Home Production and Social Security Reform*

Michael Dotsey Wenli Li Fang Yang†

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Abstract

This paper incorporates home production into a dynamic general equilibrium model of overlapping generations with endogenous retirement to study Social Security reforms. As such, the model differentiates both consumption goods and labor effort according to their respective roles in home production and market activities. Using a calibrated model, we conduct a policy experiment where we eliminate the current pay-as-you-go Social Security System. We find that the experiment has important implications for labor supply as well as consumption decisions and that these decisions are influenced by the presence of a home production technology. Comparing our economy to a one-good economy without home production, the welfare gains of eliminating Social Security are magnified significantly especially in the long run. These policy analyses suggest the importance of modeling home production and distinguishing between both time use and consumption goods depending on whether they are involved in market or home production.

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†Michael Dotsey and Wenli Li: Research Department, Federal Reserve Bank of Philadelphia, Ten Independence Mall, Philadelphia, PA 19106 (Email: michael.dotsey@phil.frb.org; wenli.li@phil.frb.org). Fang Yang: Department of Economics, Louisina State University, Business Education Complex, Room 2300, Baton Rouge, LA 70803-6306 (Email: fyang@lsu.edu).

1 Introduction

The significant challenges facing the unfunded U.S. Social Security System have stimulated a large literature analyzing the implications of Social Security reforms using a wide array of models.[1] This paper makes a contribution to this literature by investigating how the presence of home production influences the effects of Social Security reforms. The inclusion of home production in life-cycle models adds important features that provide compelling reasons for including it in the study of Social Security reforms.

The study of home production dates back to the seminal work of Becker (1965) and Mincer (1962). Its subsequent integration into standard business cycle models has successfully helped these models match the low correlation between wages and hours worked and the high volatility of hours worked relative to wages over the business cycle. In international economics, models with home production have been useful in accounting for the large and persistent income disparity across countries and shed new light on the welfare implications of the income disparity.[2]

Recently, the incorporation of home production into standard life-cycle models has proven equally important in explaining a number of life-cycle facts. Home production allows households to substitute labor supply between market hours and home hours and to substitute consumption between market-produced goods and home-produced goods. These margins of substitution are important in explaining a host of life-cycle features. For example, Rogerson and Wallenius (2009) demonstrate that home production alone is qualitatively capable of generating realistic retirement patterns. Dotsey, Li, and Yang (forthcoming) document the close relationship between time use over the life cycle with the consumption patterns of the related goods and show that a life-cycle home production model can help explain this behavior. Further, Aguiar and Hurst (2007) indicate that a home production model is useful for explaining the life-cycle pattern of time devoted to shopping, the differential in prices paid for similar goods, and importantly the substantial divergence between consumption and expenditure patterns over the life cycle. Additionally, Aguiar and Hurst (forthcoming) show that the hump-shape pattern in consumption varies considerably across goods depending on the degree to which these

[1] These models include features such as altruism, liquidity constraints, longevity and individual income risks, the separation of labor participation and hours worked, endogenous benefit claims, and housing. See Fuster (1999), Fuster, Imrohoroglu and Imrohoroglu (2003, 2007), Hurst and Willen (2007), Nishiyama and Smetters (2007), Imrohoroglu and Kitao (2009, 2012), Chen (2010), Yang (2013), and Laitner and Silverman (forthcoming).

[2] Economists that have contributed to this line of research include Greenwood and Hercowitz (1991), Benhabib, Rogerson and Wright (1991), Greenwood, Rogerson, and Wright (1995), McGrattan, Rogerson and Wright (1997), Hornstein and Praschnik (1997), Fisher (1997), Baxter and Jermann (1997), Chang (2000), Gomme, Kydland, and Rupert (2001), Rogerson (2009), and Rogerson and Wallenius (2009).

goods are readily substitutable with goods that can be produced at home. Thus, it appears that both over the life cycle and at business cycle frequencies home production is an important element governing the behavior of households.

As emphasized in Gomme and Rupert (2007), home production forces one to think differently about model calibration. In particular, what factors should be included in the productive capital stock, what is the appropriate capital/labor ratio, and what is the estimated labor elasticity that is consistent with various model moments are all affected by the inclusion of home production. More important, home production allows households a form of insurance in that low productivity households can substitute into home production. All of these elements affect behavior and in particular the aggregate amount of desired savings. Hence, government policies such as Social Security, whose primary impact is on savings behavior, could potentially have very different effects depending on whether home production is a feature of the model. In turn, the welfare consequences of those policies could be drastically altered by the presence of home production.

