The Effect of Public Pensions on Women's Labor Market Participation over a Full Life-Cycle*

Virginia Sánchez-Marcos and Carlos Bethencourt
Universidad de Cantabria and Universidad de La Laguna

December 2017

*We wish to thank the Spanish Ministry of Science and Technology for financial support under Grant ECO2009-09614.
Contact information: Virginia Sánchez-Marcos, Departamento de Economía, Universidad de Cantabria, Avda. de los Castros 39005 Santander, SPAIN, sanchezv@unican.es. Carlos Bethencourt, Departamento de Economía, Universidad de La Laguna, Facultad de Económicas, La Laguna 38071 Tenerife, SPAIN, cbethenc@ull.es

Abstract

Spousal and survivor pensions are two important provisions of the US Social Security pension system. In this paper we assess the impact of these benefits on the female employment rate in the context of a full life-cycle model in which households decide on female labor supply and savings. One important aspect of our model is that we allow for returns to labor market experience so that participation decisions affect not only current earnings and Social Security pension eligibility but also future earnings. We quantify the effect on female labor supply and on household inequality of (i) removing spousal benefit, (ii) removing both spousal and survivor pension benefits and (iii) extending from 35 to 40 the number of periods of the working career that are considered when calculating the retired worker's pension. We find that reforms (i) and (ii) significantly increase female employment throughout the life-cycle, whereas reform (iii) has a very mild effect. The effect of (ii) on income inequality in older household is large, whereas the effect on consumption inequality is small. All three reforms have substantial effects on Social Security expenditure and fiscal revenues.

1 Introduction

Over the last few year,s several papers have explored the impact of Social Security on incentives to work.[1] Most of these papers exclusively analyze the case of men. In a partial equilibrium framework, Rust and Phelan (1997), French (2005) and French and Jones (2012) find that public pension plans have major effects on the labor supply of older male workers, but that the labor supply of young men is not very responsive to changes in pension rules. In a general equilibrium framework, Wallenius (2013) and Erosa, Fuster and Kambourov (2012) find that differences in Social Security programs and taxation account for a substantial fraction of the differences in men's aggregate hours worked between the US and continental European countries. However, there has been little analysis of the effect of Social Security on female labor supply, in particular in terms of analyzing the impact over a full life-cycle. We believe that this may be of interest for several reasons. First, at an individual level the system redistributes in favor of low earners since the pension formula is a concave function of average lifetime earnings. This may favor women more than men because of the well-documented gender earnings gap. Second, the pension system provides second earners with a spousal benefit equivalent to 50% of the first earner's pension benefit, if she is not eligible for a retired worker's pension or if her retired worker's pension is lower than that. If the first earner passes away, this is increased to 100% of the deceased spouse's pension (survivor pension benefit). These provisions work as a minimum pension for second earners and, as the literature has shown, minimum pensions may have a substantial impact on labor supply at an older age. See for instance Jiménez-Martín and Sánchez-Martín (2007). The elimination of spousal and survivor benefits can increase female labor supply by reducing household Social Security wealth and by reducing the effective tax rate on the second earner's labor income. It is especially important to assess this reform at a time when developed countries are facing serious problems in achieving financial stability in their public pension systems. Finally, the pension formula establishes that benefits are a function of the 35 years of highest adjusted earnings over the whole working career, so the system redistributes from those individuals with a history of contributions longer than 35 years towards those with 35 years of contribution only. This favors individuals with spells out of the labor market that occur at child-bearing ages, typically in the case of mothers.

The aim of this paper is to achieve a further understanding of female labor market incentives under

[1] Blundell, French and Tetlow (2017) offers an excellent survey.

the Social Security pension rules in the US. We use a partial equilibrium life-cycle model in which forward-looking households make decisions on savings and female labor market participation. In the model, labor market participation decisions affect current earnings, future earnings (through a learning-by-doing technology) and Social Security pension benefits. Households face uncertainty on earnings and survival. Our model features the US pension system and provides a satisfactory representation of the life-cycle employment behavior of women and of the distribution of public pensions for men and women observed in the data. We conduct several policy assessment exercises: (i) removal of spousal benefit; (ii) removal of both spousal and survivor pension benefits; and (iii) extension from 35 to 40 of the number of periods of the working career that are considered in calculating the retired worker's pension. We find that removing the spousal and the survivor pension benefits has a substantial effect on women's employment decisions over the life-cycle, in particular after the age of 40. The average effect goes from an increase in the employment rate of 4 percentage points, in the case in which only spousal pension benefit is removed, to 10 percentage points in the case in which both spousal and survivor pension benefits are taken away. However, extending the number of years considered in calculating pension benefits has a negligible effect on participation.

There are a few other papers with a similar focus to ours. First, in the context of a reduced form participation model, Blau (1997) finds a moderately small negative impact of spousal benefit provision on labor force participation by older married women. Second, van der Klaauw and Wolpin (2008) and Casanova (2010) estimate structural dynamic models of saving and participation decisions of households, but consider only older couples. In the context of general equilibrium models, Nishiyama (2010) and Kaygusuz (2015) consider a two-adult household model to assess changes in the US Social Security pension rules. In contrast to Kaygusuz (2015), who uses a seven-year period model, we consider a one-year period model and introduce earnings and wage uncertainty. One distinctive features of our model with respect to both the aforesaid papers is that wages are endogenous through a learning-by-doing technology. The endogeneity of wages is an important aspect that may enhance the response of the labor supply at early ages to changes in incentives to work. The importance of labor market experience is emphasized in Wallenius (2013), but her analysis focuses on males only. Finally, a recent paper by Groneck and Wallenius (2017) explores the labor supply effects and the redistributional consequences of the US Social Security system across marital status.

Our paper is also related to a strand of the literature that analyzes the determinants of female labor market participation and its trend over time. Greenwood, Seshadri and Yorukoglu (2005) explore the role played by the development and dissemination of household appliances in explaining the increase in the labor force participation of women. There are other papers that emphasize changes in medical/contraceptive technology, such as for instance Goldin and Katz (2002) and Albanesi and Olivetti (2016). In the context of a life-cycle model, Attanasio, Low and Sánchez-Marcos (2008) explore the effect of child-care costs and female wages relative to males on the employment behavior of different cohorts of women. The impact of family-friendly policies on female labor supply has also been extensively explored in empirical papers such as Waldfogel (1998) or Ruhm (1998) and in quantitative papers such as Erosa, Fuster and Restuccia (2010), Domeij and Klein (2013) and Low and Sánchez-Marcos (2015). More recently, Eckstein and Lifshitz (2011), Fernández and Wong (2014) and Guvenen and Rendall (2015) analyze the impact of changes in education distribution, marital stability, wages and fertility on female labor market behavior across several cohorts. Finally, Guner, Kaygusuz and Ventura (2012) focus on the consequences of different tax policies on female labor supply. Our paper contributes to this literature by focusing on Social Security pension rules, the effects of which have only partially been explored on female labor supply.

One limitation of our analysis is that we assume the exogenous labor supply of husbands. This may be a reasonable assumption for middle-aged men, but it is controversial for men close to retirement. Therefore, our results provide an upper bound of the female labor supply response to different policy reforms, as the effects may be lower if husbands are also allowed to react. Nevertheless, we believe that our paper makes a contribution to the literature by focusing on the response of women's labor supply (given exogenous labor income from husbands), in contrast to most of the previous literature that instead focuses on the response of men's labor supply (but completely ignores other sources of household earnings). Finally, we acknowledge that ignoring general equilibrium effects is a limitation of our research as assuming fixed wages and interest rates may lead to the response of labor supply and savings to policy changes being overstated. However, we leave the analysis of those effects for future work.

The rest of the paper is organized as follows. Section 2 describes the model economy used for the analysis and Section 3 gives the calibration for the US economy. Section 4 presents the policy assessment

exercises and a robustness analysis of the results. Finally, Section 5 concludes.

2 Model Economy

In this section we set out the model economy that we use to analyze the reform of several aspects of the US Social Security pension system. We consider a partial equilibrium life-cycle model in which unitary households face earnings and lifespan uncertainty. Households enter the economy with no assets and make decisions on savings and female labor market participation. We consider only the extensive margin decision of female labor supply and assume that all working women work the same number of hours.[2] Men work in all periods up to an exogenously given retirement age at which they claim their corresponding Social Security pensions. We ignore any general equilibrium effects of the policy reforms that we implement, but female wages are endogenous as we assume that they depend on labor market experience. This is an important feature in studying female labor supply decisions because it introduces an additional trade-off of labor market spells. First, there is empirical evidence that accumulated labor market experience is highly correlated with wages (see for instance Eckstein and Wolpin, 1989). In these circumstances, labor market spells related to child-bearing have a trade-off in terms of future wages that may be important in understanding labor supply decisions. Second, according to the current rules of the US Social Security pension system, the individual pension benefit is a concave function of average lifetime earnings. Finally, we assume that women, if eligible, claim their Social Security pensions at an exogenous given age. However, as we show in section 4.4, alternative assumptions on the claiming age do not significantly affect the impact on female labor supply of the reforms that we assess.[3]

2.1 Demographics

Household size evolves exogenously over a life cycle. We assume that all households are initially made up of two adults who remain married. Therefore, we ignore the possibility of divorce, but we offer a detailed discussion about this assumption in section 4.4.[4] Household size changes deterministically with the arrival and emancipation of children, but it changes stochastically as individuals die. This is an

[2] French and Jones (2012) find that in the case of men, most changes in life cycle labor supply in response to changes in pension rules occur along the extensive margin.

