

Home Production and Social Security Reform*

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Abstract

This paper incorporates home production and endogenous retirement into a dynamic general equilibrium model of overlapping generations to study Social Security reforms. Home production takes as input not only labor but also consumption good including housing. The model parameters including those that govern households' preferences are calibrated to match consumption and labor moments calculated from micro data. We find that eliminating the current pay-as-you-go Social Security system in such a framework has important implications on both labor supply and consumption. Specifically, without Social Security benefits households work much more in the market especially at old age. Young households on the other hand engage more in home production. Households also consume much more housing services especially early in the life cycle than other market-produced goods. We then investigate a similar framework without home production and find that eliminating Social Security benefits generates higher welfare gains in the presence of home production. Finally, we contrast our model to a one-asset economy without home production. We show that the one-asset economy does a relatively poor job of matching the consumption profile. Moreover, the welfare gains of eliminating social security are significantly lower than both the benchmark economy and the economy with two assets but no home production, suggesting that both margins are important.

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1 Introduction

The significant challenges facing the unfunded U.S. Social Security have led to a large macroeconomic literature analyzing the implications of a variety of Social Security reforms. The models used for this purpose are quite diverse and include features such as altruism,¹ liquidity constraints, longevity and individual income risks,² the separation of labor participation and hours worked (Prescott, Rogerson, and Wallenius 2009), endogenous benefits claim (Imrohoroglu and Kitao 2009, 2010), and housing (Chen 2010). This paper makes an important contribution to this literature by incorporating home production into a general equilibrium model of overlapping generations with endogenous labor supply. We find that a carefully calibrated model with home production better matches life cycle consumption and labor profiles and is, therefore, a more reliable setting for analyzing the effects of various reforms to Social Security. We show that including home production produces much larger long-run welfare gains in response to a reduction in Social Security benefits and the associated distortionary taxes needed to fully fund the program than those in an economy without home production.

A key way in which models with home production differ from standard dynamic general equilibrium models is that home production allows households to substitute between additional margins, both in labor supply (market hour versus home hour) and in consumption (market-produced good versus home-produced good). Recent research have proven these margins important in households' labor supply and consumption decisions. For example, Rogerson (2009) shows that introducing home production in a standard labor supply model implies that differences in tax and transfer systems can explain one quarter of the differences in hours of work across countries. Rogerson and Wallenius (2009) demonstrate that home production alone is qualitatively capable of generating retirement. Aguiar and Hurst (2009, 2010) suggest that home production play an important role in understanding the behavior of consumption at retirement. Dotsey, Li, and Yang (2010) extend a standard consumption model to include home production and show that home production indeed is crucial in matching households' consumption of different goods and labor supply over the life cycle.³

¹These papers include Abel (1985, 1986), Laitner (1988), Altig and Davis (1993), Michel and Pestieau (1998), Fuster (1999), Caballe and Fuster (2000), Fuster, Imrohoglu, and Imrohoglu (2003, 2007), and Yang (2010).

²These features were first introduced by Hubbard and Judd (1987) and followed up by Imrohoroglu, Imrohoroglu, and Joines (1995), and Cooley and Soares (1999), among many others.

³The incorporation of home production in otherwise standard macro models has also proven useful in understanding a variety of macroeconomic issues, including domestic and international business cycles, fiscal policies, and asset equilibrium puzzles (Baxter and Jermann 1997, Benhabib, et al. 1991, Bils, et al. 2009, Campbell and Ludvigson 2001, Canova and Ubide 1998, Gomme, et al. 2001, Greenwood and Hercowitz 1991, Greenwood, et al. 1995, and McGratten, et al. 1997).

As is standard in the home production literature, we assume that home production takes residential capital stock which we term housing, intermediate market good, and home hours to produce a home good that is substitutable with the market good and leisure. Instead of mixing housing and the intermediate market good, however, we model them separately. More importantly, we allow households' preference over different goods and leisure and their home production technology to take flexible functional forms that exhibit constant elasticity of substitution and calibrate the preference parameters according to micro data on consumption and time use. Finally, we endogenize households' decision to claim Social Security benefits along the lines of Kitao and Imrohroglu (2011) and capture many realistic features of Social Security system such as linking households Social Security benefits with their past earnings and claimant age.

Our analyses reveal that households' preference over the home-produced good, the market-produced good, and leisure are not additively separable. In particular, the home good is substitutable with market good and the composite home and market good exhibits Hicksian substitutability with leisure. Furthermore, housing services and intermediate home input are substitutes in home production but the composite of housing services and home input complements home hours in the production of home goods. These parameterizations generate household life cycle consumption and labor supply profiles that are consistent with those estimated from the micro data.

With these parameterization, we conduct a policy experiment where we eliminate Social Security benefits completely and compute changes in steady state levels of labor hours, consumption, and welfare. We show that both labor hours and total consumption respond strongly to the elimination. In particular, market hours move up sharply (6.2 percent) while leisure comes down significantly (-1.5 percent). Home hours change little (0.4 percent). In terms of consumption, housing experiences the most increase (17.1 percent), followed by the market good (3.4 percent) and then the home input (0.6 percent). Furthermore, the steady state welfare gains, at 19.1 percent, are 3 percentage points larger than the welfare gains of eliminating Social Security in an economy without home production.

Two key channels drive the results above. First, elimination of Social Security increases precautionary savings and saving for retirement, which raises the steady state capital stock, leading to an reduction in the steady state interest rate. As the cost of housing services declines, consumption of housing services increases which in turn drives up hours in home production. Second, elimination of the payroll tax on market labor induces people to substitute away from home production and into market production. This substitution effect, however, is offset by the positive wealth effect coming from higher wages and the fact that there is more housing making home production more

productive after the reform. Note that in our benchmark economy, because housing complements home hours in home production, the consumption of housing is to some extent constrained by the supply of home hours.

The rest of the paper is organized as follows. In section 2, we describe the model economy. In section 3, we present model calibration. In section 4, we conduct the experiment of eliminating Social Security. In section 5, we recalibrate the model without home production and conduct the same policy experiment. Section 6 concludes.

2 The Model Economy

Our model economy follows Dotsey, Li, and Yang (2010) with two exceptions. Social Security benefits now depend on households' average life time earnings and households choose when to claim for the benefits as in Imrohorglu and Kitao (2009). Adding this important degree of realism to the model requires an additional state variable, so for computational reasons we eliminate owner-occupied housing and instead treat all housing in the economy as rental. As is shown in Chen (2010), this simplification on housing is not likely to affect our results noticeably.

2.1 Demographics

The economy is populated by overlapping generations of households of age $t = 1, 2, \dots, T$, where T is the maximum possible age. The life span is uncertain and households of age t faces an exogenous probability of survival, λ_t , where $0 \leq \lambda_t \leq 1$. Since the demographic patterns are stable, agents at age t make up a constant fraction of the population at any point in time. Annuity markets are assumed to be absent and accidental bequests are distributed to all households in the economy.

2.2 Preferences and Home Production

Households value consumption of a composite good c that consists of a market-produced nondurable good, c_m , and a home-produced good, c_h , and leisure, l . Preferences are assumed to be time separable, with a constant discount factor β .

