we can identify η_C.

$$\log\left[\frac{p^{S,i}(k_4^i = 4|z_4^i, \theta)}{p^{S,i}(k_4^i = 1|z_4^i, \theta)}\right] = \frac{1}{\sigma_\epsilon}\left\{\frac{(Y_4^i(z_4^i))^{1-\eta_C}}{1-\eta_C}\left[(1-\rho_4^H)^{1-\eta_C} - (1-\rho_4^L))^{1-\eta_C}\right]\right.$$
$$\left. + \frac{\beta b_1}{1-\eta_C}\left[[b_2 + (\rho_4^H Y_4^i(z_4^i))]^{1-\eta_C} - [b_2 + (\rho_4^L Y_4^i(z_4^i))]^{1-\eta_C}\right]\right\}$$

E.0.2 Identifying β_L, η_L

Once we have identified η_C, then the following equations from the late work-life of singles helps us pin down β_L and η_L jointly.

$$
\begin{aligned}
\log\left[\frac{p_3^{S,i}(k_3^i = 2|z_3^i, \theta)}{p_3^{S,i}(k_3^i = 1|z_3^i, \theta)}\right] = \frac{1}{\sigma_\epsilon}\Bigg\{ & \frac{(1-\rho_3^L)^{1-\eta_C}}{1-\eta_C}\left[(Y_3^i(M_3^M, z_3^i))^{1-\eta_C} - (Y_3^i(M_3^H, z_3^i))^{1-\eta_C}\right] \\
& + \frac{\beta_L}{1-\eta_L}\left[(L_3^M)^{1-\eta_L} - (L_3^a)^{1-\eta_L}\right] \\
& + \frac{\beta(1-\rho_4^L)^{1-\eta_C}}{1-\eta_C}\left[(Y_4^i(z_4^i(M_3^M, \rho_3^L, z_3^i)))^{1-\eta_C} - (Y_4^i(z_4^i(M_3^H, \rho_3^L, z_3^i)))^{1-\eta_C}\right] \\
& + \frac{\beta^2 b_1}{1-\eta_C}\left[[b_2 + (\rho_4^L Y_4^i(z_4^i(M_3^M, \rho_3^L, z_3^i))]^{1-\eta_C} - [b_2 + (\rho_4^L Y_4^i(z_4^i(M_3^H, \rho_3^L, z_3^i))]^{1-\eta_C}\right] \\
& - \beta\sigma_\epsilon \log\frac{p_4^{S,i}(k_4^i = 2|z_4^i(k_3^i = 2, z_3^i))}{p_4^{S,i}(k_4^i = 2|z_4^i(k_3^i = 1, z_3^i))}\Bigg\}
\end{aligned}
$$

$$
\begin{aligned}
\log\left[\frac{p_3^{S,i}(k_3^i = 5|z_3^i, \theta)}{p_3^{S,i}(k_3^i = 1|z_3^i, \theta)}\right] = \frac{1}{\sigma_\epsilon}\Bigg\{ & \frac{(1-\rho_3^L)^{1-\eta_C}}{1-\eta_C}\left[(Y_3^i(M_3^L, z_3^i))^{1-\eta_C} - (Y_3^i(M_3^H, z_3^i))^{1-\eta_C}\right] \\
& + \frac{\beta_L}{1-\eta_L}\left[(L_3^H)^{1-\eta_L} - (L_3^L)^{1-\eta_L}\right] \\
& + \frac{\beta(1-\rho_4^L)^{1-\eta_C}}{1-\eta_C}\left[(Y_4^i(z_4^i(M_3^L, \rho_3^L, z_3^i)))^{1-\eta_C} - (Y_4^i(z_4^i(M_3^H, \rho_3^L, z_3^i)))^{1-\eta_C}\right] \\
& + \frac{\beta^2 b_1}{1-\eta_C}\left[[b_2 + (\rho_4^L Y_4^i(z_4^i(M_3^L, \rho_3^L, z_3^i))]^{1-\eta_C} - [b_2 + (\rho_4^L Y_4^i(z_4^i(M_3^H, \rho_3^L, z_3^i))]^{1-\eta_C}\right] \\
& - \beta\sigma_\epsilon \log\frac{p_4^{S,i}(k_4^i = 2|z_4^i(k_3^i = 5, z_3^i))}{p_4^{S,i}(k_4^i = 2|z_4^i(k_3^i = 1, z_3^i))}\Bigg\}
\end{aligned}
$$