[3] In Appendix A we provide a detailed description of the solution method for the model we set out below.

[4] According to Social Security rules, divorced women whose marriage had lasted more than 10 years are eligible to claim spousal benefit based on the ex-spouse's earnings record if they remain unmarried.

essential feature of the model since we are interested, among other things, in exploring the effect of the survivor pension benefit on female labor supply. However, all household members die at age T. In addition, we assume that from period T^R onwards both spouses are retired from the labor market.

2.2 Earnings

The earnings process includes two important aspects of the data: earnings uncertainty and earnings growth over a life-cycle. First we assume that both female and male earnings, y_t^f and y_t^m, are subject to permanent shocks, v_t^f and v_t^m, which are positively correlated. In particular we assume

$$\begin{aligned} v_t^f &= v_{t-1}^f + \xi_t^f \\ v_t^m &= v_{t-1}^m + \xi_t^m \text{ where } \xi_t = (\xi_t^f, \xi_t^m) \sim N\left(\mu_\xi, \sigma_\xi^2\right) \quad (1) \\ \mu_\xi &= (-\frac{\sigma_{\xi^f}^2}{2}, -\frac{\sigma_{\xi^m}^2}{2}) \qquad \text{and} \qquad \sigma_\xi^2 = \begin{pmatrix} \sigma_{\xi^f}^2 & \rho_{\xi^f,\xi^m} \\ \rho_{\xi^f,\xi^m} & \sigma_{\xi^m}^2 \end{pmatrix} \quad (2) \end{aligned}$$

The assumption of permanent shocks implies that the variance of earnings increases over the life-cycle, consistent with what is observed in the data (see for instance Huggett, Ventura and Yaron, 2011). Under this assumption, the slope of the variance of the earnings life-cycle profile gives the variance of the permanent shock.

Second, in order to capture the increasing male earnings life-cycle profile we feed exogenous growth as a two parameter function of age. Therefore, the husband's earnings are calculated as follows

$$\ln y_t^m = \ln y_0^m + \alpha_1^m t + \alpha_2^m t^2 + v_t^m \quad (3)$$

In contrast, growth in wives' earnings is endogenous. We assume a learning-by-doing technology and denote by x_t the total number of years of labor market experience in period t. Therefore, experience at the beginning of period $t+1$ is given by $x_{t+1} = x_t + p_t$, where p_t is the discrete female labor supply choice which takes value 1 if the wife works and 0 otherwise. We assume that female earnings are a two-parameter function of experience

$$\ln y_t^f = \ln y_0^f + \alpha_1^f x_t + \alpha_2^f x_t^2 + v_t^f \quad (4)$$

2.3 Social Security

In the economy there is a pay-as-you-go pension system that mimics the current US system. There is a Social Security payroll tax τ^{ss} that is a proportional tax on individual earnings with an earnings ceiling for contributions. Social Security benefits b^g, with $g = \{f, m\}$, are a concave function of each individual's average lifetime earnings. In line with US Social Security rules, the individual pension benefit is calculated as a concave function of the individual's average lifetime earnings. More specifically, it is a function of the N years of highest adjusted earnings over the whole working career, including years with zero earnings if needed to total N years. This is known as Average Indexed Monthly Earnings (AIME). Furthermore, a minimum number of years of contribution N^{min} is required for individuals to be eligible for a public pension. We consider that each married household is entitled to the husband's retired worker's pension benefit. In addition, the wife is eligible for a Social Security pension benefit in the amount of her corresponding retired worker's pension or a fraction of her husband's pension benefit (spousal benefit), whichever is higher.[5] Survivors get their own retired worker's pension benefit or their spouse's pension benefit (survivor pension benefit), whichever is higher. As a result, women may be dually entitled as retired workers and as spouses or survivors.

The complete labor market history of each individual is needed in order to calculate each individual AIME and thus the corresponding pension benefit. However, keeping track of the complete labor market history of each spouse is computationally very costly and unfeasible in this model which allows for savings decisions and features the degree of earnings uncertainty at an individual level observed in the data. At this point we proceed in the same way as many other papers in the literature which consider an approximation of the AIME.[6] Our approximation is based on the last working period earnings and the number of years of contribution to the pension system. In Appendix B we provide a detailed description of this approximation and we discuss its degree of accuracy.

According to Social Security rules, individuals can begin to receive their Social Security benefit once they reach the earliest claim age (T^{ECA}). The benefit is adjusted downward if it is claimed before the normal retirement age, that we denote by T^{NCA}, and upward if it is postponed until after the normal

[5] We assume here that the husband is the main breadwinner.

[6] See for instance Erosa, Fuster and Kambourov (2012) who assume that each individual obtains a pension that depends on the average lifetime earnings of her ability type and ignore the stochastic individual component of earnings in determining pensions. Other approaches are followed in Pistaferri and Low (2015) or Imrohoroğlu and Kitao (2012).

retirement age. Furthermore, as a result of the Earnings Test, a Social Security beneficiary (either as a retired worker or as a spouse) who is below normal retirement age and receives labor income that exceeds an exempt amount will see part of her benefit taxed away (τ^{et}). However, the benefit is adjusted upwards once the individual reaches the normal retirement age in order to compensate her for withheld benefits. In particular, the Social Security Administration calculates the number of months that benefits have been withheld and will recalculate the benefit at normal retirement age by adding those months to the original claiming age.

After retirement, public pensions b^m and b^f are the only source of household income apart from the returns on assets.

2.4 Taxes

We assume that there is a progressive income tax on the household's income. It is an important feature of the tax system that the household (rather than the individual) constitutes the basic unit of taxation, which results in high tax rates on secondary earners. Therefore, the first dollar made by a married female entering the labor market is taxed at her husband's current marginal rate. In the context of a very similar model to ours, Guner, Kaygusuz and Ventura (2012) show that this has important consequences on married women's labor supply.

2.5 Child care cost

We assume that, if a woman with children decides to work, then the household incurs child care expenses. Child care costs evolve exogenously with household composition, in particular, with the number and age of children living at home. We denote the child care units needed at age t by k_t and the price of each unit of child care by q. Therefore, the total child care cost f_t paid by a two-earner household in period t is given by $f_t = qk_t$.

2.6 Household's problem

Households derive utility from consumption and disutility from female labor supply. In particular we assume that there is a fixed utility cost of work that may change with women's age.

The recursive formulation of a married household's problem before period T^R is as follows

$$V_t^{M,p_t}(a_t, x_t, v_t, b_t, s_t) = \max_{a_{t+1}} u(c_t, p_t, e_t) +$$
$$\beta[\pi_{t,t+1}^f \pi_{t,t+1}^m E_t \max(V_{t+1}^{M,0}(a_{t+1}, x_{t+1}, v_{t+1}, b_{t+1}, s_{t+1}), V_{t+1}^{M,1}(a_{t+1}, x_{t+1}, v_{t+1}, b_{t+1}, s_{t+1})) +$$
$$\pi_{t,t+1}^f (1-\pi_{t,t+1}^m) E_t \max(V_{t+1}^{Wf,0}(a_{t+1}, x_{t+1}, v_{t+1}, b_{t+1}, s_{t+1}), V_{t+1}^{Wf,1}(a_{t+1}, x_{t+1}, v_{t+1}, b_{t+1}, s_{t+1})) +$$
$$\pi_{t,t+1}^m (1 - \pi_{t,t+1}^f) E_t V_{t+1}^{Wm}(a_{t+1}, x_{t+1}, v_{t+1}, b_{t+1}, s_{t+1})] \quad (5)$$

where a_t represents beginning-of-period household assets, x_t is beginning of period female labor market experience, v_t is the vector of husband and wife earnings shocks, b_t is the vector of husband and wife Social Security benefits, s_t is the vector of the number of periods for which a female retired worker's pension is withheld and the number of periods for which her spousal benefit is withheld between claiming age and normal retirement age (as a result of the Earnings Test).[7] These therefore comprise the set of state variables in the model economy. Thus, utility depends on total household consumption c_t, the number of adult-equivalent members of the household e_t, and the participation decision p_t. The participation choice and the consumption choice at period t determine the endogenous state variables (assets and labor market experience) at the start of the next period. Households can save, but are not allowed to borrow.[8] Finally, $V^{M,p_t}(.)$ is the value function of a married household, $V^{Wf,p_t}(.)$ is the value function of a widow household and $V^{Wm}(.)$ is the value function of a widower household. The probability of surviving from age t to age $t+1$ for an individual of gender g is given by $\pi_{t,t+1}^g$, $g = \{f, m\}$. Finally, β is the discount factor.

The household intertemporal budget constraint can be written as follows

$$a_{t+1} = (1+r)\left(a_t + \left(y_t^f - f_t - \tau_f^{ss} - T_t^2 + T_t^1 - \tau^{et}\right) p_t + y_t^m - \tau_m^{ss} - T_t^1 + b_t^m + b_t^f - c_t\right) \quad (6)$$

where r is the interest rate, τ_g^{ss}, $g = \{f, m\}$ represents Social Security contributions, T_t^1 represents income taxes paid by one-earner households and T_t^2 represents income taxes paid by two-earner house-

[7] Note that a woman is eligible for spousal benefit only once her husband becomes a public pension beneficiary. Therefore, a wife's Social Security pension benefit at the claiming age may be different from her pension benefit after her husband retires.

[8] This is a common assumption in the literature that evaluates public pensions. See for instance İmrohoroğlu and Kitao (2012) and French and Jones (2012).

holds. As stated above, τ^{et} stands for benefits taxed away as a result of the Earnings Test applied to workers between the claiming age and the normal retirement age.