The home good is produced by home production that requires an intermediate home

input, housing, and labor. In particular,⁴

$$(1) \quad c_h = f^{our}(d, s, n_h) = \{\omega_2[\omega_1 d^{1-\frac{1}{\zeta_1}} + (1-\omega_1)s^{1-\frac{1}{\zeta_1}}]^{1-\frac{1}{\zeta_2}} + (1-\omega_2)(n_h)^{1-\frac{1}{\zeta_2}}\}^{\frac{1}{1-\frac{1}{\zeta_2}}},$$

where d denotes the intermediate home input, s denotes the rental stock, and n_h the labor input in home production. We assume that rental is the only way of consuming housing services in this economy. The parameters ω_1 and ω_2 control the weights associated with the intermediate home input and housing, and in turn the weight associated with the resulting composite good and hours used in home production. ζ_1 governs the intra-class substitutability between the home intermediate input and housing, and ζ_2 governs the inter-class elasticity of substitution between the composite home input and hours used in home production.⁵

The period utility function is given by

$$(2) \quad U(c, l) = \frac{[\omega_4 c^{1-\frac{1}{\zeta_4}} + (1-\omega_4)l^{1-\frac{1}{\zeta_4}}]^{1-\frac{\gamma}{\zeta_4}} - 1}{1-\gamma},$$

where

$$(3) \quad c = [\omega_3 c_m^{1-\frac{1}{\zeta_3}} + (1-\omega_3)c_h^{1-\frac{1}{\zeta_3}}]^{1-\frac{1}{\zeta_3}}.$$

The term ω_4 represents the relative weight of the composite consumption good in utility, ζ_4 represents the degree of substitution between the composite consumption good and leisure, γ denotes the relative risk aversion parameter, ω_3 denotes the relative weight of the market good in the composite consumption good, and ζ_3 measures the degree of substitution between the market good and the home-produced good.

Two features of our model are unique to the literature on Social Security and we seek to better understand the importance of these features for Social Security reform. The first and the most important is the introduction of home production which allows households to substitute between market and nonmarket activities. The second is the modeling of housing. Chen (2010) studies Social Security reforms with housing. The innovation here is to allow for housing to interact with nonmarket activity.

⁴Note that we use a lower case letter to represent the home production technology as home production takes place at the household level.

⁵Following Sato (1967), we justify our aggregation by the fact that intra-class elasticity between home input and housing is potentially higher than the inter-class elasticity between home input and home hours or housing and home hours because home input and housing are more similar in techno-economic characteristics.

2.3 Labor Productivity

Labor productivity consists of two components. The first is deterministic and age dependent with all consumers of the same birth cohort facing the same exogenous profile, e_t . The second is stochastic with each worker, i , receiving a stochastic productivity shock ε_t^i , which follows a Markov process

$$(4) \quad \ln \varepsilon_t^i = \rho_\varepsilon \ln \varepsilon_{t-1}^i + v_t^i, \quad v_t^i \sim N(0, \sigma_\varepsilon^2).$$

The Markov process is the same for all households and there is no uncertainty over the aggregate labor endowment. The total productivity of a worker at age t is then given by the product of the worker's age- t productivity shock and age- t deterministic efficiency index: $e_t \varepsilon_t^i$. Thus this part of our model follows the vast literature that assumes this parsimonious yet empirically plausible income process.⁶

2.4 Borrowing Constraints

Following Aiyagari (1996), Hugget (1993) and many subsequent papers, we impose an exogenous borrowing constraint in the economy. In particular, at any given period the household's financial asset denoted by a' must satisfy

$$(5) \quad a' \geq -e' \underline{\varepsilon}' w,$$

where $\underline{\varepsilon}'$ is next period's lowest possible realization of labor efficiency shock and w denotes the economy wide wage per efficiency unit of labor for the next period. In other words, we require that a household can only borrow up to an amount that is equal to its lowest possible labor income next period assuming that it spends all its time working for the market.

2.5 Market Production

There is only one type of market good produced according to the aggregate market production function

$$(6) \quad F(K, N^m) = K^\alpha (N^m)^{1-\alpha},$$

where K is the aggregate market capital stock and N^m is the aggregate market labor input. The final good can be directly consumed, invested in physical capital, housing,

⁶To name a few, French (2005), Hansen (1993), and Heathcote, Storesletten and Violante (2010)

or used as an intermediate input in home production.⁷ Physical capital, and housing depreciate at rates δ^k , and δ^s , respectively.

2.6 Financial Institutions

Following Gervais (2002), we assume there exists a two-period-lived financial institution that pools households capital to purchase final goods and uses them as housing services, which it then rents out to households for use in home production. Specifically, at the end of the first period, the intermediary accepts deposits and buys residential capital. In the second period, it repays deposits with interest at rate r . Residential capital is rented to agents at a price η per unit. At the end of the second period, the financial institution sells the undepreciated residential stock to a new agency. The no-arbitrage condition implies that the rental rate on housing is given by

$$(7) \quad \eta = r + \delta^s.$$

2.7 Social Security

The government operates a pay-as-you-go Social Security system similar to the current U.S. system. Specifically, the government taxes labor earnings below Social Security cap y_{\max} , at a constant rate of τ . Retired households receive Social Security benefits each period until they die. The Social Security benefits that individuals receive are linked to their average lifetime earnings according to a piecewise linear function that resembles the current US Social Security program as well as the age at which individuals claim it.

2.8 Timeline

At the beginning of each period, after they observe their current idiosyncratic labor shocks, and receive a bequest, households make their labor supply decisions and rent capital to firms. They also purchase the intermediate home input and housing for the current period. At this point, market production takes place. Home production also takes place using labor, the home input, and housing. After production, households receive factor payments and make their consumption and asset allocation decisions. At the end of the period, capital and housing depreciate and uncertainty about early death is revealed. Accidental bequests from those who die early are distributed to new agents

⁷For simplicity, we have combined both nondurable expenditures such as raw food with consumer durables such as appliances into a composite durable good used in home production. We term this composite good home input. An interesting extension would be to treat these separately, especially for modelling the cyclicity of consumption.

next period to first satisfy an exogenous beginning of period asset position, and if funds are leftover, they are distributed to the other agents in the economy.

2.9 The Household's Problem

In a stationary equilibrium, the interest rate is constant at r as is the wage rate w per efficiency unit of labor. The household's state variables are given by $(t, a, \varepsilon, y, t_r)$, which denote the agent's current age (t), financial assets (a), labor productivity of the current period (ε), average labor income (y) and retirement age (t_r). We have

$$(8) \quad V(t, a, \varepsilon, y, t_r) = \max_{\{c_m, s, d', a', n_m, n_h, f'\}} \left\{ U(c, 1 - n_m - n_h) + \beta \lambda_t EV(t + 1, a', \varepsilon', y', t'_r) \right\}$$

subject to

$$(9) \quad c_m + \eta s + d + a' \leq b + (1 + r)a + e_t \varepsilon w n_m - \tau \max(y_{max}, e_t \varepsilon w n_m) + pen(t_r, y),$$

$$(10) \quad y' = [(t - 1)y + \min(e_t \varepsilon w n_m, y_{max})] / t, \text{ if } t_r = 0,$$

$$(11) \quad y' = y \text{ if } t_r > 0,$$

$$(12) \quad t'_r = t + 1 \text{ if } f' = 1; t'_r = 0 \text{ if } f' = 0,$$

$$(13) \quad c_m \geq 0, s \geq 0, 0 \leq n_m, n_h \leq 1, a' \geq -e_{t+1} \varepsilon' w,$$

where τ denotes the Social Security income tax before retirement, w denotes the wage, $pen(t_r, y)$ is the pension after retirement and it depends the retirement age and the average life-time earnings at the time of retirement, and f' indicates the retirement decision. In any sub-period, an agent's resources depend on asset holdings, a , labor endowment, $e_t \varepsilon$, or pension, $pen(t_r, y)$, and received bequests, b . Note that agents receive a pension only after retirement. The composite consumption good c is defined as in equation (3), the home-produced good is defined as in equation (1) using current period housing s , home input d' , and home hours n_h as inputs. Average Social Security earnings accumulates according to equations Equation (10) if the agent has not claimed Social Security benefit.

A formal definition of a stationary equilibrium that includes market clearing conditions is provided in Appendix A. The model is solved numerically. Appendix B describes the computation algorithm in greater detail.

3 Calibration

We choose the parameters of our model in two steps. In the first step, we pick parameters that are based on economic statistics from the data as well as choosing parameters, such as relative risk aversion, that are consistent with the literature. In the second step, we jointly estimate the remaining parameters that minimize a loss function based on the difference between certain model and data moments calculated off households' time use and consumption. The calibrated parameters and the statistics that generate them are given in Table 1 and the estimated parameters are given in Table 2. Table 3 indicates how close the model moments match the data moments.