To analyze the role that home production plays in the effects of eliminating Social Security, we look at two economies: one with home production and one without. The latter is a standard one-good economy that has been widely used in the existing literature.[3] For both economies, we first estimate the parameters of the two models in order to match various aggregate moments of the microdata. We show that the one-good economy does not match consumption data profiles as well as our benchmark home-production economy, and that the parameter estimates differ in important ways across the two models. These differences imply that including home production produces larger long-run welfare gains in response to an elimination of Social Security benefits than would occur in a comparable model without home production. The reasons are twofold and related to the general aspects of home production just discussed. The first reason derives from the feature that home production generally leads to a model that implies a more elastic labor supply rendering the payroll labor tax more distortionary. The second is that home production introduces insurance possibilities that are not present when only market-produced goods are available and, thus, reduces the need for government redistributive policies.

To be more specific, in both models, welfare improvements are largely driven by the removal of a distortionary tax and the increased desire for precautionary saving. As is standard, both channels imply a larger capital stock and greater steady-state consumption. But the one-good economy lacks margins of substitution that are central features of the model of home production. Namely, the home-production economy includes rental

[3] For example, with the exception of Chen (2010), all existing studies of Social Security reforms (see those cited in footnote 1) are conducted in one-good economies.

housing and the relative price of this good is directly influenced by the real interest rate. Because housing services contribute to utility and eliminating Social Security reduces the real interest rate, the existence of housing services that appear separately in the model provides for additional welfare gains. This channel has been explored by Chen (2010). The other margin of substitution present in the home-production economy is the ability to substitute work at home for work in the market place and low productivity workers and retirees use this margin as an insurance mechanism. Thus, the insurance provision provided by Social Security is less valued in the home-production economy. The resulting welfare gain is over 20 percent in the home production economy as opposed to roughly 9.0 percent in the standard one-good economy.

We also look at what occurs along a transition path. The particular path we analyze assumes a declining linear-labor tax along with additional government debt to offset the declining Social Security contributions. Eventually that debt is paid off, and the tax rate goes to zero. For both economies, future newborns benefit from the reform while existing generations pay a price. The general shape of the gains and losses to succeeding future generations and across age groups are qualitatively similar, but the magnitudes of the welfare effects are quite different. For example, the current middle-aged suffer the most in both economies. The decline in the interest rate reduces the return on accumulated assets, and they suffer significant losses in Social Security benefits. They also have a limited amount of time for accumulating additional assets in order to compensate for the loss of Social Security income. Further, capital accumulation has not proceeded long enough for them to achieve significant increases in the wage rate. This latter effect is prevalent to a greater extent in the home-production economy and in part accounts for the greater welfare loss of initial working generations along the transition path. However, with home production, the time it takes before future generations are unambiguously better off is shorter than in the economy without home production. The decline in house prices and the substitution into home production allows newly born agents to increase consumption rather quickly and, as mentioned, consumption is more highly weighted in the home-production economy. Eventually, the increase in the capital stock and resulting rise in the wage rate along with the decline in taxes serves to make all newborns better off in both of the economies considered.

The rest of the paper is organized as follows. In section 2, we describe the model economy and in section 3, we present the model calibration. In section 4, we conduct the experiment of eliminating Social Security, and in section 5, we recalibrate the model with only one good and conduct the same policy experiment. Section 6 investigates the transition paths and section 7 concludes.

2 The Model Economy

Our model economy follows Dotsey, Li, and Yang (forthcoming) with two exceptions. Social Security benefits now depend on households' average lifetime earnings, and households choose when to claim benefits, as in Imrohoroglu and Kitao (2012). 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 is not likely to noticeably affect our results.

2.1 Demographics

The economy is populated by overlapping generations of households of age $t = 1, 2, .., T$, where T is the maximum possible age. The life span is uncertain and households of age t face an exogenous probability of survival, λ_t. Since the demographic patterns are stable, agents at age t constitute 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.

Production of the home good requires a home input, housing, and labor. In particular,

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

where d denotes the home input, s denotes the rental stock, and n_h the labor input in home production.[4] We assume that renting is the only way of consuming housing services in this economy. The parameter ω_1 controls the weights associated with home input and housing, and the parameter ω_2 specifies the weight associated with the resulting composite good and hours used in home production. ζ_1 governs the intraclass substitutability between the home input and housing, and ζ_2 governs the interclass

[4] For 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 call this composite good home input. An interesting extension would be to treat these separately, especially for modeling the cyclicality of consumption.

elasticity of substitution between the composite home input and hours used in home production.[5]

The period utility function is given by

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

where

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

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 is 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 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 most important is the introduction of home production, which allows households to substitute between market and nonmarket activities. The second is the modeling of different consumption goods, including housing, and allowing them to interact with nonmarket activity.