A woman chooses to participate in the labor market in period t if

$$V_t^{M,1}(a_t, x_t, v_t, b_t, s_t) \geq V_t^{M,0}(a_t, x_t, v_t, b_t, s_t) \tag{7}$$

After retirement from the labor market, the married household's problem is simplified since the only decision that households make is the savings decision. The recursive formulation of a household entitled to pension benefit b is as follows

$$\begin{aligned} V_t^{M,R}(a_t, b_t) = \max_{a_{t+1}} u(c_t, e_t) + \beta[\pi_{t,t+1}^f \pi_{t,t+1}^m V_{t+1}^{M,R}(a_{t+1}, b_{t+1}) + \\ \pi_{t,t+1}^f (1 - \pi_{t,t+1}^m) V_{t+1}^{Wf,R}(a_{t+1}, b_{t+1}) + \pi_{t,t+1}^m (1 - \pi_{t,t+1}^f) V_{t+1}^{Wm,R}(a_{t+1}, b_{t+1})] \end{aligned} \tag{8}$$

where $V^{M,R}(.)$ is the value function of a married household in which both husband and wife are retired, $V^{Wf,R}(.)$ is the value function of a retired widow household and $V^{Wm,R}(.)$ is the value function of a retired widower household.

The budget constraint in period t is given by

$$a_{t+1} = (1 + r)\left(a_t + b_t^f + b_t^m - T_t - c_t\right) \tag{9}$$

where T_t represents the household's income taxes. The problem of a widow household can be defined similarly.

3 Calibration

In this section we start by describing the different data sources used for quantitative analysis (section 3.1). Then we provide a detailed description of the process we follow to take our model to the data (Section 3.2). We specify the functional forms for the utility function and the child care cost function and explain our calibration strategy. There are two different set of parameters to be calibrated. First, there are some parameter values that we borrow directly from earlier studies in the related literature.

Second, there are several parameters that we select so that our model economy resembles the data in a number of specific dimensions. Finally, we assess the ability of the benchmark model economy to account for different aspects of the data (Section 3.3).

3.1 Data

For the quantitative analysis, we calibrate our model economy to the behaviour of the cohort of women born in the US between 1944 and 1948, for whom we observe the retirement decision. We have to use three different data sources to produce the different statistics needed to calibrate our benchmark economy. Our main data source is the Integrated Public Use Microdata Series - Current Population Survey (IPUMS-CPS) which is based on a large representative sample of the US population. This is an integrated set of microdata spanning from 1962 to 2014 of the Current Population Survey (CPS). The IPUMS-CPS combines the labor information provided by the CPS with the data from US decennial censuses that are part of the Integrated Public Use Microdata Series - USA (IPUMS-USA). Thus, IPUMS-CPS takes advantage of the relatively large sample size of IPUMS-USA at ten-year intervals and fills in information for the intervening years with CPS data. We then select married women aged 60-64 in 2008 and follow them backwards and forwards to obtain relevant statistics for our quantitative analysis. More precisely, we obtain their complete life-cycle employment profile, their own earnings distribution and that of their husbands and the distribution of their own pension benefit and those of their husbands. However, IPUMS-CPS does not provide data on wealth so we use the Survey of Income and Program Participation (SIPP) 2008 wave 4 core and topical module data to calculate several statistics that we need for the quantitative analysis. SIPP is a longitudinal survey of the resident population of the United States that excludes people living in institutions and military barracks. The data in the core module file include the basic demographic characteristics of each member of the household. These include, among others, age, sex, marital status and types and amounts of income. The data in the topical module file includes assets and liabilities; real estate, dependent care, vehicles; interest accounts, stocks, mortgages, value of business and rental. We then merge the core and topical modules and calculate the wealth distribution for our sample of married households. Finally, we rely on the RAND HRS Data (version N) to calculate statistics for the distribution of the number of years of labor market experience. The RAND HRS Data file is a cleaned and streamlined version of 13 different waves (from 1992 to 2012) of the Health and Retirement Study (HRS) that contains variables covering a broad range

of measures consistently across waves. In turn, the HRS is a longitudinal data set representative of non-institutionalized individuals aged 51 and over and their spouses. It provides extensive information on demographics, income, labor status, health status and and retirement status. In particular, our interest is on a variable that reports the number of years of labor market experience for each woman at her claiming age.

3.2 Parameters and Targets

Demographics. All women in our model begin their lives for our purposes at the age of 25 with zero assets and retire from the labor market not later than 66 years of age. We assume 66 to be the normal retirement age for the cohort of women that we target. Individuals face lifetime uncertainty from the age of 66 onwards but they all die once they reach the age of 90. We target the death probabilities as reported by the Social Security Administration.[9] However, we calibrate the husband's probability of death at the age of 66 in order to target the fraction of widows in the data at that particular age (16% according to the IPUMS-CPS).[10]

We assume that the public pension claiming age is exogenous at 62 for eligible women.[11] Husbands' retirement age is exogenously given but we allow heterogeneity across households in this respect. In particular we consider five different types of households depending on the age at which the husband retires from the labor market and claims his retired worker Social Security pension: 62, 63, 64, 65 and 66. We target the distribution of husband claiming ages of our cohort.[12]

Finally, in regards to fertility, we introduce heterogeneity across households in the age at which the first child arrives. We choose to mimic the mean and standard deviation of the age on arrival of the first child, which are 22 and 4 respectively for the cohort of women that we target here.[13] To that end we assume that there are two types of households of equal measure in the total population: type one has two children, the first of whom arrives when the parents are 20 (so these households are made up of 2

[9] See Social Security Administration Actuarial Life Table, 2007.

[10] As a result of this, the fraction of widows among women aged 66 or older that our model delivers is 39%. In the data this figure is 44% in 2008.

[11] We can show that under the assumption that claiming age is 66, instead of 62, the impact of the different reforms that we analyze on the female employment rate is of the same order of magnitude.

[12] According to Haaga and Johnson (2012) and the RAND HRS the distribution of claiming age for the cohort of men born in the 1940s is as follows: 44% at 62, 14% at 63, 8% at 64, 21% at 65 and 13% at 66 or older.

[13] See Human Fertility Database for the US.

adults and 2 children in the first model period); type two has two children, with the first child arriving when the parents are 25. The second child arrives 3 years after the first in both cases, again as observed in the data.

Earnings. The deterministic component of the male earnings process (α_1^m and α_2^m in equation 3) is set so that the model is consistent with earnings growth over the life-cycle as calculated in the IPUMS-CPS. We target earnings growth of 2.4% from the age of 25 to 35 and of 0.8% from 36 to 64. Innovations to male earnings are assumed to have a unit root. The standard deviation of the innovation for the husband's earnings is assumed to be 0.08, similar to estimates by Hugget, Ventura and Yaron (2011). Furthermore, we assume the initial variance of log earnings to be 0.20, which is also consistent with their estimates. There is not much evidence on the variability of female earnings so we assume the same process as that for men's earnings. Finally, we assume that the correlation coefficient between the husband and wife's shocks is 0.25, as estimated by Hyslop (2001). The parameters that characterize the effect of female labor market experience on earnings and the initial offered earnings gender gap have to be calibrated by solving the model. To identify the effect of labor market experience on wages we target the two coefficients of a regression of female log wages on the number of years of experience and the squared number of years of experience as estimated by Eckstein and Wolpin (1989).[14] In particular, using simulated data we draw up an ordinary least square estimate of

$$\ln y_t^f = \gamma_1 + \gamma_2 x_t + \gamma_3 x_t^2 + u_t \tag{10}$$

where u_t is the error term. We select α_1^f and α_2^f in equation 4 so that the estimated values of γ_2 and γ_3 in the data and in the simulations are the same.

Finally, we select an initial offered gender earnings gap y_0^f/y_0^m which enables us to target the earnings gender gap of 0.54 in the age range 44 to 55 as obtained in the IPUMS-CPS.

Child care cost. We assume that the shape of the function k_t which determines the number of child care units needed by a family at age t depends on the number of children and their ages. We normalize to 1 the units that are required by a family with two infants (children aged 0 to 4). We assume that a 5 year old child needs 20% fewer units, as estimated using data from State Child Care Resource and

[14] They use the cohort of women aged 30 to 44 in 1967 in the National Longitudinal Survey.

Referral Network offices for pre-school children.[15] Since data on child care cost is not available after that age we assume that the cost for a child older than 5 is 80% lower than the cost of an infant and that after the age of 15 chid care cost is zero.[16] Finally the price q of each unit of child care is calibrated by solving the model. In order to identify this figure, we target the employment rate among women aged 25 to 29.