3.1 First-stage Calibration

The model period is two years.⁸ At age 24, each person enters into the model. The maximum life length T is 90. Figure 1, panel b, shows the λ_t s, the vector of conditional survival probabilities. We use the mortality probabilities in 2000, weighted by gender from the Social Security Administration life tables. The population growth rate n is set at 1% annually.

We calibrate the production parameters according to the National Income and Product Accounts and the Fixed Assets Tables for the years 1957-2007. The parameter α is the share of income that goes to the nonresidential stock of capital and is set at 0.24. This capital share is lower than that in many real business cycle calibrations because housing is not part of our model's capital stock. We set δ^k to 0.09 and δ^s to 0.01. We assume that the intermediate home input depreciates completely in two years given that household appliance and equipment accounts for less than 0.10 of total home input. The interest rate on capital net of depreciation, r , and is set to 0.05. The implied capital-output ratio is 1.714.

The deterministic age profile of the unconditional mean of labor productivity, e_t , taken from French (2005), is shown in the top panel of Figure 1. The labor-efficiency profile is hump-shaped, with a peak at age 50. The persistence ρ_y and variance σ_y^2 of the stochastic productivity process are 0.977 and 0.014, respectively (French (2005)). The variance of the initial distribution of productivity is 0.38 (Huggett (1996)). For simplicity, we assume the labor efficiency profile for home production is constant.

We calibrate the Social Security tax τ to 0.101 to match the average payroll tax.⁹

⁸Given the model period, we adjust parameters in the model accordingly. We report parameters at annual frequency, unless stated otherwise.

⁹The Social Security payroll tax rate in the US is about 10 percent after we take out the part of the benefits due to Medicare and disability insurance.

The Social Security earnings cap y_{\max} is 2.47. The retirement benefit is calculated to mimic the Old Age and Survivor Insurance component of Social Security system:

$$pen(\tilde{y}) \quad \left\{ \begin{array}{ll} 0.9\tilde{y} & \tilde{y} \leq 0.2 \\ 0.18 + 0.32(\tilde{y} - 0.2) & 0.2 \leq \tilde{y} < 1.24 \\ 0.5128 + 0.15(\tilde{y} - 1.24) & 1.24 \leq \tilde{y} < y_{\max} \\ 0.6973 & \tilde{y} > y_{\max} \end{array} \right\}$$

The bend points and Social Security earnings cap, expressed as average earnings, and marginal rates are from Huggett and Ventura (1999). Note, that after age 66 a household receives the full pension payment. If the household retires at the age of 62, it receives 75 percent of the full pension, at age 64, it receives 87 percent, if it is at age 68, it receives 1.16 percent, and it receives 1.32 percent if retirement is at any age greater than or equal to 70.

The parameter ζ_1 pins down the elasticity of substitution between housing service and home input. We set this parameter to the value identified in Dotsey, Li, and Yang (2010) because we no longer model owner-occupied housing in the current model. As a result, the consumption of housing and home input will always be in constant proportion.

We take the risk aversion parameter, γ , to be 1.5, from Attanasio et al. (1999), and Gourinchas and Parker (2002), who estimate it from consumption data. The initial distribution over state variables (wealth, initial labor productivity level) for households of age 25 is calculated using data from the Survey of Consumer Finances (2001, 2004, and 2007) for households whose heads are between ages 23 and 26. Accidental bequests are first distributed to new agents to reproduce the distribution of capital endowments.¹⁰ The rest, if there are any, is distributed evenly to all agents alive, which endogenously determines b .

3.2 Second-stage Estimation

For the second stage estimation, we use the National Income and Production Account and two micro datasets on households' consumption expenditure and time use, the Consumer Expenditure Survey (CEX) and the American Time Use Survey (ATUS). Dotsey, Li, and Yang (2010) provides detailed information on these two datasets and the classification of consumption and time use into different categories. To reiterate, we follow the tradition of Reid (1934) and separate nonmarket time into pure leisure and home hours where home hours comprise time spent on activities performed at home to produce goods

¹⁰Since the model does not allow negative wealth, negative wealth holdings in the data are treated as zero. Most households start with wealth endowments close to zero.

and services that can also be purchased in the market and are, for the most part, not enjoyable to produce (table 1 of Dotsey, Li, and Yang 2010).¹¹ In particular, we define home hours as time spent doing house work, house work service, shopping, pet care, car care, child care, adult care, shop search, car service, child care service and professional service. We define market hours as the time the head of the household spends working, job searching and commuting. We treat the remaining time as leisure.

For consumption, we include in our market good food away from home, alcohol, tobacco, apparel, other lodging, fees and admissions for entertainment, and related equipment such as televisions, radios, sound systems, pets, toys, and playground equipment, reading, and personal care. We also include education expenses and out-of-pocket medical expenses in the market good, but our results are robust to the exclusion of these categories. We include in our home input food cooked at home, household operations, household furnishing and equipment, utilities, fuels, and public services. We pro-rate transportation expenses by travel time for home production or market production and leisure that we obtained from the ATUS discussed in the previous subsection. For housing expenditures, we use rental payments for renters, and we use homeowners reported house value of owned residence. The associated annual housing service flow is defined to be 6 percent of the house value.

Regarding the estimated moments, we deviate from Dotsey, Li, and Yang (2010) and chose to match, for consumption and time use, moments calculated for the young (those between the ages 25 and 49) and the old (those between the ages 50 and 80). The reason for this departure is because we no longer have owner-occupied housing in the current set up.

Specifically, we choose the parameters, β , τ , ζ_i ($i = 2, 3, 4$), ω_i ($i = 1, 2, 3, 4$), based on the following moments: K/Y , Social Security budget balance, the economy wide consumption of home input relative to housing services, the average home input of both the young and the old (d), and their respective average market hours and home hours. We also normalize the average expenditure by economy-wide income. Thus, we simultaneously choose these 9 parameters to match the 9 selected moments as summarized in Table 3. The moments basically involve various expenditure income ratios as well as moments pertaining to the use of time. It is important to note that although our procedure jointly uses 9 moments to identify 9 parameters, certain moments are relatively more responsible for pinning down the shares and elasticities in the CES aggregates.

For example, β is largely determined by K/Y . τ is mainly pin down by Social Secu-

¹¹In particular, Reid defines home production as “those unpaid activities which are carried on, by and for the members, which activities might be replaced by market goods, or paid services, if circumstances such as income, market conditions, and personal inclinations permit the service being delegated to someone outside the household group” (Reid 1934, p.11).

rity budget balance. The three elasticity parameters (ζ_i , $i = 2, 3, 4$) play crucial roles in determining households' supply of labor to different activities and consumption of different goods. Given ζ_1 , we calibrate ω_1 by matching the ratio of home input to rental housing size. The rental house size is calculated as rental service flow s divided by 6 percent, the value of η in our model, a number typically used in the literature. The relative amount of time spent in home production across the young and the old helps to pin down ζ_2 and ω_2 . The difference regarding consumption of market good between young and old helps to pin down ζ_3 and ω_3 . Finally, the difference in the relative time worked in the market place is useful for identifying ζ_4 and ω_4 because they help determine leisure. However, the estimation is more complicated than provided by the discussion here and is not totally driven by one set of moment differentials driving one pair of elasticity and share parameters.

3.2.1 Life-cycle Profiles of Labor Supply and Consumption

Though the target moments are somewhat different, the second-stage calibrated parameters are similar to those in Dotsey, Li, and Yang (2010). The home input and housing are Hicksian substitutes in the production of the composite home good. The composite home good and home hours exhibit strong complementarity in home production. The market good and home good, on the other hand, are substitutes. Finally, the final composite consumption good made up of the market good and home good is substitutable with leisure in households' utility. The existing literature on home production has largely lumped home hours and leisure together into nonmarket hours, making the comparison with our estimates difficult. Nevertheless there is some supporting evidence. For example, Abbott and Ashenfelter (1976) find that housing, transportation, and other services tend to be complementary with nonmarket time. Barnett (1979) estimates a model of joint goods and leisure consumption and finds non-weakly-separable substitution between consumption and leisure. Greenwood and Hercowitz (1991) argue that to generate comovement in investments in durable goods in the market and at home one needs to have complementarity between durable goods and time in home production.¹² The finding that the home input and housing are complements with home hours in home production explains why after a household moves from being a two-earner family to a one-earner family, home capital typically increases, as documented in Baxter and Rotz (2009). The strong substitutability between market goods and home goods is consistent

¹²McGrattan, Rogerson, and Wright (1997), on the other hand, estimate the residential capital to be complementary to home hours in home production. They, however, don't examine the implied housing consumption over the life cycle. Separately, in his response to Greenwood and Hercowitz (1991), Chang (2002) argues that adjustment costs in capital accumulation can account for the comovement in investments.

with the findings in the literature, notably McGrattan, Rogerson, and Wright (1997) and Rupert, Rogerson and Wright (1995).