E.0.3 Identifying β_Q, η_Q

Once we have identified η_C, then the following equation from the late work-life of single males with the lowest education ($j = 1$) helps us pin down β_Q and η_Q jointly.

$$
\begin{aligned}
\log\left[\frac{p_3^{S,j}(k_3^j = 3|z_3^j, \theta)}{p_3^{S,j}(k_3^j = 1|z_3^j, \theta)}\right] = \frac{1}{\sigma_\epsilon}\Bigg\{ & \frac{(1-\rho_3^L)^{1-\eta_C}}{1-\eta_C}\left[(Y_3^j(M_3^M, z_3^j))^{1-\eta_C} - (Y_3^j(M_3^H, z_3^j))^{1-\eta_C}\right] \\
& + \frac{\beta_Q}{1-\eta_Q}\left[(Q_3^M)^{1-\eta_Q} - (Q_3^L)^{1-\eta_Q}\right. \\
& + \frac{\beta(1-\rho_4^L)^{1-\eta_C}}{1-\eta_C}\left[(Y_4^j(z_4^j(M_3^M, \rho_3^L, z_3^j)))^{1-\eta_C} - (Y_4^j(z_4^j(M_3^H, \rho_3^L, z_3^j)))^{1-\eta_C}\right] \\
& + \frac{\beta^2 b_1}{1-\eta_C}\left[[b_2 + (\rho_4^L Y_4^j(z_4^j(M_3^M, \rho_3^L, z_3^j))]^{1-\eta_C} - [b_2 + (\rho_4^L Y_4^j(z_4^j(M_3^H, \rho_3^L, z_3^j))]^{1-\eta_C}\right] \\
& - \beta\sigma_\epsilon \log\frac{p_4^{S,j}(k_4^j = 2|z_4^j(k_3^j = 3, z_3^j))}{p_4^{S,j}(k_4^j = 2|z_4^j(k_3^j = 1, z_3^j))}\Bigg\}
\end{aligned}
$$

$$
\begin{aligned}
\log\left[\frac{p_3^{S,i}(k_3^i = 6|z_3^i, \theta)}{p_3^{S,i}(k_3^i = 1|z_3^i, \theta)}\right] = \frac{1}{\sigma_\epsilon}\Bigg\{ & \frac{(1-\rho_3^L)^{1-\eta_C}}{1-\eta_C}\left[(Y_3^i(M_3^L, z_3^i))^{1-\eta_C} - (Y_3^i(M_3^H, z_3^i))^{1-\eta_C}\right] \\
& + \frac{\beta_Q}{1-\eta_Q}\left[(Q_3^H)^{1-\eta_Q} - (Q_3^L)^{1-\eta_Q}\right. \\
& + \frac{\beta(1-\rho_4^L)^{1-\eta_C}}{1-\eta_C}\left[(Y_4^i(z_4^i(M_3^L, \rho_3^L, z_3^i)))^{1-\eta_C} - (Y_4^i(z_4^i(M_3^H, \rho_3^L, z_3^i)))^{1-\eta_C}\right] \\
& + \frac{\beta^2 b_1}{1-\eta_C}\left[[b_2 + (\rho_4^L Y_4^i(z_4^i(M_3^L, \rho_3^L, z_3^i))]^{1-\eta_C} - [b_2 + (\rho_4^L Y_4^i(z_4^i(M_3^H, \rho_3^L, z_3^i))]^{1-\eta_C}\right] \\
& - \beta\sigma_\epsilon \log\frac{p_4^{S,i}(k_4^i = 2|z_4^i(k_3^i = 6, z_3^i))}{p_4^{S,i}(k_4^i = 2|z_4^i(k_3^i = 1, z_3^i))}\Bigg\}
\end{aligned}
$$