Social Security. We assume that the payroll income tax rate is equal to 12.4%, consistent with observed values for the period 1988-2016. According to the US Pension rules, the Workers' Primary Insurance Amount (PIA) is a piecewise linear function of the AIME with three bend points. The PIA formula is progressive. In 2008 the first USD 711 per month of relevant earnings attracts a 90% replacement rate. The band of earnings between USD 711 and USD 4,288 per month is replaced at 32%. These thresholds are 21% and 128% of the national average earnings respectively. A replacement rate of 15% applies between the latter threshold and the earnings ceiling. The earnings ceiling for benefits and contributions is USD 102,000 a year, corresponding to 253% of the national average earnings.[17] Furthermore, a minimum of 10 years of contributions is required for a person to be eligible for a public pension. The above PIA formula is used if an individual first applies for and receives benefit at the normal retirement age of 66. However, individuals are eligible to apply for Social Security once they reach the earliest retirement age of 62. Early receipt permanently reduces the benefit by the Actuarial Reduction Factor. In particular, those who retire at the age of 62 receive 75% of PIA, those who retire at 63 receive 80% of PIA, those who retire at 64 receive 87% of PIA and those who retire at 65 receive 93% of PIA. Individuals who initiate their claim after the official retirement age are rewarded with an additional 8% of PIA per year through Delayed Retirement Credit. As we explained above, in addition to individual pensions for those who are eligible, the public pension system provides spousal and survivor pension benefits. If it is claimed at the age of 65, the spousal benefit is equivalent to 50% of the husband's benefit. There is a 4% annual penalty for those who claim between 62 and 64. Wives eligible for both individual and spousal benefits receive the larger of the two. The survivor pension benefit is available for widows and it is equivalent to 100% of the deceased spouse's benefit if that amount is higher than the retired worker's pension of the widow. Penalties also apply to survivor pension benefit

[15] See Child Care Aware of America (2012).

[16] One could possibly rely on survey data of child care cost expenditures. However, this may be an underestimation of the true costs since the cost is not observed for those who remain out of the labor force because of the high child care cost they face.

[17] See OECD (2011).

if it is claimed before normal retirement age. However, we assume that individuals survive until the age of 66 with probability one, so survivor pension benefit is effectively not claimed before that age in the model economy.

Finally, as explained above, there is an Earnings Test by which Social Security pension benefits are taxed away if the earnings of a benefit recipient who is below the normal retirement age exceed a certain statutory threshold. In particular, one dollar for each two dollars of earnings in excess of the exempt amount is withheld until all Social Security benefits are exhausted. The earning statutory threshold in 2008 is USD 13,556. Importantly, according to the Social Security rules, we also consider in our model that after the individual reaches the normal retirement age, the benefit entitlement is adjusted upward to compensate for the benefits withheld.

Taxes. Regarding income taxation, we follow Guner, Kaygusuz and Ventura (2014) to capture the progressivity of the income tax system. In particular, we assume that the average tax levied on a household with total taxable income I_t is given by $t(\tilde{I}_t) = \tau_0 + \tau_1 \log(\tilde{I}_t)$ where $\tilde{I}_t$ stands for multiples of average household income (i.e. $\tilde{I}_t = \frac{I_t}{\bar{I}}$, with $\bar{I}$ being average household income). We select τ_0 and τ_1 so that the average income tax of a household with the mean income is 0.08 and the average income tax of a household with four times the mean income is 0.17, as estimated in Guner, Kaygusuz and Ventura (2014).[18] In order to calculate the household's taxable income, we consider the complex regime taxing Social Security benefits since 1983. According to this regime, benefits become subject to income taxation when the Modified Adjusted Gross Income[19] exceeds a first statutory threshold of USD 32,000. Above it, the taxable portion of benefits phases in starting at 50%. After a second statutory threshold of USD 44,000 the phase-in rate increases to 85%. The phase in continues until 85% of Social Security benefits are included in taxable income. This regime may significantly increase the marginal income tax rate for older households with potential effects on labor supply. Interestingly, although Burman, Coe, Pierce and Tian (2014) do not find evidence of bunching at either of the statutory thresholds (except among some of the self-employed), Jones and Li (2017) find that the aggregate effects of benefits taxation occur mainly along the extensive margin and that they are substantial .

[18] As in Erosa, Fuster and Kambourov (2012) we do however make the simplifying assumption that returns on assets pay a flat tax, which we assume to be 20%.

[19] Modified Adjusted Gross Income includes most of the income and adjustments reflected on adjusted gross income, plus tax-exempt interest and one-half of Social Security benefits.

Preferences. We assume a constant relative risk aversion utility function for consumption with parameter σ and a utility cost of women's work ψ_t that depends on age. Therefore our utility function can be written as follows

$$u^M(c_t, p_t, e_t) = \frac{(\frac{c_t}{e_t})^{1-\sigma}}{1-\sigma} - \psi_t p_t \tag{11}$$

where $\frac{c_t}{e_t}$ is equivalised consumption and we use the McClements scale to determine e_t.[20] In regards to the utility cost of working, we assume $\psi_t = \psi_1$ if $t < \bar{t}$ and $\psi_t = \psi_1(\frac{t}{\bar{t}})^{\psi_2}$ if $t \geq \bar{t}$, with $\psi_2 > 1$. This is intended to capture the increasing cost of working after a certain age $\bar{t}$. In particular, we consider the health status as important in accounting for the declining profile of labor market participation at old ages (see for instance van der Klaauw and Wolpin, 2008). This may also capture other incentives to exit the labor market that we ignore here[21] and it would help the model to mimic the participation rates at the end of the life-cycle that can be observed in the data. We set $\bar{t}$ at 55 and select the employment rate of women aged 40 to 44 and the employment rate among women aged 55 to 59 to calibrate ψ_1 and ψ_2. Finally, we assume a discount factor β of 0.98 and a constant coefficient of relative risk aversion of 1.5 (within the range of the estimates by Attanasio and Weber, 1995).

Other parameters. We set the net rate of return on savings to equal the average real return on three monthly T-bills at 0.015.

To summarize, Table 1 shows the list of calibrated parameters together with the targets used for their identification. Heterogeneity in the cost of working over the life-cycle helps us to be consistent with the decreasing path of employment after the age of 55. The price of child care that we calibrate implies that the child care cost for an infant is about 20% of an average worker's earnings in this economy. This is in line with the 20% reported by the OECD.[22] In regards to labor market experience, we estimate wages as a concave function of the number of years of labor market experience. Note that the gender difference in the evolution of wages over time that we estimate is important in accounting for the earnings gender gap in the model economy. In fact, according to our estimates, female earnings are likely to be 0.80

[20] According to the McClements scale, a childless couple is equivalent to 1.67 adults. A couple with one child is equivalent to 1.9 adults if the child is less than 3, to 2 adults if the child is between 3 and 7, 2.07 adults if the child is between 8 and 12, and 2.2 adults if the child is between 13 and 18.

[21] In particular, defined benefit holders tend to retire at early ages. See for instance Casanova (2010).

[22] See OECD family database Chart PF3.4.A: Childcare fees per two-year old attending accredited early-years care and education services, 2008.

Table 1: Calibration

Targets	Model	Data
Women's Employment Rate 25-29	0.43	0.41
Women's Employment Rate 40-44	0.70	0.70
Women's Employment Rate 55-59	0.65	0.62
Earnings Gender Gap (45-55)	0.54	0.54
$\hat{\gamma}_2$, Eckstein and Wolpin (1989)	0.02	0.02
$\hat{\gamma}_3$, Eckstein and Wolpin (1989)	-0.0003	-0.0002
Parameters		
ψ_1	0.0021	
ψ_2	1.5	
q	20,300	
y_0^f/y_0^m	0.59	
α_1^f	0.010	
α_2^f	-0.00014	

ψ_1 and ψ_2 are utility parameters, q is the price of each unit of child care, y_0^f/y_0^m is the initial exogenous earnings gender gap and α_1^f and α_2^f shape the effect of labor market experience on wages.

of male earnings by the age of 65 even if a woman has worked in every period. In addition, an initial female-to-male earnings ratio of 0.59 is needed to target the average female-to-male earnings of 0.54. Note that in the presence of positive self-selection of women in the labor market, as our model implies,[23] the exogenous gender earnings gap that we feed into the model (through both the effect of experience on wages and the initial gender earnings gap) is higher than the observed gender earnings gap. Interestingly, positive self-selection is consistent with evidence found by Olivetti and Petrongolo (2008).

3.3 The benchmark economy

Our aim in this section is to offer a comparison of the model economy with the data for several statistics that are relevant for the purposes of this paper. First in Figure 1 we show the full life-cycle employment profile of women born between 1944 and 1948 against the profile in our model economy. The profile

[23] In the simulations average earnings of working women are higher than average offered earnings at all ages.

in the data is smoother than that in the simulations because the amount of heterogeneity in terms of fertility histories that we are able to capture is limited. However, we believe that the model provides a reasonable representation of women's participation behavior over the life-cycle. The female employment rate increases up to the age of 45 and then stabilizes for several periods until the age of 55 when it drops smoothly to the age of 65. Interestingly, the rate of decrease in the employment rate is slightly attenuated between the claiming age and the normal retirement age. This may be related to the Earning Test and the progressivity of income tax. In particular, benefits withheld via the Earnings Test are credited to future benefits. Because the crediting formula is more or less actuarially fair for the *average* recipient, women, who live longer, may benefit from the Earnings Test, which would encourage them to work. In addition, after the early claiming age some women have husbands who have retired from the labor market, so the marginal income tax rate on female earnings is lower.