We chart the simulated life-cycle hours and consumption profiles against the corresponding data profiles in Figure 2. The data profiles are created using the American Time Use Survey (2005-2007) and the Consumer Expenditure Survey (2003-2006) as in Dotsey, Li, and Yang (2010). Note that the model does a reasonably good job at matching the data profiles. The supply of home hours is flat early in the life cycle and begins to rise after households reach age 55 when the market labor efficiency starts to decline. By contrast, market hours are stable till age 55 and then decline steadily. By age 65, the average household devotes less than 10 percent of their time in market work. The consumption profiles are hump shaped. Notice that the consumption profile for the home input and housing track each other when measured as log deviations from their respective levels at age 30. Additionally, the hump shape in the consumption of the market good is more pronounced than that of the home input.

Figure 3 plots the cumulative fraction of all retirees who claim an initial Social Security entitlement at a particular age for both the model and the data. The data come from the 2008 Social Security Annual Statistical Supplement table 6.a4. Using statistics constructed from more years does not appreciably change the chart (see Imrohroglu and Kitao 2011). The model does a reasonably good job at matching the data profiles except that the model predicted initial entitlement age distribution is a little flatter than the data. In other words, more households claim their Social Security Benefits at earlier ages in the model than in the data.

4 Policy Analysis

We now study the long-run effects of eliminating Social Security. To do so, we eliminate both Social Security benefits and payroll taxes. As a result, households have to save through private markets for their retirement. We first report the aggregate statistics and then analyze the welfare implications of this reform.

4.1 Aggregate Statistics

Table 4 summarizes the aggregate effects of Society Security and contrasts them with the benchmark economy with Social Security benefits. Eliminating the Social Security pension has three effects on household savings. The first is the standard overlapping generations result that reducing pay-as-you-go Social Security increases saving and the capital stock. Second, reducing the pension is similar to reducing the annuity for old age

households. Given an uncertain life span households now save more. Third, the pension partly acts as a redistribution or insurance mechanism with poor households receiving more payments than they otherwise could afford. Reducing the pension payment impels these households to save more for themselves.

According to our analysis, eliminating Social Security system leads to a decline of about 12 percent in the equilibrium interest rate as households need to save through the private market for their retirement and to insure against idiosyncratic income shock. Accordingly, the aggregate capital output ratio increases to 1.79 from 1.71, an increase of over 5 percent and the wage rate increases by 1.47 percent. The increase in the wage rate and the reduction in payroll tax leads to higher supply of market hours, an increase of over 6 percent compared to the benchmark. Households are overall richer.

The fall in the interest rate reduces the cost of housing as rental cost comes down. Aggregate housing consumption rise more than 17 percent. This relatively large effect is also found by Chen (2010). The higher housing consumption requires a larger supply of home hours. However, the downward pressure on home hours from the increased demand in market hours largely offsets the upward pressure from higher housing consumption. On balance, households' supply of home hours moves up by a slight 0.433 percent. Leisure, by comparison, falls by close to 1.5 percent. Households substitute cheaper housing for home input. As a result, the 0.56 percent increase of home input is much smaller than the increase in housing services. Households consumption of market goods also increases, and the 3.442 percent increase is more than the increase in home input but much smaller than the increase in housing services.

4.2 Life-cycle Effects

We plot the life-cycle profiles of market hours and home hours before and after Social Security reform in Figure 4. Social Security reform increases the return on supplying market hours as there is no longer payroll tax and wage rate is higher. The reform also reduces the cost of engaging in home production as the interest rate is lower which makes housing services cheaper. Young households, however, are on average less productive in market activities. The end result is that households younger than 40 reduce their market hours and increase their home hours slightly. By contrast, households older than 40 increase their market hours and reduce their home hours. Though not charted, at each given age, we observe that relatively productive people engage more in market production than home production after the elimination of Social Security benefits.

In terms of consumption, the lower interest rate enables households to choose a much flatter consumption profile over the life cycle. Note that in our economy, the ratio

of consumption of home input and housing are constant. Consequently, the profiles measured as standard deviation from consumption at age 30 track each other perfectly. The reduction in consumption hump is more evident in home input and housing than in market consumption. This is because in our model, home hours are compliments to home input and housing. As home hours for young increase, so do housing and home input for young.

4.3 Welfare Implications

In this section, we explore the long-run welfare implications of Social Security reform, i.e., our analysis does not take into account of the transition cost associated with the move from one steady state to another. Following the literature, McGrattan, Rogerson, and Wright (1997) in particular, the welfare effects are measured by the percentage changes in market consumption that makes an unborn household (before the realization of all state contingencies) indifferent between two steady states holding the consumption of leisure constant. According to our calculation, aggregate welfare increases by 19.050 percent after the complete elimination of Social Security.

5 Investigating the Role of Home Production

To isolate the role that home production plays in driving the results associated with our policy analysis, we reestimate a version of our benchmark economy without home production. We do so by setting the weight in home hours, ω_2 , to zero. With this, the period utility function collapses into multi-level Constant Elasticity of Substitution formulation over the different type of consumption good (market good, home input, and housing) and leisure. As a result, the consumption of housing and home input will always be in constant proportion. We can no longer separately identify the two parameters ζ_3 and ω_3 that govern the relative consumption of home input and housing without the presence of home production. We therefore fix ζ_3 at the value calibrated in the benchmark.

5.1 Calibration

We choose the same first-stage parameters as in the benchmark. Table 5 reports the estimated parameters in the second stage. In the new economy without home hours, all the weight on home hours is switched to housing and home input composite which is in a big unit. This raises consumption for home goods, and to match the same moments on market consumption, households put a higher weight on market consumption (higher

ω_3). Likewise, lower weight on consumption ω_4 is needed to match now higher leisure (as home hours are part of leisure without home production). We do not report it here but the match of the model moments with the data is on average worse than the benchmark model.

5.2 Policy Implications

We conduct the same policy experiment as in the benchmark by eliminating the Social Security benefits. We report changes in the aggregate statistics in table 6 and changes in life cycle profiles in Figure 5.

After eliminating Social Security benefits, households have to increase their savings for retirement. However, since they now value leisure more, the incentive to increase the savings is not as strong as in the benchmark experiment. Consequently, the equilibrium interest rate does drop but not as much as occurred in the benchmark economy. It remains almost 10 basis points above the rate that resulted in the post-reform benchmark economy. As in the benchmark experiment, the capital output ratio rises and so does the wage, but the rise in both are not as big as in the benchmark experiment. Households also work much more in the market economy and the increase is slightly larger than the benchmark experiment since households no longer need to increase home hours. In terms of consumption, housing consumption increases much more than they do in the benchmark even though the interest rate does not fall as much. In our benchmark economy, because housing complements home hours in home production, the consumption of housing is to some extent constrained by the supply of home hours. For example, when wages are high, households will want to supply more market hours and reduce their home hours which in turn puts downward pressure on housing consumption. Without home production, this channel no longer operates and the demand for housing is more interest elastic. Similar argument explains the larger increase of home input in the model without home production. Changes in the aggregation consumption of market good are not materially different across the two economies.