E.0.4 Identifying Γ - Males

Once the utility parameters are identified, we can identify the home production parameters (Γ^j) for single males by varying the education level - it will be relative to the lowest education level. Any equation can be used for this where there is variation in home production choice, for example:

$$
\begin{aligned}
&\log\left[\frac{p_3^{S,j=3}(k_3^{j=3}=4|z_3^{j=3},\theta)}{p_3^{S,j=3}(k_3^{j=3}=1|z_3^{j=3},\theta)}\right]-\log\left[\frac{p_3^{S,j=1}(k_3^{j=1}=4|z_3^{j=1},\theta)}{p_3^{S,j=1}(k_3^{j=1}=1|z_3^{j=1},\theta)}\right]\\
&\quad=\frac{1}{\sigma_\epsilon}\Bigg\{\frac{(1-\rho_3^L)^{1-\eta_C}}{1-\eta_C}\Bigg[\left[(Y_3^{j=3}(M_3^L,z_3^{j=3}))^{1-\eta_C}-(Y_3^{j=3}(M_3^H,z_3^{j=3}))^{1-\eta_C}\right]\\
&\quad-\left[(Y_3^{j=1}(M_3^L,z_3^{j=1}))^{1-\eta_C}-(Y_3^{j=1}(M_3^H,z_3^{j=1}))^{1-\eta_C}\right]\Bigg]\\
&\quad+\frac{\beta_Q}{1-\eta_Q}\left\{\left[(Q_3^M)^{1-\eta_Q}-(Q_3^L)^{1-\eta_Q}\right]\times\left[(\Gamma^{j=3})^{1-\eta_Q}-1\right]\right\}\\
&\quad+\frac{\beta(1-\rho_4^L)^{1-\eta_C}}{1-\eta_C}\Bigg[\left[(Y_4^{j=3}(z_4^{j=3}(M_3^L,\rho_3^L,z_3^{j=3})))^{1-\eta_C}-(Y_4^{j=3}(z_4^{j=3}(M_3^H,\rho_3^L,z_3^{j=3})))^{1-\eta_C}\right]\\
&\quad-\left[(Y_4^{j=1}(z_4^{j=1}(M_3^L,\rho_3^L,z_3^{j=1})))^{1-\eta_C}-(Y_4^{j=1}(z_4^{j=1}(M_3^H,\rho_3^L,z_3^{j=1})))^{1-\eta_C}\right]\Bigg]\\
&\quad+\frac{\beta^2 b_1}{1-\eta_C}\Bigg[\left[[b_2+(\rho_4^L Y_4^{j=3}(z_4^{j=3}(M_3^L,\rho_3^L,z_3^{j=3}))]^{1-\eta_C}-[b_2+(\rho_4^L Y_4^{j=3}(z_4^{j=3}(M_3^H,\rho_3^L,z_3^{j=3}))]^{1-\eta_C}\right]\\
&\quad-\left[[b_2+(\rho_4^L Y_4^{j=1}(z_4^{j=1}(M_3^L,\rho_3^L,z_3^{j=1}))]^{1-\eta_C}-[b_2+(\rho_4^L Y_4^{j=1}(z_4^{j=1}(M_3^H,\rho_3^L,z_3^{j=1}))]^{1-\eta_C}\right]\Bigg]\\
&\quad-\beta\sigma_\epsilon\log\frac{p_4^{S,j=1}(k_4^{j=1}=2|z_4^{j=1}(k_3^{j=1}=4,z_3^{j=1}))}{p_4^{S,j=1}(k_4^{j=1}=2|z_4^{j=1}(k_3^{j=1}=1,z_3^{j=1}))}+\beta\sigma_\epsilon\log\frac{p_4^{S,j=3}(k_4^{j=3}=2|z_4^{j=3}(k_3^{j=3}=4,z_3^{j=3}))}{p_4^{S,j=3}(k_4^{j=3}=2|z_4^{j=3}(k_3^{j=3}=1,z_3^{j=3}))}\Bigg\}
\end{aligned}
$$

We can write down a similar equation for $j=2$.

E.0.5 Identifying Γ - Females

For females, we will first pin down the home production efficiency parameter for less than high school educated females.

$$
\begin{aligned}
&\log\left[\frac{p^{S,i=1}(k_4^{i=1}=2|z_4^{i=1},\theta)}{p^{S,i=1}(k_4^{i=1}=1|z_4^{i=1},\theta)}\right]-\log\left[\frac{p^{S,j=1}(k_4^{j=1}=2|z_4^{j=1},\theta)}{p^{S,j=1}(k_4^{j=1}=1|z_4^{j=1},\theta)}\right]\\
&\quad=\frac{1}{\sigma_\epsilon}\left\{\frac{\beta_Q}{1-\eta_Q}\left[(Q_4^M)^{1-\eta_Q}-(Q_4^L)^{1-\eta_Q}\right]\times\left[(\Gamma^{i=1})^{1-\eta_Q}-1\right]\right\}
\end{aligned}
$$

We can then use any equation like the one used for single males in context of single females, or we can use the above equation and vary it by education type. Both will help us pin down $\Gamma^{i=2}$ and $\Gamma^{i=3}$.