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, at age, t, receiving a stochastic productivity shock ε_t^i, which follows a Markov process

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

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

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

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.

2.4 Borrowing Constraints

We impose an exogenous borrowing constraint on the economy. In particular, at any given period the household's financial asset denoted by a' must satisfy

$$a' \geq -e' \underline{\varepsilon}' w, \tag{5}$$

where $\underline{\varepsilon}'$ is the next period's lowest possible realization of a 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

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

where K is the aggregate market capital stock and L is the aggregate market labor input. The final good can be directly consumed, invested in physical capital, or housing, or used as an intermediate input in home production. Physical capital and housing depreciate at rates δ^k, and δ^s, respectively.[6]

2.6 Financial Institutions

Following Gervais (2002), we assume there exists a two-period-lived financial institution. 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 then rented to agents at a price η per unit. At the end of the second period, the financial institution sells the nondepreciated residential stock to a new agency. The

[6] We assume that the home input depreciates completely given that household appliances and equipment account for less than 10 percent of total home input.

no-arbitrage condition implies that the rental rate on housing is given by

$$\eta = r + \delta^s. \tag{7}$$

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 the Social Security cap $y_{\max}$, at a constant rate, τ. Retired households receive Social Security benefits each period, and these benefits are linked to their average lifetime earnings according to a piecewise linear function that resembles the current U.S. Social Security program. As well, the benefits depend on the age at which individuals begin claiming them.

2.8 Timeline

At the beginning of each period, after observing their current idiosyncratic labor shocks and their exogenous bequest, households make their labor supply decisions and rent capital to firms. They also purchase the home input and rent housing for the current period. At this point, market production takes place. Home production also takes place using labor, 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 in the following period to first satisfy an exogenous beginning-of-period asset position, and if funds are left over, 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 in the current period (ε), average lifetime earnings (y), and retirement age (t_r). We have

$$\begin{aligned} V(t, a, \varepsilon, y, t_r) = \max_{\{c_m, s, d, a', n_m, n_h, f'\}} \Big\{ & U(c, 1 - n_m - n_h) + \\ & \beta\lambda_t EV(t+1, a', \varepsilon', y', t_r') \Big\} \end{aligned} \tag{8}$$

subject to

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

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

$$y' = y \text{ if } t_r > 0, \tag{11}$$

$$t_r' = t+1 \text{ if } f' = 1, \; t_r' = 0 \text{ if } f' = 0, \tag{12}$$

$$c_m \geq 0, \; s \geq 0, \; 0 \leq n_m, n_h \leq 1, a' \geq -e_{t+1} \underline{\varepsilon}' w, \tag{13}$$

where $pen(t_r, y)$ is the pension after retirement and it depends on the retirement age and the average lifetime earnings at the time of retirement, and f' indicates the retirement decision. In any subperiod, 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 claiming Social Security, and even after that, they can still work and are subject to the payroll tax. The composite consumption good c is defined as in equation (3), and 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 accumulate according to equation (10) if the agent has not claimed any Social Security benefits.

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 aggregate moments calculated from data on 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.[7] Given our estimated parameters, we indicate that the model also captures life-cycle profiles of labor and both market and nonmarket consumption.

[7] Though our model is exactly identified, because the problem is highly nonlinear, we are not able to match all the target moments exactly.

In modeling the home-production technology, we follow the literature by equating hours spent in home production with time spent on home in activities that are not enjoyable and also produce goods or services that can be purchased in the market.[8] Otherwise the time is classified as leisure. Restricting the definition of home work to activities that have market substitutes helps generate greater interaction between consumption of market- and home-produced goods.

As is standard in the literature, we include residential capital stock (housing) in home production. We, however, differentiate home input, an intermediate market good, from the residential capital stock and model it as an additional input into home production. We allow households' preference over different goods and leisure as well as their home-production technology to take flexible functional forms that exhibit constant elasticity of substitution. Additionally, we endogenize households' decisions to claim Social Security benefits along the lines of Imrohoroglu and Kitao (2012). Finally, our calibration captures many realistic features of the Social Security system, such as the link between households' Social Security benefits and their past earnings and age when benefits are initially claimed.