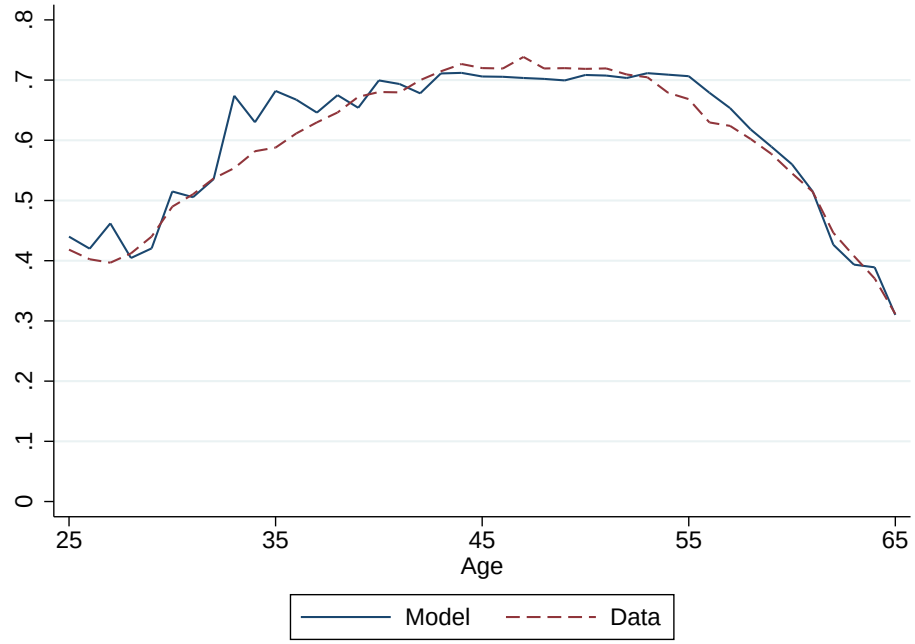

Figure 1: Female employment rate over the life-cycle

Second, in the first panel of Table 2 we report the distribution of the number of years of experience at the age of 60. Our model makes a reasonable job of accounting for the distribution of the number of years of experience. This is important because this distribution is a summary statistic of the behavior

of women over their life-cycle and is essential to determine their Social Security pension benefits.[24] Third, in regards to labor income, the second panel of Table 2 shows the earnings distribution for men and women in middle age (45 to 54). It is important to note that the male earnings distribution is exogenous, but the female earnings distribution is endogenous because of both the self-selection of women into the labor market and the returns on labor market experience that shape wages over the life-cycle. The different percentiles are fairly similar to what can be observed in the data, although there are some discrepancies at the bottom of the distribution. Finally, another important dimension in which our model has to be assessed is households' asset holdings relative to income. As reported in Table 3, the median assets across household income percentiles for households aged 55 to 64 vary in a similar fashion to those in the data, and are increasing with household income. Furthermore, the size of the asset holdings is similar to the data at all percentiles.

Lastly, we look at the distribution of Social Security pension benefits in table 4.[25] There are points worth noting. First, the distribution of male pension benefits is fairly similar to the data. Second, the fraction of women who are entitled to a Social Security pension as retired workers only is 0.67, slightly above the fraction observed in the data. Other women either only receive spousal pension benefit or they are dually entitled as retired workers and spouses.[26] Therefore, the fraction of women who are eligible for spousal benefit, either as their only source of income or as a supplement to their retired worker's pension, is substantial. Finally, we report the distribution of pension benefits for women who are entitled as retired workers exclusively and the distribution of pension benefits for other women. Female Social Security pension benefits in the model economy are fairly similar to those data.

All in all we believe that the model provides a satisfactory picture of what is observed in the data in terms of female labor market participation, earnings, assets and Social Security pension benefits, and, is therefore an appropriate framework for the policy assessment exercises presented in Section 4.

[24] The model however under predicts the amount of experience at the top of the distribution.

[25] It has to be taken into account that there is one source of discrepancy between the model and the data since data values are calculated including disability pensions that tend to be lower than *normal* retired worker's pensions. Unfortunately in the IPUMS-CPS survey those who receive a disability pension cannot be identified separately from other Social Security beneficiaries. According to the Social Security Administration in 2008, about 30% of Social Security beneficiaries aged 62 to 65 were receiving a disability pension. An average disabled worker's pension is about 9% lower than a *normal* retired worker's pension.

[26] Unfortunately in the data we cannot distinguish those women who receive a spousal pension benefit only from those who receive it as a supplement to their retired worker's pension.

Table 2: Distribution of experience and earnings in the benchmark economy

	Model	Data
Number of years of experience (women aged 60)		
5%	5	7
10%	10	13
25%	22	23
50%	31	33
75%	35	40
90%	36	44
95%	36	45
Earnings (workers aged 45 to 54)		
Husband		
25%	35,556	30,460
50%	45,472	49,636
75%	73,337	72,821
Wife		
25%	19,220	15,084
50%	27,100	27,346
75%	42,120	43,516

Data sources: RAND HRS Data Version N. IPUMS-CPS, 1962-2012 waves, 2008 US dollars. SIPP 2008, Core and Topical. 2008 US dollars.

Table 3: Median assets by income percentiles in the benchmark economy

	Model	Data
20%	101,546	113,450
40%	146,101	136,400
60%	203,140	202,722
80%	278,582	265,949
100%	475,844	460,399

Data sources: SIPP 2008, Core and Topical. 2008 US dollars. Households aged 55-64

Table 4: Distribution of pensions

	Model	Data
Men's percentiles:		
25%	12,883	11,676
50%	16,103	15,500
75%	20,155	18,537
Fraction of women entitled as workers	0.67	0.60
Women's percentiles (entitled as retired workers only):		
25%	9,117	8,043
50%	10,772	10,234
75%	14,081	13,248
Women's percentiles (other):		
25%	5,808	4,470
50%	7,463	6,809
75%	7,463	8,124

Data source: IPUMS-CPS, 1962-2012 waves. 2008 US dollars.

4 Policy Assessment

In this section we explore the effect of three different reforms of the public pension system in the US. First, we analyze the impact of removing spousal benefits (reform 1). Second, we remove both spousal and survivor pension benefits (reform 2) and study the effects. Finally, we increase from 35 to 40 the number of periods considered in calculating the AIME (reform 3). This last reform means that for individuals who have worked for only 35 periods at a constant wage the retired worker's pension would be reduced by about 12% if labor supply is kept constant. We close this section with a robustness analysis of the results to several of the assumptions in our benchmark economy.

4.1 The effect on employment

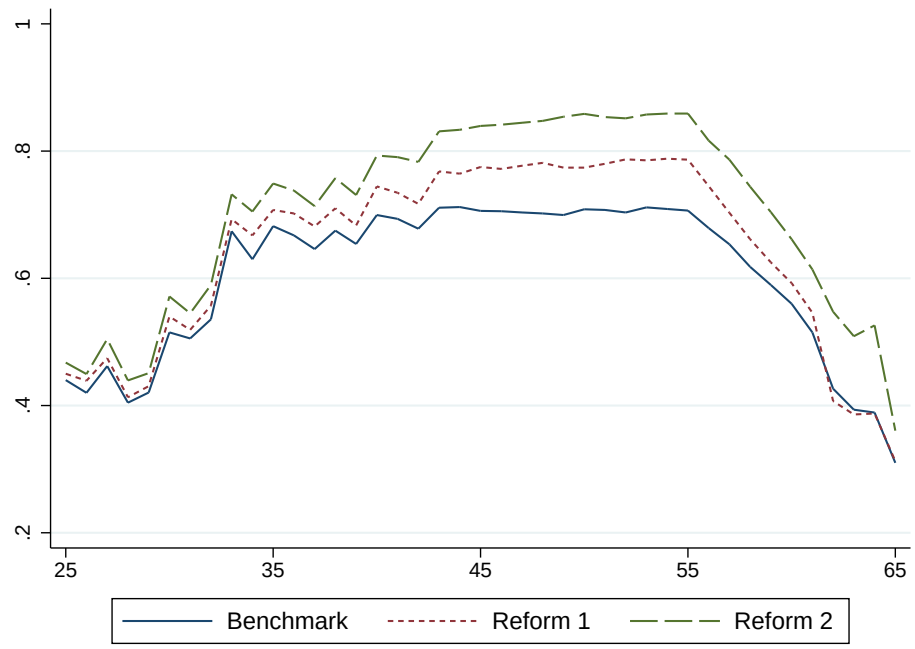

Figure 2: Life-cycle female employment rate

The very substantial impact of reforms 1 and 2 on the life-cycle employment profile is depicted in Figure 2. Table 5 reports the employment rate changes for different age groups. The largest effect of reform 1 is found in late middle age, in particular from 45 to 59, with an average increase of 7 percentage points within each age group. The effect is also strong within the 40 to 44 age group, with almost 5

Table 5: Change in employment rate with respect to the benchmark (percentage points)

	Reform 1	Reform 2	Reform 3
25-29	1.20	3.30	0.65
30-34	2.33	5.66	0.04
35-39	3.19	7.29	-0.02
40-44	4.69	10.74	0.20
45-49	7.26	14.21	0.16
50-54	7.49	14.80	0.16
55-59	5.49	13.27	0.40
60-65	0.62	10.41	0.53

Reform 1: removing spousal benefit, Reform 2: removing both spousal and survivor pension benefits and Reform 3: increasing the number of periods used in calculating the AIME from 35 to 40.

additional points of participation with respect to the benchmark. The employment rate among women younger than 40 shows a more moderate increase as a result of the reform but at about 2 percentage points the effect is not negligible. Obviously, the effect of reform 2 is larger in magnitude as it removes spousal and survivor pension benefits altogether. After the age of 40 the increase in the employment rate is about 13 percentage points on average. Noticeably, the effect is also substantial at younger ages, ranging from 3 percentage points at ages 25 to 29 to almost 11 percentage points at ages 40 to 44. In order to assess the magnitude of these effects it is important to note that as a result of reform 2, the average household's pension income would be reduced by 42% in the absence of any labor supply response. Furthermore, the elimination of the survivor pension benefit would leave women who are not eligible for a retired worker's pension with savings as the only insurance mechanism against lifetime uncertainty.[27]

[27]The predicted effects of the policy reforms that we find are larger than in Kaygusuz (2015), who predicts an increase in the female participation rate of 4.7 percentage points. Ignoring labor market uncertainty and returns to experience and focusing on a cohort of women who are more attached to the labor market than the one we consider in our benchmark calibration, are reasons for the smaller effect. In Nishiyama (2010) the effect on the female employment rate is about 1.5 percentage points on average, but the presence of single women in the economy reduces the aggregate effect of the policy. Furthermore, this paper also ignores returns to experience. Finally, in a recent paper by Groneck and Wallenius (2017) the predicted change of removing spousal and survivor pension benefits is of 7.8 percentage points in the married female employment rate (under the assumption that additional tax revenue is used for government consumption). Although these authors take into account returns to labor market experience, their focus is on younger women who are more attached to the labor market and they incorporate the risk of divorce into the analysis, which can potentially mitigate the effect of the policy reform.