Comparing the consumption and time use profiles between the young and old, the lower new equilibrium interest rate still flattens both the consumption and the hours profiles, but not by as much as in the benchmark experiment. Notice that the consumption profile for the home input, housing, and market consumption track each other when measured as log deviations from their respective levels at age 30. Finally, using the same welfare metric as in the benchmark experiment, we find that eliminating Social Security benefit leads to an increase in welfare of 16.050 percent, 3 percentage points lower than the benchmark experiment. In our benchmark model with home production,

households use home production as an additional means to smooth consumption or to make up income shortfall in old age. Thus the benefit of Social Security is smaller.

6 Comparison with One-Asset Economy

Our analysis so far indicates that home production plays an important role in matching life cycle profiles of households market and nonmarket activities and an economy without home production biases down the welfare gains of eliminating Social Security benefits by 3 percentage points. In this section, we investigate a one-asset economy where households consume only one good which comprises of the market good, home input, and housing services as defined in our benchmark economy. All other model features are preserved including the functional form of constant elasticity of substitution between this aggregate consumption and leisure for the period utility. This one-asset economy setup has been used widely in the existing Social Security literature as cited in the introduction.

Given that housing capital is now part of the aggregate capital, the new capital output ratio is 3.661. The average depreciation rate is 0.047. The capital share in production α is 0.357. We calibrate the discount factor β to 0.956 to match the 5 percent interest rate. The elasticity parameter for consumption and leisure ζ_4 and the weight on consumption ω_4 are set to 1.421 and 0.081 respectively to match the average market hours for the old (0.102) and the young (0.212). At 0.109 for the old and 0.205 for the young, the model does a decent job at matching the moments. As shown in Figure 6, the model actually does a fairly good job at matching the market labor profile. It, however, generates too much hump in consumption profile compared to the data.¹³

We then conduct a similar policy experiment as before by eliminating the Social Security benefits completely. As expected, aggregate capital increases substantially by 15.460 percent as households engage in more precautionary savings. Market labor supply also increases in response to zero payroll tax rate, but only by 4.121. Note that both increases are much larger than our benchmark economy and the alternative economy that differentiates different consumption good but with no home production. Finally, the welfare gains of eliminating Social Security benefits drop to 10.280 percent.

To summarize, relative to our benchmark economy that incorporates home production and differentiates consumption of different goods, the one-asset economy over predicts the hump shape in consumption profile and underestimates by almost 10 percentage points the welfare gains of complete elimination of Social Security benefits.

¹³The empirical profile for the aggregate consumption is generated using the same methodology as in the benchmark.

7 Conclusion

We study the aggregate economic and welfare effects of Social Security reform in an environment with home production technology and explicit modeling of consumption of different goods. There is an extensive literature that studies possible reform of the Social Security system. Such studies, however, abstract from the key role of home production in household sector and treats all consumption goods the same. We show that such studies that fail to do a detailed reestimation that can match key life-cycle moments will be subject to error. The life-cycle consumption profiles will not be matched. More importantly, the welfare bias can be as much as 10 percentage points.

Interesting extensions of the current framework includes the distinction of owner-occupied housing and rental housing as well as incorporation of other important labor income, capital income as well as consumption taxes. We leave them to future research.

Appendix A. Definition of the Stationary Equilibrium

We focus on the stationary equilibrium of the economy where factor prices and agent distribution over state space are constant over time. Each agent's state is denoted by x . Let S denote the aggregate housing stock available for renting, D the aggregate stock of home input, C_m the aggregate consumption of the market good, I_h the aggregate investment on housing, I_d the aggregate investment on home input, I_k the aggregate investment on physical capital, N_m aggregate market hours supplied, and N_h aggregate home hours supplied.

Definition 1. A stationary equilibrium is given by government policies including tax rate τ , and pension $pen(t_r, y)$; an interest rate r and a wage rate w ; value functions $V(x)$; allocations $c_m(x)$, $a'(x)$, $d'(x)$, $s(x)$, $n_m(x)$, $n_h(x)$, $f(x)$; bequest b ; and a constant distribution of people over the state variables x , $v(x)$, such that the following conditions hold:

(i) Given the government policies, the interest rate, the wage, and the expected bequest, the value functions and allocations solve the above described maximization problem for a household with state variables x .

(ii) $v(\cdot)$ is the invariant distribution of households over the state variables.

(iii) The price of each factor is equal to its marginal product.

$$\begin{aligned} r &= F_1^m(K, N^m) - \delta^k, \\ w &= F_2^m(K, N^m). \end{aligned}$$

(iv) The expected bequest is consistent with the actual bequest left

$$\int bv(dx) + \int_{t=0} (a(1+r) + (1-\delta^d)d)v(dx) = \int (1-\lambda_t)[(1+r)a' + (1-\delta^d)d']v(dx).$$

(v) Government budget is balanced at each period

$$\tau \int \min\{\varepsilon e_t w n_m, y_{\max}\} v(dx) = \int pen(t_r, y) v(dx).$$

(vi) All markets clear.

$$\begin{aligned}
S &= \int sv(dx), \\
D &= \int d'v(dx), \\
K &= \int av(dx) - S, \\
C_m &= \int c_mv(dx), \\
N_m &= \int \varepsilon e_t n_m v(dx), \\
I_d &= \int [d' - (1 - \delta^d)d]v(dx), \\
I_k &= K' - (1 - \delta^k)K, \\
I_h &= S' - (1 - \delta^h)S \\
F^m(K, N_m) &= C_m + I_k + I_d + I_h.
\end{aligned}$$

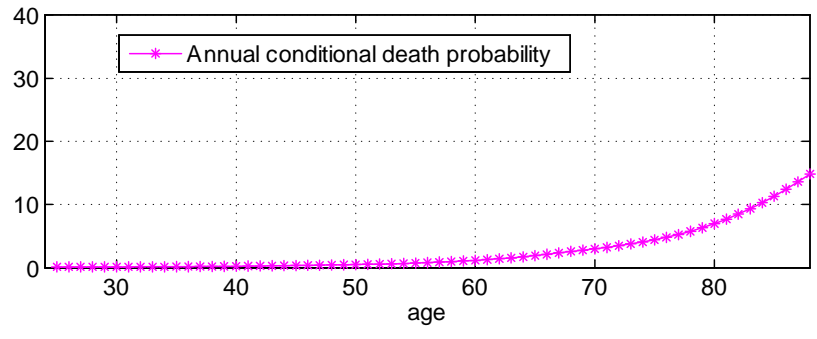
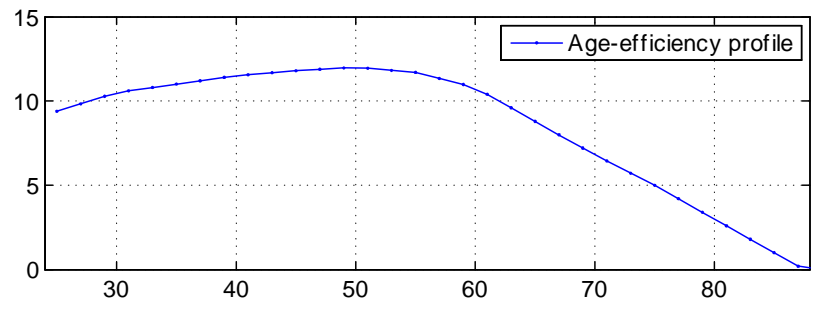
Appendix B: Computation of the Model

To compute the steady state of our model, we first discretize the income process into 5 points. The state space for average lifetime earnings and asset holdings are discretized into unevenly spaced grids. The upper bounds on the grids are chosen to be large enough so that they do not constitute a constraint on the optimization problem. We chose 20 grid points for the asset variables and 15 for the average lifetime earnings. The choice variables are searched over 150 grid points for assets, 100 points on market hours, and continuous for other variables. We use linear approximation to approximate valuation functions for the points not on the state grids.

We solve for the steady-state equilibrium as follows:

1. Make an initial guess of interest rate r , the wage rate w and tax rate τ .
2. Guess the size of accidental bequests.
3. Set the value function after the last period to be 0 and solve the value function for the last period of life for each of the points of the grid. This yields policy functions and value functions in the last period.
4. By backward induction, repeat step 3 until the first period in life.
5. Compute the associated stationary distribution of households by forward induction using the policy functions starting from the known distribution over types of age.
6. Check whether the associated accidental bequests are consistent with the initial guess. If so, continue to step 7. If not, go back to step 2 and update accidental bequests.