3.1 First-Stage Calibration

The model period is two years.[9] Each person enters the model at age 24. The maximum life span T is 90. The bottom panel of Figure 1 shows the λ_t's, the vector of conditional survival probabilities. We use the mortality probabilities weighted by gender from the Social Security Administration life tables from 2000.

We calibrate the production parameters according to the National Income and Product Accounts (NIPA) and the Fixed Assets Tables for the years 1957 to 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 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, within the range of those used in the literature. The interest rate on capital net of depreciation, r, 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, is taken from French (2005) and is shown in the top panel of Figure 1.[10] The labor-efficiency

[8] An alternative approach would be to follow (Becker 1965) where the enjoyment of each consumption good requires a combination of market expenditure and time inputs.

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

[10] We scale up the profile by a factor of 26 to target an economywide income of $31,900, the average income calculated from Consumer Expenditure Survey (CEX) after taking out the family size, marital status, and interview year effect.

profile is hump-shaped, with a peak at age 50. The persistence ρ_ε and variance σ_ε^2 of the stochastic productivity process are 0.96 and 0.045, respectively, and the variance of the initial distribution of productivity is 0.38 (Huggett 1996). For simplicity, we assume that the labor efficiency profile for home production is constant.[11]

The Social Security earnings cap $y_{\max}$ is 2.47. The retirement benefit at age 66 is calculated to mimic the Old Age and Survivor Insurance component of the Social Security system:

$$pen(\widetilde{y}) = \left\{ \begin{array}{ll} 0.9\widetilde{y}, & \widetilde{y} \leq 0.2; \\ 0.18 + 0.32(\widetilde{y} - 0.2), & 0.2 \leq \widetilde{y} < 1.24; \\ 0.5128 + 0.15(\widetilde{y} - 1.24), & 1.24 \leq \widetilde{y} < y_{max}; \\ 0.6973, & \widetilde{y} \geq y_{max}. \end{array} \right\}$$

The bend points and Social Security earnings cap, expressed as fractions of average earnings, and marginal rates, are from Huggett and Ventura (2000). If a household retires at the age of 62, it receives 75 percent of the full pension; at age 64, it receives 87 percent; at age 66, it receives the full pension; 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 services and the home input. We set this parameter to the value identified in Dotsey, Li, and Yang (forthcoming) 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, and therefore, the parameter ζ_1 is not identifiable.

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 24 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, which implies most households start with close to zero wealth. The rest of the bequests, if there are any, are distributed evenly to all living agents, which endogenously determines b.

[11] The results only change marginally if we use an age-varying labor efficiency profile for home production as in Dotsey, Li, and Yang (forthcoming).

3.2 Second-Stage Estimation

For the second-stage estimation, we use the NIPA and two microdata sets on households' consumption expenditures and time use, CEX, and the American Time Use Survey (ATUS). Dotsey, Li, and Yang (forthcoming) provide detailed information on these two data sets 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 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 forthcoming).[12] 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 consumed 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 furnishings and equipment, utilities, fuels, and public services. We prorate transportation expenses by travel time for home production or market production that we obtained from the ATUS. For housing, we use rental payments for renters, and we use homeowners' reported house value of owned residences. We then calculate the rental house size as rental payment divided by 6 percent, the value of η in our model.

Regarding the estimated moments, we deviate from Dotsey, Li, and Yang (forthcoming), who use differences across home owners and renters in estimation, and instead choose to match moments on consumption and time use calculated for the young (those between ages 24 and 49) and the old (those between ages 50 and 80).[13] 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 economywide consumption of the home input relative to housing stock, the average home input of both the young and

[12] In 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)

[13] The reason for this departure is that we no longer have owner-occupied housing in the current set up.

the old, and their respective average market hours and home hours. We also normalize the average expenditure by economywide income. Thus, we simultaneously choose these nine parameters to match the nine 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 nine moments to identify nine parameters, certain moments are relatively more responsible for pinning down the shares and elasticities in the Constant Elasticity of Substitution (CES) aggregates.

For example, β is largely determined by K/Y and τ is mainly pinned down by Social Security budget balance. The three elasticity parameters ($\zeta_i,\ i = 2, 3, 4$) play crucial roles in determining households' supply of labor to different activities and consumption of different goods. Given ζ_1, which is taken from the paper mentioned earlier, we calibrate ω_1 by matching the ratio of home input to housing size. 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 in consumption of the market good across young and old helps to pin down ζ_3 and ω_3. Finally, the difference in the relative time worked in the marketplace by each of these cohorts is useful for identifying ζ_4 and ω_4 because they help determine leisure. However, the estimation is more complicated than indicated by the discussion here and is not totally driven by one set of moment differentials driving one pair of elasticity and share parameters.