E.0.6 Identifying α

Before we identify the efficiency scale, we need to identify the returns to home production for female α. We identify this by comparing households with different husband types but same female type (and not of same education level as wife) and varying the home production choice.

$$\frac{\log\left[\frac{p^{H,ij_1}(k_4^{ij_1}=2|z_4^{ij_1},\lambda_{ij_1}(\theta),\theta)}{p^{H,ij_1}(k_4^{ij_1}=1|z_4^{ij_1},\lambda_{ij_1}(\theta),\theta)}\right]-\frac{\beta_L\lambda_{ij_1}(\theta)}{1-\eta_L}\left[(L_4^M)^{1-\eta_Q}-(L_4^H)^{1-\eta_Q}\right]}{\log\left[\frac{p^{H,ij_2}(k_4^{ij_2}=3|z_4^{ij_2},\lambda_{ij_2}(\theta),\theta)}{p^{H,ij_2}(k_4^{ij_2}=1|z_4^{ij_2},\lambda_{ij_2}(\theta),\theta)}\right]-\frac{\beta_L\lambda_{ij_2}(\theta)}{1-\eta_L}\left[(L_4^L)^{1-\eta_Q}-(L_4^H)^{1-\eta_Q}\right]}$$
$$=\frac{[(Q_4^M)^{\alpha}(Q_4^L)^{1-\alpha})]^{1-\eta_Q}-(Q_4^L)^{1-\eta_Q}}{[(Q_4^H)^{\alpha}(Q_4^L)^{1-\alpha})]^{1-\eta_Q}-(Q_4^L)^{1-\eta_Q}}$$

As η_Q is already identified, we are able to identify α from the above equation.

E.0.7 Identifying Γ - Households

We will follow the same procedure as with single females and compare households with single males as well. We will compare households of type $i = 1, j = 2$, $i = 2, j = 1$ and $i = 3, j = 2$ with single males of education less than high school education (essentially not for couples with same education level):

$$\log\left[\frac{p^{H,ij}(k_4^{ij}=5|z_4^{ij},\lambda_{ij}(\theta),\theta)}{p^{H,ij}(k_4^{ij}=1|z_4^{ij},\lambda_{ij}(\theta),\theta)}\right]-\log\left[\frac{p^{S,j=1}(k_4^{j=1}=2|z_4^{j=1},\theta)}{p^{S,j=1}(k_4^{j=1}=1|z_4^{j=1},\theta)}\right]$$
$$=\frac{1}{\sigma_\epsilon}\left\{\frac{\beta_Q(\tilde{\Gamma}_i)^{1-\eta_Q}}{1-\eta_Q}\left[[(Q_4^M)^{\alpha}(Q_4^M)^{1-\alpha})]^{1-\eta_Q}-[(Q_4^L)^{\alpha}(Q_4^L)^{1-\alpha})]^{1-\eta_Q}\right]\right.$$
$$\left.-\frac{\beta_Q}{1-\eta_Q}\left[(Q_4^M)^{1-\eta_Q}-(Q_4^L)^{1-\eta_Q}\right]\right\}$$

For identifying homophily parameter, we compare within couples (LHS-LHS with LHS-HS, for example):

$$\log\left[\frac{p^{H,ij}(k_4^{ij'}=5|z_4^{ij'},\lambda_{ij'}(\theta),\theta)}{p^{H,ij'}(k_4^{ij'}=1|z_4^{ij'},\lambda_{ij'}(\theta),\theta)}\right]-\log\left[\frac{p^{H,ij}(k_4^{ij}=5|z_4^{ij},\lambda_{ij}(\theta),\theta)}{p^{H,ij}(k_4^{ij}=1|z_4^{ij},\lambda_{ij}(\theta),\theta)}\right]$$
$$=\frac{1}{\sigma_\epsilon}\left\{\left[\frac{\beta_Q(\tilde{\Gamma}_i)^{1-\eta_Q}}{1-\eta_Q}\left[[(Q_4^M)^{\alpha}(Q_4^M)^{1-\alpha})]^{1-\eta_Q}-[(Q_4^L)^{\alpha}(Q_4^L)^{1-\alpha})]^{1-\eta_Q}\right]\right.\right.$$
$$\left.\left.\times\left[(\Gamma^{i=j'})^{1-\eta_Q}-1\right]\right]\right\}$$