7. Check whether market clearing conditions hold, and whether the government budget is balanced. If so, an equilibrium is found. If not, go to step 1 and update the initial guess.



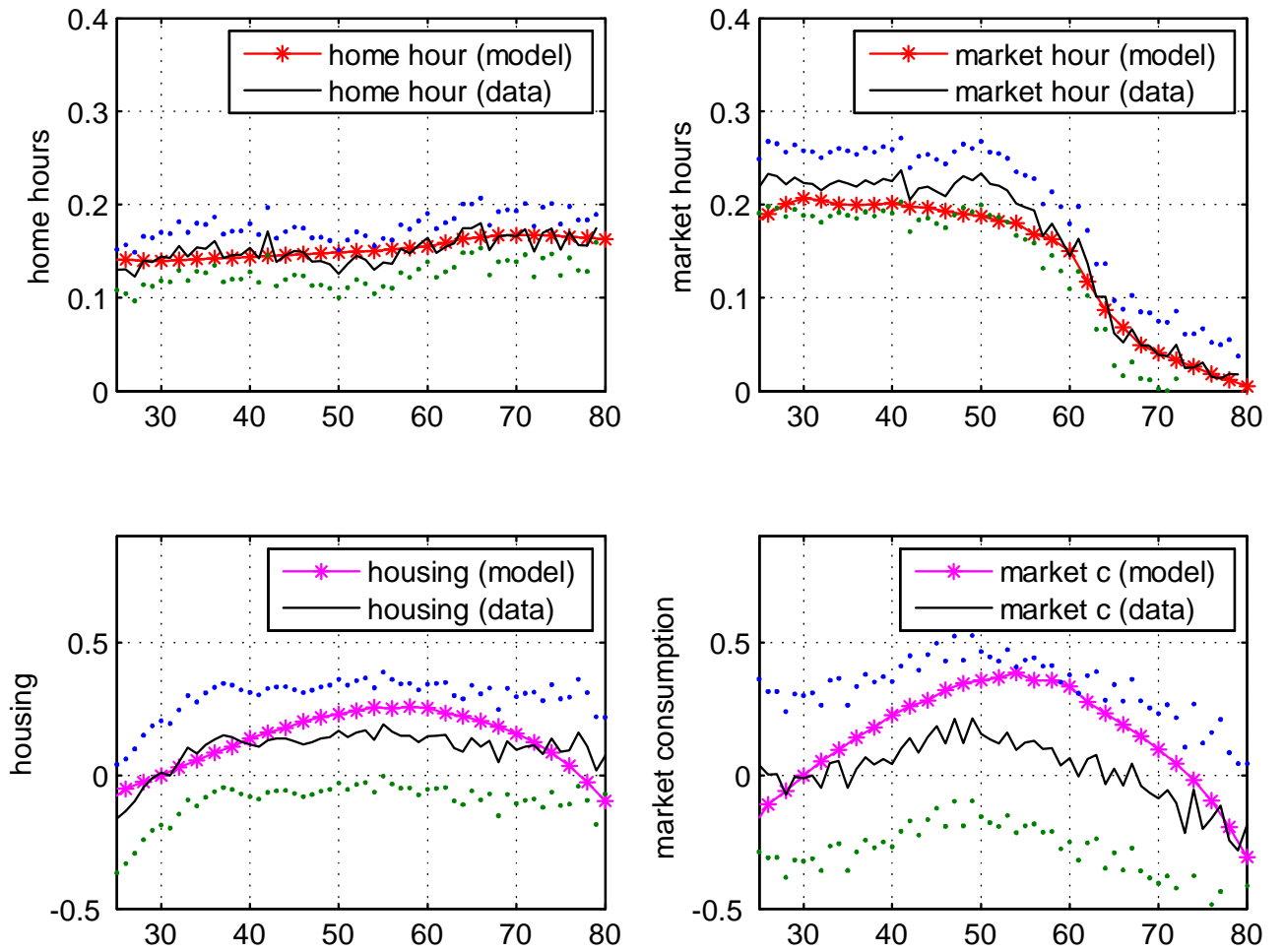


Figure 2. Life-cycle Labor Supply and Consumption Profiles (the dotted lines represent the two-standard deviation error band)