3.3 Resulting Life-Cycle Profiles of Consumption and Labor Supply

Though the target moments are somewhat different, the second-stage calibrated parameters are similar to those in Dotsey, Li, and Yang (forthcoming). The home input and housing are Hicksian substitutes in the productions of the composite home good, while the composite of home input and housing exhibits strong complementarity with home hours 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 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. McGrattan, Rogerson, and Wright (1997) estimate the residential capital to be complementary to home hours in home production. 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). It also helps to jointly explain the relatively flat life-cycle profile in the consumption of housing services and the degree of substitution into home hours as labor productivity in the market declines. The strong substitutability between market goods and home goods is consistent with the findings in the literature, notably McGrattan, Rogerson, and Wright (1997) and Rupert, Rogerson and Wright (2000).

The estimates of ς_2 and ω_4 have relatively important implications for our results. The complementarity between the composite home input and housing ($\varsigma_2 = 0.800$) implies that when more housing is purchased agents also devote more time to home production. Thus, any reform that increases the demand for housing will increase consumption through greater home production. The estimate of ω_4 is important because it puts more weight on consumption than we find in the one-good economy. In the one-good economy, home hours are classified as leisure, and in order to match the average amount of leisure greater weight must be put on leisure in the utility function.

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 ATUS (2005-2011) and the CEX (2003-2010) as in Dotsey, Li, and Yang (forthcoming). 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 until age 50 and then decline steadily. By age 65, the average household devotes less than 10 percent of its time to market work. The consumption profiles are hump-shaped. Notice that in our model the consumption profile for the home input and housing track each other when measured as log deviations from their respective levels at age 40; thus we only depict the data for housing.[14] Additionally, the hump shape in the consumption of the market good is more pronounced than that of housing (and by extension the home input). Thus, our model is consistent with the findings of Aguiar and Hurst (forthcoming).

Figure 3 plots the cumulative fraction of all retirees who claim an initial Social

[14] Since the data profile for home input is more humped than that for housing, our model profile is actually a better fit for home input.

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 Imrohoroglu and Kitao 2012). The model does a reasonably good job of matching the data profile except that the model predicts an initial entitlement age distribution that is a little flatter than the data. In other words, slightly 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 and the associated payroll taxes. We first report the aggregate statistics, the life-cycle effects, and then analyze the welfare implications of this reform.

4.1 Aggregate Statistics

Table 4 summarizes the aggregate effects of removing Social Security by comparing our benchmark economy with and without 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 also save more to ensure that they have adequate wealth late in life. 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.

When both aggregate capital K and aggregate labor L increase, the change of r and w depend on the relative increase of K/L as $r = \alpha(K/L)^{\alpha} - \delta^{k}$. According to our analysis, eliminating the Social Security system leads to a decline of 60 basis points in the equilibrium interest rate as households save more through the private market for their retirement and to insure against idiosyncratic income shocks. Accordingly, the aggregate capital output ratio increases to 1.80 from 1.71, an increase of over 5 percent and the wage rate increases by 1.50 percent. The increase in the wage rate and the reduction in the payroll tax leads to an increase in market hours of over 6 percent compared to the benchmark with Social Security. Overall, households are also wealthier and the wealth effect attenuates the increase in hours worked.

In the absence of Social Security, households are wealthier, and thus they consume more. However, the increase in consumption varies substantially across goods. The fall in the interest rate reduces the relative cost of housing by directly lowering rents. Aggregate housing consumption rises by more than 20 percent in relation to the benchmark.[15] Households also substitute cheaper housing for home input. As a result, the 0.26 percent increase of the home input is much smaller than the increase in housing services. Households' consumption of market goods also increases, and the 3.36 percent increase is larger than the increase in home input, but much smaller than the increase in housing services. The increase in the consumption of housing services induces households to increase their supply of home hours because housing services and home hours are complements in home production. However, the increase in market hours due to the increase in the wage rate has an offsetting effect on the supply of home hours that largely offsets the upward pressure from higher housing consumption. On balance, households' supply of home hours moves up by a slight 0.90 percent. Leisure, by comparison, falls by close to 1.56 percent. Aggregate effective labor, defined as hours weighted by efficiency units, increases less than total market hours, indicating that less productive individuals increase labor supply more than productive ones.