To help understand the consequences of policy reforms 1 and 2 on employment, in Table 6 we investigate their impact across households conditional upon several characteristics. First, we consider exogenously given characteristics such as the age at which the first child arrives and the age at which the husband retires. The effects of the policy reforms are similar across households which have children at different ages and across households in which the husband retires from the labor market at different ages. It is interesting to note that the higher the female employment, the lower the husband's retirement age. This may suggests that if the husband's retirement age was endogenous, the effect on female labor supply could be dampened. Second, we classify households according to the type of entitlement of wives in the benchmark economy, which is an endogenous outcome. We distinguish between the group of women who are entitled as retired workers only and the group of women who are either dually entitled or entitled as spouses only. Not surprisingly, we observe that the effect of the policy reforms is very different across these two groups (with an increase of 5 percentage points after reform 2 for the first group and an increase of 21 percentage points for the second group). Although the effect of the reforms is small among women in the first group, it is positive. The positive impact for this group is related to the presence of uncertainty in the economy, where the elimination of the *minimum pension* for second earners (that the spousal benefit guarantees) fosters female labor supply. However, the effect is very large among women who belong to the second group. This group of women has a strong incentive to increase participation in order to be eligible for a worker's Social Security pension benefit. Their average experience at claiming age increases from 6 to 10 in the case of reform 1 and from 6 to 14 in the case of reform 2. As Table 7 reports, the strongest effect of the policy reforms are found in late middle age.

All in all the effect on the female employment rate of reforms 1 and 2 is sizeable, with an average increase of 4 percentage points in the case of reform 1 and 10 percentage points in the case of reform 2. Furthermore, the effect is visible at all ages. Hence we conclude that the consideration of a full life-cycle model is important for assessing the elimination of spousal and survivor pension benefits, which are currently important provisions of the public pension system in the US.

Finally, we explore the impact of extending from 35 to 40 the number of periods to be considered in calculating the AIME. As reported in the last column of Table 5 this type of reform has a mild effect of less than 1 percentage point on the female employment rate. The effect is more visible at the beginning and end of the life-cycle.

Table 6: Employment rate by different household characteristics

	Benchmark	Reform 1	Reform 2
All	0.60	0.64	0.70
Age on having first child			
young	0.63	0.67	0.73
old	0.57	0.62	0.68
Husband's retirement age			
62	0.62	0.66	0.71
63	0.61	0.65	0.71
64	0.61	0.66	0.72
65	0.57	0.61	0.68
66	0.56	0.60	0.68
Woman entitled as			
retired worker only	0.83	0.84	0.88
spousal beneficiary	0.14	0.24	0.35

4.2 The effect on inequality

The implications of the reforms analyzed here go beyond their effect on the female employment rate. Table 8 shows the effect of the policy reforms on several other statistics for households aged 66 and older. The average female benefit decreases from 13,349 in the benchmark economy to 11,685 in the economy without spousal benefits. As a result, the average household's Social Security income also decreases. This is obviously due to the fact that married women who are not eligible for a retired worker's pension are not receiving any benefits from Social Security. Furthermore, as a result of the increase in the employment rate, there are more women eligible for retired worker's pensions (the fraction goes from 67% to 83%), but these are on average less productive than the women who were already eligible in the benchmark economy. The further removal of survivor pension benefit reduces the average female benefit to 9,734. Note that the elimination of the survivor pension benefit increases the fraction of women who are eligible for a retired worker's pension to 89%, but still leaves some women with no public pension, during marriage and widowhood. Of course the negative direct effect of this pension reform on the average pension dominates the positive effect of the slight increase in the average years of

Table 7: Employment rate before and after the reforms by type of entitlement in the benchmark

	Benchmark	Reform 1	Reform 2
Entitled as retired worker only			
25-29	0.57	0.59	0.61
30-34	0.78	0.80	0.83
35-39	0.90	0.92	0.95
40-44	0.94	0.97	0.98
45-49	0.96	0.98	0.99
50-54	0.97	0.98	0.99
55-59	0.92	0.92	0.95
60-65	0.63	0.62	0.74
Entitled as spousal beneficiary			
25-29	0.13	0.14	0.17
30-34	0.15	0.18	0.22
35-39	0.18	0.23	0.31
40-44	0.20	0.29	0.44
45-49	0.18	0.36	0.55
50-54	0.18	0.39	0.58
55-59	0.10	0.27	0.43
60-65	0.03	0.06	0.13

Table 8: The effect on pensions and inequality

	Benchmark	Reform 1	Reform 2	Reform 3
Average women's pension	13,349	11,685	9,734	11,922
Fraction of women entitled as workers	0.67	0.83	0.89	0.66
Average household's Social Security income	23,316	22,487	19,971	22,456
Gini Index of household's Social Security income	0.1765	0.1704	0.2935	0.1789
Average household's consumption	40,614	40,639	40,479	40,262
Gini Index of household's consumption	0.2285	0.2258	0.2409	0.2298
Average household's wealth	185,389	192,918	242,805	191,271
Gini Index of household's wealth	0.4633	0.4611	0.4207	0.4766

Households aged 66 and older.

experience of eligible women, which goes up from 29 in the benchmark to 30 after reform 1 and to 31 after reform 2.[28] Finally, as can be seen in the fourth row of the Table, reform 2 has a dramatic effect on the household's pension income inequality with the Gini index going from 0.1765 in the benchmark to 0.2935. However, the impact on the household's consumption inequality is much more moderate (the Gini index goes up from 0.2285 to 0.2409) and it is noticeable that the average household's consumption for the elderly remains pretty stable. The interpretation of this result is that households use assets to smooth consumption over their life-cycle. Finally, the average household's wealth increases substantially, in particular after reform 2. The increase in wealth is uneven across households as reflected on the decrease of the Gini index of wealth.

4.3 The effect on public expenditure and fiscal revenues

Finally, Table 9 reports the impact of each reform on Social Security expenditure and on fiscal revenues. As expected, the reduction in Social Security expenditure is very sizeable in the case of all three reforms. In addition, Social Security revenues and income tax revenues increase as a result of the increase in labor supply that the policy reforms imply (with the exception of reform 3 where the effects on employment are found to be negligible). The increase in Social Security revenues goes from 1.2% after reform 1 to 3.3% after reform 2, whereas revenues from income tax go up by 1.9% as a result of reform 1 and by

[28] Having more years of experience positively affects the AIME (and therefore the pension benefit), directly through the number of periods considered in computing it and indirectly through higher wages.

Table 9: Variation in expenditure and revenues (percentage change)

	Reform 1	Reform 2	Reform 3
Social Security expenditure	-3.1	-11.0	-3.8
Social Security revenues	1.2	3.2	0.0
Income tax revenues	2.0	5.0	0.0

4.9% as a result of reform 2.

4.4 Robustness analysis

In this section we provide a discussion of several assumptions of our analysis that may affect the results of the policy experiments that we undertake.

Claiming age. We assume in our benchmark economy that the public pension claiming age is exogenous at 62. In order to assess the robustness of our results to this assumption, we show the effect of the three policy reforms under the alternative assumption of an exogenous claiming age of 66 in Table 11 of Appendix C. The magnitude of the changes in the female employment rate in response to the elimination of the spousal and the survivors pension benefits or to the increase from 35 to 40 of the number of periods considered to calculate the AIME is of similar size to that in our benchmark economy.

Younger cohorts. As explained in section 3 we target a cohort of women for which we observe the complete labor market history and several statistics related to their Social Security benefits. One concern with our analysis may be that the effect of the reforms that we analyze may be smaller among younger cohorts of women that tend to be more attached to the labor market. As discussed in the Introduction, the literature exploring the causes of changes in female labor participation is large. Several studies find that lower child care costs, larger returns to experience, a lower gender wage gap and a higher divorce rate are among the driving forces of the trend in female labor supply over the last few decades in the US. In order to assess what would be the effect of the policy reforms that we analyze here on the participation of younger cohorts of women we implement a reduction of child care costs, an increase in the returns to experience and an increase in the exogenous gender wage gap with respect to our benchmark economy

such that the life-cycle employment profile and the gender earnings gap are similar to those observed for the cohort of women born in 1964-68.[29] As a result of the higher female labor market attachment, the fraction of women who are entitled as workers goes up from 67% in the case of the 1944-49 cohort to 74% in the case of the 1964-1968 cohort. This figure is close to the 71-75% projections in Butrica and Smith (2012). Within this new scenario we compute what would be the effect of the policy reforms and report them in Table 12 of Appendix C. The effect of the reforms is moderately smaller than the one computed for the cohort of women born in 1944-48. The female employment rate increases by 8.6 percentage points, instead of 10. The similarity of the results may be related to the fact that differences in employment between the two cohorts are much more pronounced at early ages than at later ages, together with the fact that the strongest effect of the policy reform is found precisely at those later ages.