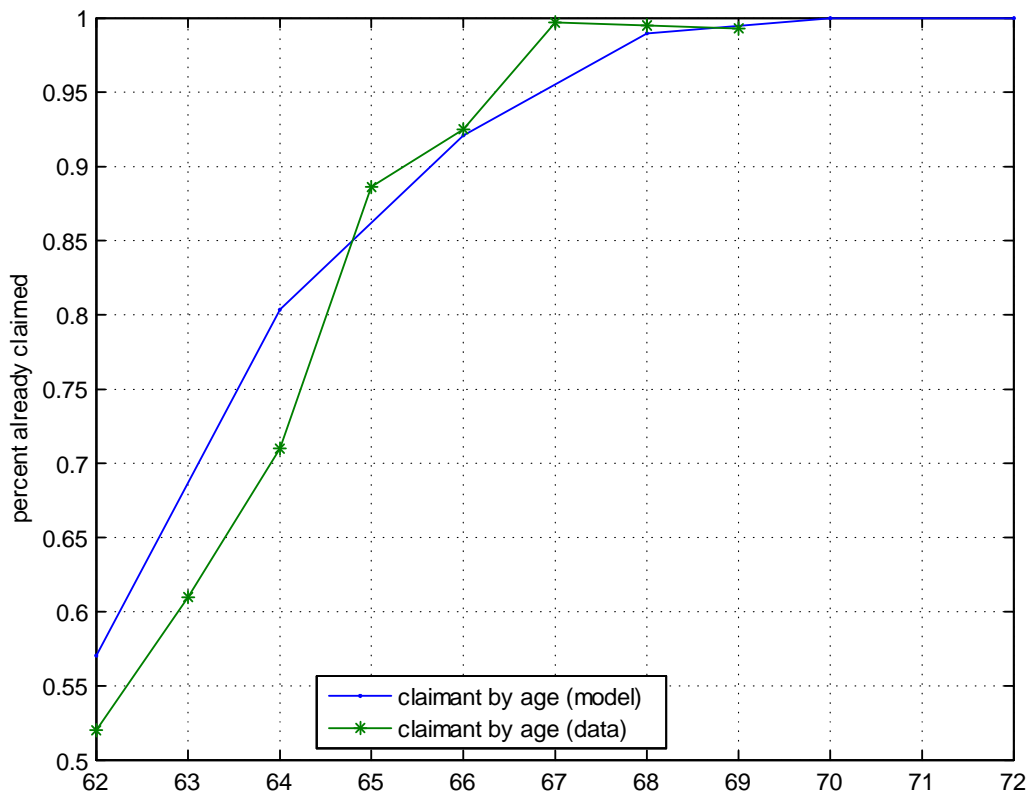


Figure 3. Social Security Claims by Age

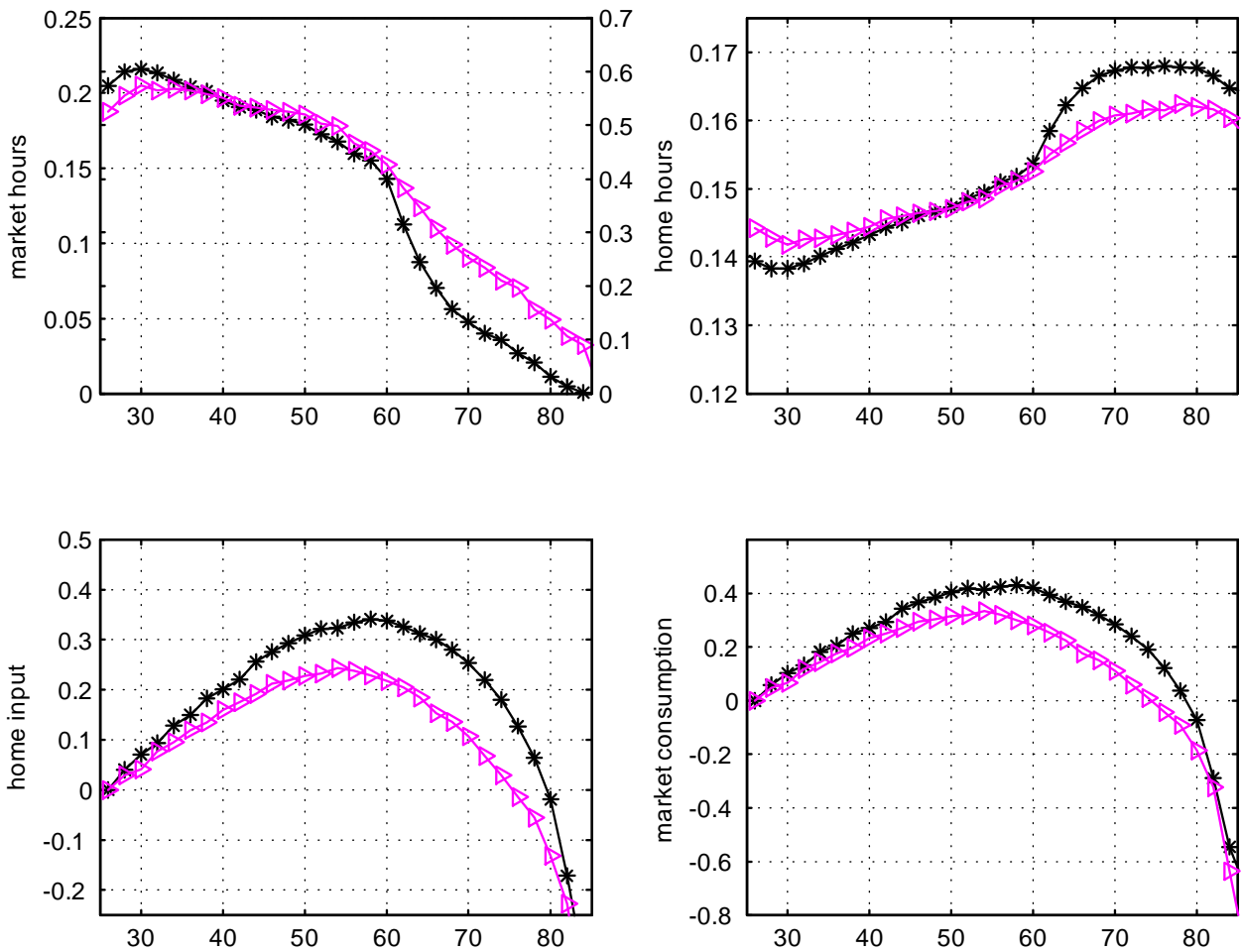


Figure 4. Life-cycle Profiles of Labor Supply and Consumption with Home Production
 (-*: benchmark with Social Security Benefit; - Δ : benchmark without Social Security
 Benefit)

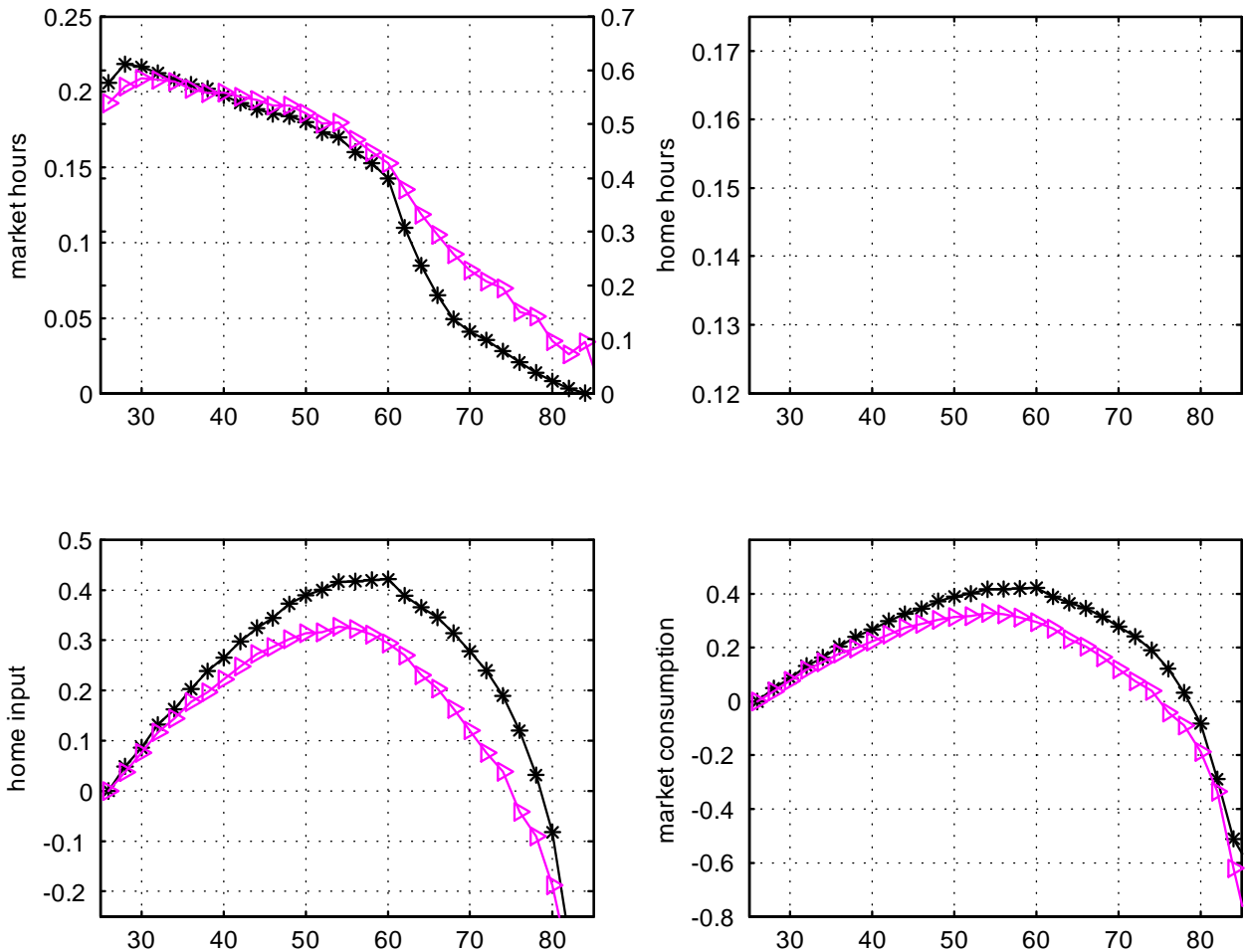


Figure 5. Life-cycle Profiles of Labor Supply and Consumption without Home Production (-*: with Social Security benefits; - Δ : without Social Security benefits)