4.2 Life-Cycle Effects

In Table 5, we report consumption, market hours, and home hours, at different points of the life cycle before and after Social Security reform. Social Security reform increases the return to supplying market hours when there is no longer a payroll tax and the wage rate is higher. The reform also increases hours spent in home production when households are young, as the lower interest rate makes housing more affordable and the complementarity of the home input results in more home input being purchased as well. Middle-aged households are affected less because they are relatively more productive, and using home hours is relatively expensive for them. The absence of Social Security benefits also gives older households additional incentives to work in the market. The end result is that households younger than 34 reduce their market hours and increase their home hours. By contrast, households older than 54 increase their market hours and reduce their home hours.

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, for a given interest rate, the ratio of the consumption of home input to housing is constant among households. The reduction in the consumption from age 54 to age 84 is less evident in home input and housing than in market consumption. This is because in

[15] This relatively large effect is also found by Chen (2010).

our model, home hours are complements to the aggregate of home input and housing. As hours working at home increase as households age, so do housing and home input, effectively flattening the associated life-cycle profiles.

4.3 Welfare Implications

In this section, we explore the long-run welfare implications of Social Security reform. The transitional dynamics will be discussed in section 6. Following McGrattan, Rogerson, and Wright (1997), 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 the two steady states holding the amount of leisure constant. We follow their procedure because market consumption is the only consumption good that is common across our two models. By this measure, we find that aggregate welfare increases by 20.75 percent (see Table 6) after the complete elimination of Social Security.

Social Security provisions affect welfare in several ways. On the positive side, Social Security benefits provide partial insurance against mortality risk. Social Security also redistributes wealth among retirees, and thus provides partial risk sharing against income uncertainty.[16] However, Social Security provisions are financed through distortionary payroll taxes, which lead to a reduction in labor supply and hence the capital stock. The reduction in labor supply leads to reduced income, which is particularly costly to those who are credit constrained. Social Security also reduces precautionary saving and hence the capital stock implying that the productive capacity of the economy without Social Security is considerably greater. In our analysis, as in the existing literature, the distortionary effects outweigh the welfare-improving effects.

To explore the distributional effects of the reform, we group households according to their initial market labor productivities at age 24. Interestingly, the welfare gains of eliminating Social Security benefits are negatively correlated with an individual's initial productivity. The least productive households receive the most gains (43 percent) and the most productive households receive the least gains (4 percent). The welfare gains for the other three groups are 32 percent, 22 percent, and 14 percent, from less to more productive. These results suggest that the distortionary effects associated with payroll taxes and the lower wages associated with the existence of Social Security outweigh the distributional effects, and that these distortions are particularly acute for those individuals who face a borrowing constraint, namely, the least productive households.

[16] For a useful discussion in a model with fixed labor supply, see Storsletten, Telmer, and Yaron (1999).

4.4 Welfare Results in Partial Equilibrium

One important feature of general equilibrium models with uninsurable income risks is that interest rates respond strongly after the removal of any public policy that crowds out private savings. Indeed, as evidenced in column 3 of Table 4, interest rates declined by nearly 13 percent after the elimination of Social Security benefits. In order to quantify the importance of this general equilibrium feedback effect, we conduct an additional analysis where we abolish Social Security, holding factor prices (interest rates as well as wages) fixed. The results are reported in column 4 of Table 4. Note that the aggregate capital reported in column 4 is capital demand. Capital supply by households in our economy is much larger as evidenced by households' asset holdings. In partial equilibrium, the two need not be the same.

As expected, without a payroll tax, households increase their market hours though not by nearly as much as in general equilibrium since the wage rate does not increase. In the absence of Social Security benefits, households also save much more for old age and to protect themselves against uninsurable income risk than they do in the general equilibrium due to the higher interest rate that affords households a greater return on savings. As a result, households hold more assets and are richer. The aggregate capital output ratio, on the other hand, is only a function of the relative prices and is, therefore, unchanged from the benchmark.

Because households are richer, they increase all three consumption goods relative to the benchmark. The higher rental price in partial equilibrium than in general equilibrium implies that households will increase to a greater degree their consumption of home input and the market good relative to housing than they do when general equilibrium effects on factor prices are taken into account. The net effect of a larger increase in home input and a smaller increase in housing is that home hours also increase slightly more while leisure declines slightly less than in the general equilibrium.