F Parameters

F.1 Parameters Set Outside the Model

F.2 Estimated Parameters

Table F.1: Parameters Set Outside the Model

Parameter	Meaning	Value	Source
β	Discount Factor	0.98	**voena2015yours**
r	Rate of Return on Assets	0.03	**voena2015yours**
b_1	Weight on Bequest	-107.6	**de2014bequests**
b_2	Curvature of Bequest Function	16.5	**de2014bequests**

Table F.2: Payroll Tax Parameters

Variable	Age $25-50$	Age $51-62$
Cap on Earnings (in 1000 Dollars)	75.53	104.97
Payroll Tax	5.31	6.20
Medicare	1.13	1.45

Note: These are calculated using Payroll Tax and Cap data from SSA. For ages 25-50 years, the years 1965-1999 are averaged and for ages 51-62 years, the ages 1991- 2011 are averaged.

Table F.3: Income Tax Parameters

Variable	Age $25-50$	Age $51-62$
Married Couples		
Income $\leqslant$65,000	0.18	0.17
Income >65,000 and $\leqslant$ 200,000	0.35	0.29
Income $\geqslant$ 200,000	0.53	0.36
Single Households		
Income $\leqslant$ 32,500	0.16	
Income >32,500 and $\leqslant$ 100,000	0.32	
Income $\geqslant$ 100,000	0.52	
Income $\leqslant$ 32,500		0.14
Income >32,500 and $\leqslant$ 100,000		0.28
Income $\geqslant$ 100,000		0.36

Note: These are calculated using Income Tax Rates and Brackets over the years. For ages 25-50 years, the years 1965-1999 are averaged and for ages 51-62 years, the ages 1991- 2011 are averaged.

Table F.4: Social Security Bend Points

Bend Point	Value
Bend Point 1 (in 1000 Dollars)	9.75
Bend Point 2 (in 1000 Dollars)	58.78

Note: These are calculated using Social Security bend points over the years. We use the years 2002 onwards.

Table F.5: Human Capital in T=1 by Father's Income

	Male	Female
Low	13.30	15.84
High	86.70	84.16

Source: Author's calculations from Panel Study of Income Dynamics, 1968-2019 and Health and Retirement Survey, 1992-2018

Table F.6: Consumption in T=1 by Father's Income

	Low Ability		High Ability	
	HS and below	College	HS and below	College
Male	39.74	39.74	70.83	70.83
Female	37.11	37.11	71.13	71.13

Source: Author's calculations from Panel Study of Income Dynamics, 1968-2019 and Health and Retirement Survey, 1992-2018

Table F.7: Human Capital in T=2 by Education

	Male		Female	
	HS and below	College	HS and below	College
Wage, Age 25-50	27.05	30.50	20.28	24.85

Source: Author's calculations from Panel Study of Income Dynamics, 1968-2019 and Health and Retirement Survey, 1992-2018

Table F.8: Returns to Human Capital

Variable	Value
Depreciation	0.00
Returns to Human Capital	1.13

Source: Author's calculations from Panel Study of Income Dynamics, 1968-2019 and Health and Retirement Survey, 1992-2018

Table F.9: Estimated Parameters

Parameter	Type	Estimate
η_Q	Utility Parameter	0.10
η_L	Utility Parameter	1.15
β_Q	Utility Parameter	1.21
β_L	Utility Parameter	1.46
α	Home Production	0.76
η_C	Utility Parameter	2.16
Γ_1^f	Home Production	15.11
Γ_2^f	Home Production	14.09
Γ_2^m	Home Production	13.40
$\Gamma_1^{c,f}$	Home Production	2.03
$\Gamma_2^{c,f}$	Home Production	1.40
Γ^h	Home Production	1.92
σ_n	Marriage	1.00
FC_{pt}^f	Fixed Costs	8.09
FC_{pt}^m	Fixed Costs	1.39
FC_{ft}^f	Fixed Costs	17.40
FC_{ft}^m	Fixed Costs	4.64