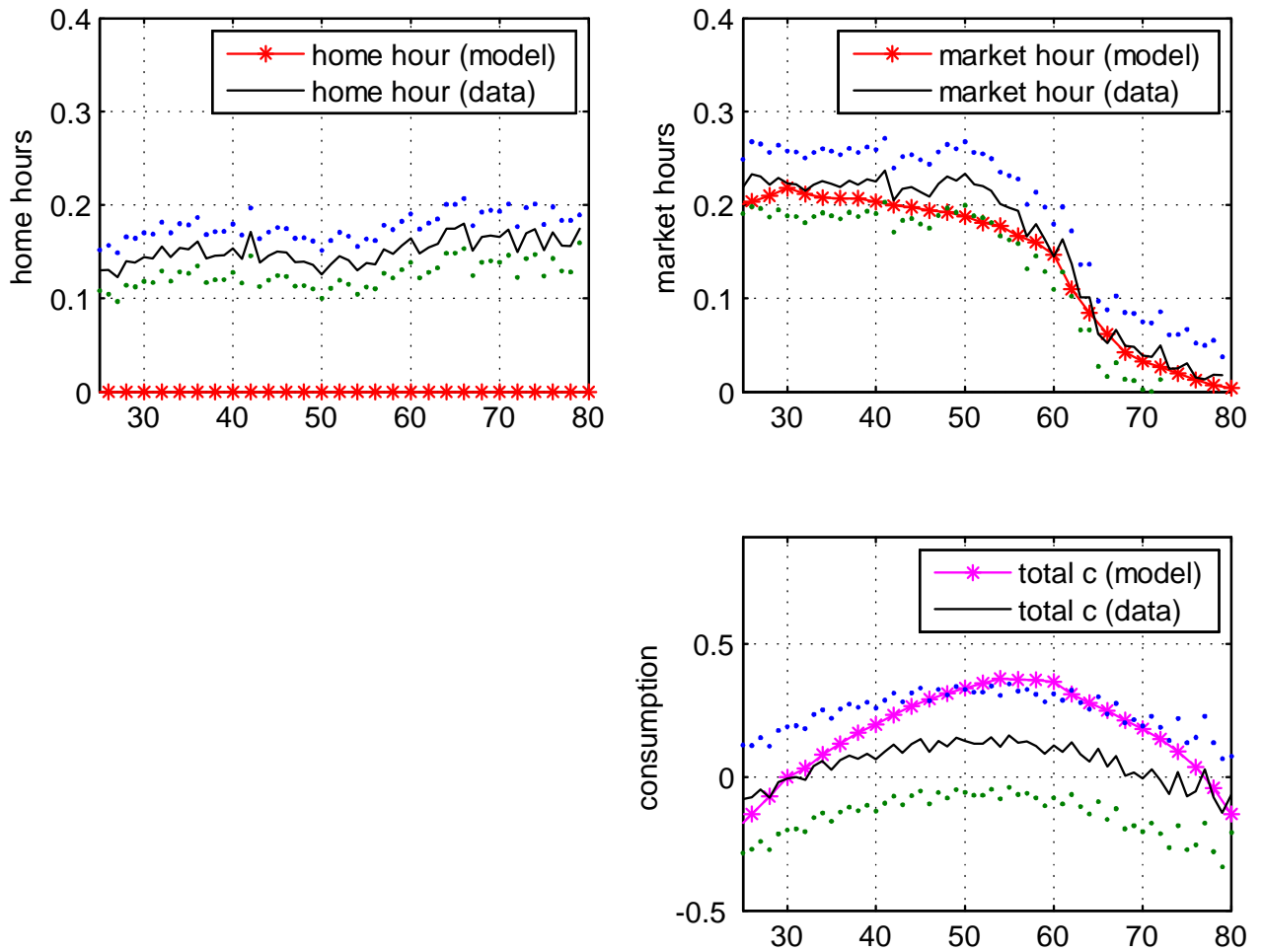


Figure 6. Life-cycle Labor Supply and Consumption Profiles – One-asset Economy
 (the dotted lines represent the two-standard deviation error band)

Table 1. Calibration According to the Data and the Literature

| Parameters | | Value | Source |
|-------------------|------------------------------------------|--------------|--------------------------------------------------------|
| Demographics | | | |
| T | maximum life expectancy | 90 | |
| λ_t | survival probability | see Figure 1 | Social Security Administration Life Tables |
| Technology | | | |
| α | capital share in National Income Accts. | 0.240 | authors' calculation |
| δ^k | annual depreciation rate of capital | 0.090 | authors' calculation |
| δ^h | annual depreciation rate of housing | 0.010 | authors' calculation |
| δ^d | biannual depreciation rate of home input | 1.000 | authors' calculation |
| Endowment | | | |
| e_t | age-efficiency profile | see figure 1 | French (2005) |
| ρ_y | AR(1) coefficient of income process | 0.960 | French (2005) |
| σ_y^2 | innovation of income process | 0.045 | French (2005) |
| Government policy | | | |
| $pen(t_r, y)$ | Social Security benefit | | see text |
| home production | | | |
| ζ_1 | sub. betw. d and h | 1.369 | Dotsey, Li and Yang (2010) |
| Preference | | | |
| γ | risk aversion coefficient | 1.500 | Attanasio, et. al (1999), Gourinchas and Parker (2002) |

Table 2. Calibration to Match Data Moments

| Parameters (9) | Value |
|--------------------------------------------------|-------|
| β discount factor | 0.952 |
| τ social security tax rate | 0.101 |
| ω_1 weight on durable | 0.734 |
| ζ_2 sub. betw. d and h composite and n_h | 0.792 |
| ω_2 weight on d and h composition | 0.826 |
| ζ_3 sub. betw. market and home goods | 1.709 |
| ω_3 weight on market goods | 0.164 |
| ζ_4 sub. betw. consumption and leisure | 1.421 |
| ω_4 weight on consumption | 0.230 |

Table 3. Calibration Results

| Moments | Model | Data |
|------------------------------------------------|-------|-------|
| capital output ratio (K/Y) | 1.714 | 1.710 |
| Social Security budget balance | 0.000 | 0.000 |
| home input/housing | 0.110 | 0.110 |
| The Young (between ages 25 and 49) | | |
| average expenditure on home input goods/income | 0.236 | 0.245 |
| average share of home hours | 0.142 | 0.145 |
| average share of market hours | 0.212 | 0.199 |
| The Old (between ages 50 and 80) | | |
| average expenditure on home input goods/income | 0.256 | 0.265 |
| average share of home hours | 0.155 | 0.157 |
| average share of market hours | 0.102 | 0.113 |

Table 4. Aggregate Effects of Eliminating Social Security Benefits in the Benchmark Economy

| Variable | Steady State with SS Benefits | Steady State without SS Benefits (changes relative to the init. steady state) |
|-------------------------------------|-------------------------------|----------------------------------------------------------------------------------|
| Social Security tax rate (τ) | 0.101 | 0.000 (-100%) |
| interest rate (r) | 0.050 | 0.044 (-12.640%) |
| wage (w) | 0.724 | 0.735 (1.470%) |
| capital output ratio (K/Y) | 1.714 | 1.795 (4.729%) |
| aggregate capital | 62.475 | 68.271 (9.278%) |
| aggregate labor | 76.540 | 78.704 (2.832%) |
| total housing | 1.980 | 2.319 (17.114%) |
| home input | 0.218 | 0.219 (0.560%) |
| market consumption | 0.571 | 0.591 (3.442%) |
| market hour | 0.153 | 0.163 (6.174%) |
| home hour | 0.150 | 0.151 (0.433%) |
| leisure | 0.697 | 0.687 (-1.451%) |
| Welfare changes | | 19.050% |

Table 5. Calibration to Match Data Moments – without Home Production

| Parameters (6) | Without Home Production |
|----------------------------------------------|-------------------------|
| β discount factor | 0.953 |
| τ social security tax | 0.102 |
| ω_1 weight on durable | 0.734 |
| ω_3 weight on market goods | 0.582 |
| ζ_4 sub. betw. consumption and leisure | 1.419 |
| ω_4 weight on consumption | 0.090 |

Table 6. Aggregate Effects of Eliminating Social Security Benefits

| Variable | relative changes after the reform | | difference |
|--------------------------------|-----------------------------------|-----------|------------|
| | no home prod. | benchmark | |
| interest rate (r) | -11.923% | -12.640% | -0.802% |
| wage (w) | 1.384% | 1.470% | 0.096% |
| capital output ratio (K/Y) | 4.449% | 4.729% | 0.314% |
| aggregate capital | 9.984% | 9.278% | -0.614% |
| aggregate labor | 3.861% | 2.832% | -0.987% |
| total housing | 20.544% | 17.114% | -3.430% |
| home input | 4.453% | 0.560% | -3.892% |
| market consumption | 3.133% | 3.442% | 0.308% |
| market hour | 7.232% | 6.174% | -1.058% |
| home hour | | 0.433% | |
| leisure | -1.303% | -1.451% | -0.148% |
| welfare | 16.050% | 19.050% | -3.000% |

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