Never-married women and the risk of divorce. Our focus in this paper is only on married women, but one may be concerned with the fact that the fraction of women who remain single over their entire life has increased substantially over time. Obviously, the aggregate effect of the reforms we study here would be smaller the higher the fraction of never-married women, since the elimination of the spousal and survivor benefits are expected to have no effect on them. However, according to Butrica and Smith (2012b) the fraction of never married women at the age of 70 is projected to increase from 6% among the *leading boomer*s (1946-1955) to 10% among *GenXers* (1966-1975). Therefore, even among recent cohorts, the fraction of never-married women is moderate. Finally, the incidence of divorce has increased substantially among the population. In spite of that, remarriage is very frequent and according to Butrica and Smith (2012b) the projected fraction of divorced women at the age of 70 is around 20% for both of the aforementioned cohorts.[30] More importantly, according to these authors, the percentage of divorced women at the age of 70 who have at least one marriage that lasted at least 10 years[31] is projected to be stable at around 70%.[32] All in all, we believe that the effect of the policy reforms would remain substantial in a scenario in which marital status uncertainty is considered, but we leave that

[29] In particular we implement a 50% increase in the returns to experience, similar to Fernández and Wong (2014), a reduction of the child care cost to target the 66% employment rate of the 1964-68 cohort at ages 25-29 and a decrease in the exogenous gender wage gap to target the ratio of male earnings relative to female of 0.62.

[30] The fraction of divorced women at the age of 70 increases from 16% in *war babies* (1936-1945) to 20% in the *leading boomers* (1946-55).

[31] Divorced women who were married for at least 10 years are eligible for the spousal and survivor pension benefit.

[32] This figure went down from 80% in *war babies* (1936-1945) to 70% in *leading boomers* (1946-55).

analysis for future research.

5 Conclusions

In this paper we use a partial equilibrium life-cycle model of household savings and female labor market participation decisions to assess several reforms of the US Social Security pension system. In our model individuals face earnings uncertainty as well as lifetime uncertainty. In addition, a distinctive feature is that returns on labor market experience operate so participation decisions affect not only current earnings and Social Security pension benefits but also future earnings. Within this framework we assess the effect of removing spousal benefit, removing spousal and survivor pension benefits altogether and extending from 35 to 40 the number of periods of the working career that are considered in calculating the retired workers' Primary Insurance Amounts. Our focus is on the effects of these reforms on the female full life-cycle participation profile. We find that the effect is very substantial after the age of 40, but is also sizeable before that age. Average participation increases by 4 percentage points when spousal benefit is eliminated and by 10 percentage points when both spousal and the survivor pension benefits are taken away. The extension from 35 to 40 in the number of periods that are considered in calculating a retired workers' Primary Insurance Amounts has a negligible effect on the female employment rate. Finally, although removing spousal and survivor pension benefits dramatically increases Social Security income inequality there is only a small increase in consumption inequality because households use savings to smooth consumption over the life-cycle. All three of the reforms that we analyze substantially reduce Social Security expenditure and reforms 1 and 2 both produce an important increase in fiscal revenues.

References

[1] Albanesi, S. and C. Olivetti (2016) "Gender Roles and Medical Progress," *Journal of Political Economy* 124 (3), pages 650-695.

[2] Attanasio, O., Low, H. and V. Sánchez-Marcos (2008) "Explaining Changes in Female Labor Supply in a Life-Cycle Model," *American Economic Review*, 98 (4), pages 1517-1552.

[3] Attanasio, O. and G. Weber (1995) "Is Consumption Growth Consistent with Intertemporal Optimization? Evidence from the Consumer Expenditure Survey," *Journal of Political Economy*, 103 (6), pages 1121-1157.

[4] Blau, F.D.(1997)"Social Security and the labor supply of older married couples," *Labor Economics* 4, 373-418.

[5] Blau, F.D. and L.M. Kahn (2013) "Female Labor Supply: Why is the US Falling Behind?," *American Economic Review*, 103 (3), pages 251-256.

[6] Blundell, R., E. French and G. Tetlow (2017) "Retirement Incentives and Labor Supply". Handbook of the Economics of Population Aging, Chapter 1, Vol 1B, Elsevier. Eds A. Woodland and J. Piggott.

[7] Burman, L., N. Coe, K. Pierce and L. Tian (2014) "The effects of the taxation of Social Security benefits on older workers's income and claiming decisions". National Tax Journal, 67(2), pp. 459-486.

[8] Butrica, B.A. and E. K. E. Smith (2012) "The Impact of Changes in Couples Earnings on Married Womens Social Security Benefits". Social Security Bulletin, Vol. 72, No. 1.

[9] Butrica, B.A. and E. K. E. Smith (2012b) "The Retirement Prospects of Divorced Women". Social Security Bulletin, Vol. 72, No. 1.

[10] Casanova, M. (2010) "Happy Together: A Structural Model of Couples' Joint Retirement Choices," unpublished.

[11] Child Care Aware of America (2012), Child Care in America, State Fact Sheets.

[12] Danforth, J.P. (1979) "On the Role of Consumption and Decreasing Absolute Risk Aversion in the Theory of Job Search. In Studies in the Economics of search, Ed. S. A. Lippman and J. J. McCall, 10931. New York: New-Holland.

[13] Domeij, D. and P. Klein (2013) "Should Day Care be Subsidized?," *Review of Economic Studies*, 80 (2), pages 568-595.

[14] Eckstein, Z. and O. Lifshitz (2011) "Dynamic Female Labor Supply," *Econometrica*, 79 (6), pages 1675-1726.

[15] Eckstein, Z. and K.I. Wolpin (1989) "Dynamic Labour Force Participation of Married Women and Endogenous Work Experience," *Review of Economic Studies*, 56 (3), pages 375-390.

[16] Erosa, A., Fuster, L. and G. Kambourov (2012) "Labor supply and government programs: A cross-country analysis," *Journal of Monetary Economics*, 59 (1), pages 84-107.

[17] Erosa, A., Fuster, L. and D. Restuccia (2010) "A General Equilibrium Analysis of Parental Leave Policies," *Review of Economic Dynamics*, 13 (4), pages 742-758.

[18] Fernández, R. and J. Wong (2014) "Divorce Risk, Wages, and Working Wives: A Quantitative Life-Cycle Analysis of Female Labor Force Participation," *The Economic Jounal*, 124, pages 319358

[19] French, E. (2005) "The Effects of Health, Wealth, and Wages on Labour Supply and Retirement Behaviour," *Review of Economic Studies*, 72 (2), pages 395-427.

[20] French, E. and J. Jones (2012) "Public pensions and labor supply over the life cycle," *International Tax and Public Finance*, 19 (2), pages 268-287.

[21] Goldin, C. and L.F. Katz (2002) "The Power of the Pill: Oral Contraceptives and Women's Career and Marriage Decisions," *Journal of Political Economy*, 110 (4), pages 730-770.

[22] Greenwood, J., Seshadri, A. and M. Yorukoglu (2005) "Engines of Liberation," *Review of Economic Studies*, 72 (1), pages 109-133.

[23] Groneck, M. and J. Wallenius (2017) "It sucks to be single! Marital status and redistribution of Social Security". SSE Working Papaer Series in Economics 2017:1.

[24] Guner, N., Kaygusuz, R. and G. Ventura (2012) "Taxation and household labor supply," *Review of Economic Studies*, Volume 79, No 3, 11131149.

[25] Guner, N., Kaygusuz, R. and G. Ventura (2014) "Income taxation of U.S. households: Facts and parametric estimates," *Review of Economic Dynamics*, 17, 55958

[26] Guvenen, F. and M. Rendall (2015) "Women's Emancipation through Education: A Macroeconomic Analysis," *Review of Economic Dynamics*, 18(4), pages 931-956.

[27] Haaga, O. and R.W. Johnson (2012) "Social Security claiming: Trends and Business Cycle Effects," The Program on Retirement Policy, Discussion Paper 12-01.

[28] Hugget, M., Ventura, G. and A. Yaron (2011) "Sources of Lifetime Inequality," *American Economic Review*, 101 (7), pages 2923-2954.

[29] Hyslop, D.R. (2001) "Rising U.S. Earnings Inequality and Family Labor Supply: The Covariance Structure of Intrafamily Earnings," *American Economic Review*, 91 (4), pages 755-777.

[30] İmrohoroğlu, S. and S. Kitao (2012) "Social Security, benefit claiming, and labor force participation: a quantitative general equilibrium approach," *American Economic Journal: Macroeconomics* 2012, 4(3): 96127.

[31] Jiménez-Martín, S. and Sánchez-Martín (2007)" An evaluation of the life-cycle effects of minimum pensions on retirement behavior," *Journal of Applied Econometrics*, 22(5), 923-950.

[32] Jones, J.B. and Y. Li (2017) "The effects of collecting income taxes on Social Security benefits", Federal Reserve Bank of Richmond WP 17-02.

[33] Kaygusuz, R. (2015) "Social security and two-earner households," *Journal of Economic Dynamics and Control*, 59, pages 163-178.

[34] Low, H., Meghir, C. and L. Pistaferri (2010) "Wage Risk and Employment Risk over the Life Cycle," *American Economic Review*, 100 (4), pages 1432-1467.

[35] Low, H. and Sánchez-Marcos, V. (2015) "Female labour market outcomes and the impact of maternity leave policies," *IZA Journal of Labor Economics*,4:14.