In terms of welfare (Table 6), eliminating Social Security benefits generates a gain of 20.03 percent, not much lower than the 20.75 percent in the general equilibrium. With interest rates and wages fixed, precautionary savings increase by more than in general equilibrium but labor income declines. As a result, households' total income in partial equilibrium is similar to that in general equilibrium. In terms of consumption, the increase in consumption in partial equilibrium is offset by the decline in leisure.

The comparison between the general equilibrium results and the partial equilibrium results indicates that the large welfare gain after the reform in our model with home production is not largely driven by the reductions in the interest rate. The least productive households still receive the largest gain, but the gain is smaller than in the general equilibrium experiment because they no longer benefit from an increase in the wage rate. The gain for the most productive households, which are also wealthier, is higher than in the general equilibrium experiment since the interest rate does not drop after the reform, which implies a higher return on wealth.

5 Analyzing the One-Good Economy

The traditional literature on Social Security reforms has exclusively focused on a one-good economy. To facilitate the comparison of our economy with the literature, we investigate an economy where households consume only one good, which is the sum of the market good, the home input, and housing services as defined in our benchmark economy. We, however, maintain the functional form of constant elasticity of substitution between aggregate consumption and leisure for the period utility.

Specifying a one-good economy requires reclassifying hours, capital, and the output-capital ratio. In turn, in order to match various data moments, these changes imply very different parameters and in particular a lower labor supply elasticity. Specifically, in the one-good economy housing capital is now part of the aggregate capital stock, and for consistency, housing services are added to market output. With these adjustments, the new capital output ratio is 3.668, and the average depreciation rate is 0.042.[17] The resulting capital share in production α is now 0.339 in order to match the 5 percent interest rate that we used to calibrate the benchmark model. We rescale the labor efficiency profile to arrive at the same aggregate wealth as in the benchmark. We reestimate the discount factor β, Social Security payroll tax rate τ, the elasticity parameter for consumption and leisure ζ_4, and the weight on consumption ω_4. The elasticity parameter for consumption and leisure ζ_4 and the weight on consumption ω_4 are set to 1.521 and 0.069, respectively, to match the average market hours for the old (0.118) and the young (0.205). The implied Frisch labor-supply elasticity of the one-good economy is 2.85 as opposed to 5.11 in the benchmark.[18] The model implied market hours are 0.109 for the old and 0.220 for the young, roughly matching the empirical moments. We summarize our new calibration in Table 7 and chart the model implied life-cycle profiles and data generated profiles in Figure 4. As shown, while completely missing the profiles of home hours by construction, the model does a fairly good job at matching the market labor profile. However, it generates too pronounced a hump in the consumption profile when

[17] Our housing measurement in the benchmark comes from CEX. As is well known, the number there is somewhat higher than that captured by NIPA. In order to faciliate comparison with the benchmark, we calibrate the capital output ratio in the one-good economy using the CEX implied housing stock.

[18] These elasticities are calculated using mean hours and consumption expenditures in the model, and therefore, do not analyze the different elasticities that would be obtained for the constrained households in the model.

compared to the data.[19,20]

We then conduct the same policy experiment as in the benchmark model. We report the aggregate statistics in Table 8 and average consumption and labor-supply at different points of life cycle before and after the policy change in Table 9. Aggregate capital increases substantially, by 18.31 percent, much larger than that in our benchmark economy. In the benchmark, the increase of total wealth after the reform is also very high (15.82 percent). However, since most of the increase goes to housing, in the benchmark model, the increase in capital is more moderate, and as a result, the decrease in the interest rate and the increase in the wage rate are also smaller than in the one-good economy. The substantial increase in the wage rate in the one-good economy also explains why market labor supply increases by 7.989 percent, a rate larger than the increase in the benchmark despite the lower labor-supply elasticity. Because of a lower equilibrium interest rate, the life-cycle profiles of both labor supply and consumption flatten out with the young and the very old increasing their market hours and market consumption more than the middle-aged. Overall, the change in consumption profiles behave similarly to those of the market good defined in the benchmark economy.

Finally, we show the welfare gain by initial productivity in Table 10. The welfare gains of eliminating Social Security benefits drop to 9.25 percent, over 10 percentage points lower or roughly half as much as the welfare gains in the benchmark economy. The main reason for this result is the change in the parameters of the utility function in the two models. Consumption varies much more than leisure when Social Security is eliminated and it has a greater weight in utility in the home production economy. Further, because the home-production economy provides some modest insurance against income risk Social Security is less valued in the benchmark economy.