[36] Nishiyama, S. (2010) "The Joint Labor Supagesy Decision of Married Couples and the Social Security Pension System," Working Papers No. 229, University of Michigan, Michigan Retirement Research Center.

[37] OECD (2011) "Pensions at a Glance. Retirement-Income Systems in OECD and G20 Countries".

[38] Olivetti, C. and B. Petrongolo (2008) "Unequal Pay or Unequal Employment? A Cross-Country Analysis of Gender Gaps," *Journal of Labor Economics*, 26 (4), pages 621-654.

[39] Pistaferri, L. and H. Low (2015) "Disability Insurance and the Dynamics of the Incentive-Insurance Trade-off". *American Economic Review* , 105(10), pages 2986-3029.

[40] Ruhm, C. (1998) "The Economic Consequences of Parental Leave Mandates: Lessons from Europe," *The Quarterly Journal of Economics*, 113 (1), pages 285-317.

[41] Rust, J. and C. Phelan (1997) "How Social Security and Medicare Affect Retirement Behavior in a World of Incomplete Markets," *Econometrica*, 65 (4), pages 781-832.

[42] van der Klaauw, W. and K. Wolpin (2008) "Social security and the retirement and savings behavior of low-income households," *Journal of Econometrics*, 145 (1-2), pages 21-42.

[43] Waldfogel, J. (1998) "The Family Gap for Young Women in the United States and Britain: Can Maternity Leave Make a Difference?," *Journal of Labor Economics*, 16 (3), pages 505-45.

[44] Wallenius, J. (2013) "Social security and cross-country differences in hours: A general equilibrium analysis," *Journal of Economic Dynamics and Control*, 37 (12), pages 2466-2482.

Appendix A

In this Appendix we describe the solution method for the model economy used in our analysis.

Households have a finite horizon, so the model is solved numerically by backward recursion from the terminal period. At each age we solve the value function and optimal policy rule, given the current state variables and the solution to the value function in the next period. This approach is standard. The complication in our model arises from the combination of a discrete choice (whether or not to participate) and a continuous choice (on savings). This combination means that the value function is not necessarily concave. In addition to age, there are four state variables in this problem: asset stock (a_t), the permanent component of earnings of the husband, the permanent component of earnings of the wife (v_t) and the experience level of the wife (x_t). However, after the claiming age (and before the age at which retirement is compulsory) three additional state variables are needed in order to solve the household's problem: female public pension benefit (b_t^f), the number of periods for which the female retired worker's pension is withheld and the number of periods for which spousal benefit is withheld as a result of the Earnings Test (s_t). Due to computational restrictions it is not feasible to keep track of all these state variables so we adopt the simplifying assumption that, after the exogenously given claiming age of 62, there is no labor market uncertainty. Under this assumption the number of state variables needed is reduced since the permanent component of female earnings at the claiming age and the other state variables (in particular x_t and s_t) can be used both to calculate earnings and to calculate the pension benefit in each period after 62.

We discretize income variables and the experience level, leaving the asset stock as the only continuous state variable. Since both permanent components of earnings are non-stationary, we can approximate it by a stationary, discrete process only because of the finite horizon of the process. We select the nodes to match the paths of the mean shock and the unconditional variance over the life-cycle. In particular, the unconditional variance of the permanent component must increase linearly with age, with the slope given by the conditional variance of the permanent shock.

Value functions are increasing in assets (a_t) but they are not necessarily concave, even if they are made conditional on labor market status in t. The non-concavity arises because of changes in labor market status in future periods: the slope of the value function is given by the marginal utility of consumption, but this is not monotonic in asset stock because consumption can decline as assets increase and expected labour market status in future periods changes. By contrast, in Danforth (1979) employment is an absorbing state, so the conditional value function is concave. Under certainty, the number of kinks in the conditional value function is given by the number of periods of life remaining. If there is enough uncertainty, then changes in work status in the future will be smoothed out leaving the expected value function concave: whether or not an individual will work in $t+1$ at a given a_t depends on the realization of shocks in $t+1$. Using uncertainty to avoid non-concavities is analogous to the use of lotteries elsewhere in the literature. This problem is also discussed in Attanasio, Low and Sánchez-Marcos (2008), Low, Meghir and Pistaferri (2010) and Low and Pistaferri (2015), among others. The choice of participation status in t is determined by the maximum of the conditional value functions in t. In solving the maximization problem at a given point in the state space, we use a simple golden search method.

Appendix B

This Appendix provides a detailed description of the approximation used for each individual AIME. As we explained in Section 2, we approximate the AIME as a function of earnings in the last working period and the number of years of contribution to the pension system. More specifically, for each period we calculate fictitious earnings based on the stochastic component of earnings at the claiming age (which we denote here by t^m_{cl} and t^f_{cl} for men and women respectively).[33] There is however a drawback of relying

[33]This is similar to the approach in Low and Pistaferri (2015).

on the last working period stochastic component of the earnings because the nature of the stochastic process that we assume means that the variance in earnings is increasing over the life cycle. In order to deal with this, we proceed in slightly different ways approximating the AIME for men and women. In the case of men we make the $\widehat{AIME}^m$ a function of the average of the fictitious earnings over the last N working periods

$$\ln \widehat{AIME}^m = \gamma_1^m + \gamma_2^m \ln \sum_{k=1}^{N} \frac{exp(\ln y_0^m + \alpha_1^m (t_{cl}^m - k) + \alpha_2^m (t_{cl}^m - k)^2 + v_{t_{cl}^m - 1}^m)}{N} \tag{12}$$

with $v_{t_{cl}^m - 1}^m$ being the stochastic component of earnings in the last working period. The parameters γ_1^m and γ_2^m are the estimated coefficients of a linear regression of $\ln AIME^m$ (true AIME) on the average of the last N working periods fictitious earnings in the simulated data.

In the case of women, who may have a number of periods of contribution of $x_{t_{cl}^f} < N$, we use a different formula to prevent the effect of periods with zero earnings on the approximated AIME being smoothed out (as would happen if we used the formula above). In fact, it is very important for our analysis to capture incentives to work through the AIME. Therefore we calculate the $\widehat{AIME}^f$ as follows

$$\ln \widehat{AIME}^f = \frac{\sum_{k=1}^{min(N, x_{t_{cl}^f})} exp(\ln y_0^f + \alpha_1^f (x_{t_{cl}^f} - k) + \alpha_2^f (x_{t_{cl}^f} - k)^2 + exp(\gamma_1^f + \gamma_2^f \ln v_{t_{cl}^f - 1}^f))}{N} \tag{13}$$

where in this case γ_1^f and γ_2^f are the estimated coefficients of a linear regression of the log of the average of the stochastic component of earnings over the working career on the log of its value in the last working period $v_{t_{cl}^f - 1}^f$ in the simulated data.

The parameter values that we estimate for the approximation are $\gamma_1^m = 2.47$, $\gamma_2^m = 0.78$, $\gamma_1^f = 0.93$ and $\gamma_2^f = 0.67$. Note that we need to solve the model and iterate in these parameters so that individual decisions are based on the formula that uses parameter values that are consistent with the simulated data.

To assess the accuracy of our approximations in Table 10 we compare the distribution of the true

Table 10: Accuracy of AIME approximation

	True	Approximation
Men's Percentiles:		
1%	16,122	16,775
5%	20,089	20,589
10%	23,729	24,929
25%	32,583	35,773
50%	48,089	44,510
75%	70,618	64,866
90%	96,950	93,083
95%	116,558	112,702
100%	146,817	137,514
Women's Percentiles:		
1%	4,996	4,714
5%	7,736	7,411
10%	9,942	9,559
25%	15,244	15,680
50%	23,530	23,369
75%	35,778	35,281
90%	48,916	45,687
95%	57,935	55,162
100%	70,957	68,975

$AIME^g$ and the distribution of $\widehat{AIME}^g$, with $g = \{f, m\}$, in the simulated data. We believe that the approximation is satisfactory.

Appendix C

In this Appendix we report the effect of the policy reforms in two alternative scenarios to our benchmark economy that we discussed in section 4.4. First, in Table 11 we show the changes in employment rates by age under the assumption that claiming age is 66 instead of 62. Second, in Table 12 we present what the variation in employment rates would be for a younger cohort of women with higher attachment to the labor market.

Table 11: Change in employment rate with respect to the benchmark (percentage points)
Claiming Age at 66

	Reform 1	Reform 2	Reform 3
25-29	1.28	3.36	0.62
30-34	2.38	5.79	0.07
35-39	3.35	7.32	-0.08
40-44	4.83	10.68	0.17
45-49	7.26	14.39	0.28
50-54	7.76	14.96	0.15
55-59	5.43	13.56	0.45
60-65	0.62	10.60	0.88

Reform 1: removing spousal benefit; Reform 2: removing both spousal and survivor pension benefits and Reform 3: increasing the number of periods used in calculating the AIME from 35 to 40.

Table 12: Change in employment rate with respect to the benchmark (percentage points)
Cohort 1964-68

	Reform 1	Reform 2	Reform 3
25-29	1.98	4.65	0.80
30-34	2.42	5.28	0.08
35-39	3.12	6.63	0.00
40-44	3.73	8.78	0.24
45-49	5.11	10.52	0.17
50-54	5.35	11.88	0.12
55-59	4.08	10.97	0.59
60-65	0.53	9.90	0.42

Reform 1: removing spousal benefit; Reform 2: removing both spousal and survivor pension benefits and Reform 3: increasing the number of periods used in calculating the AIME from 35 to 40.