Ranking households by their initial market labor productivity from lowest to highest, the welfare gains are 13.42 percent, 11.85 percent, 9.94 percent, 7.51 percent, and 3.81 percent, respectively. However, the gains are much smaller compared with the benchmark economy for households with lower initial labor productivity. This highlights the role of home production as an insurance mechanism for those agents with lower initial productivity who on average have low lifetime productivity in the market.

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

[20] Imrohoroglu and Kitao (2009) generate an even larger hump in consumption, which peaks much later in life than in the data.

5.1 Comparing the Welfare Results

In order to better understand the different magnitude of the welfare results in the two economies, benchmark as opposed to one good, we analyze an intermediate case where we remove productive home hours but maintain a home-produced good that uses a combination of housing services and home good as inputs. Note that this economy has the same capital and capital-output ratio as in the benchmark economy. We then set ω_2 to zero, and keep ω_1 and ζ_1 the same as in the benchmark economy and recalibrate the rest of the preference parameters to match the various data moments. Since home production is no longer constrained by the provision of home hours, we need a much larger weight on the market good than in the benchmark economy. Specifically, ω_3 takes the value of 0.55 as opposed to 0.13 in the benchmark economy. The parameter ζ_3 takes a value 1.71 that is somewhat less than the 2.19 value we used for the benchmark. The values for the parameters ω_4 and ζ_4, at 0.09 and 1.46, are close to the values we calibrated in the one-good economy. The implied Frisch labor elasticity at 2.85 is the same as the one-good economy.

This model, therefore, serves as a bridge between the two models just analyzed. Adding a home-produced good provides an additional margin of substitution beyond what is present in the one-good economy. Adding back home production returns us to the benchmark specification. Eliminating home production in this economy leads to an increase in aggregate savings of 17.27 percent, close to that of the one-good economy. Much of the increase in wealth, however, goes to housing leading to an increase of over 21 percent in housing services, about 2 percentage points higher than the increase in the benchmark. Both the increase in productive capital and labor supply lie in between the increases in the other two economies. The end result is that total welfare increases by 16.48 percent. The 7 percentage point difference between welfare gain in this economy and that in the one-good economy results from the changes in the relative price between housing services and the other goods as in Chen (2010). The 4 percentage point difference between welfare gain in this economy and the benchmark economy $(20.75 - 16.48)$ stems from the introduction of home production to the multi-good economy. It is worth noting that the introduction of home production neutralizes some of the benefits from the changes in the relative price as the demand for housing services are now constrained by the provision of home hours.

An indication that home production provides insurance to households can be seen by looking at the Gini coefficients of consumption by age across three different models. This is shown in Figure 5, where the three models correspond to the benchmark, the benchmark when we remove home hours in home production, and the one-good economy. Both with and without Social Security, the Gini coefficients are much lower for all ages when home production is part of the model environment. Importantly, the increase in the Gini coefficient when home production is eliminated occurs when we eliminate home hours as the Gini's are roughly equivalent for the one-good and intermediate models. Note that in all three economies, after eliminating Social Security, the distribution of consumption becomes less skewed, especially for the young. This indicates that households are able to smooth consumption better. This is because the reduction of taxes and the increase of the wage rate enables borrowing-constrained poor households to increase consumption but it does not affect rich households who save for retirement. See Yang (2013) for more discussion.

6 Transitional Dynamics

In analyzing reforms to Social Security, it is important to also investigate transitional dynamics. Here we look at a reform that provides for a gradual transition out of Social Security. Our main purpose is to compare the implications of adding home production for the transition, rather than designing an optimal transition or a transition that would be approved by a median voter as in Cooley and Soares (1999).

The particular reform we look at grandfathers retirees and prorates benefits based on how much a person has contributed to Social Security before it is abolished. Basically, we apply the Social Security formula to each individual based on his contribution to date. Additionally, a proportional tax is levied on labor income in order to fund the existing claims and is gradually lowered according to a linear schedule. The tax rate becomes zero once all claims have been satisfied. Thus, there are no claims or taxes after 66 years, which is the maximum time span for anyone who contributed to still be alive. Initially, some of the Social Security payments are funded by government debt, but by the time all payments have been made the tax rate also becomes zero and the debt has been repaid.

As shown in Figure 6, in both the home-production and one-good economies households initially work less as they intertemporally substitute effort into the future when tax rates are lower. As a result, asset holdings initially decline as well but to a lesser extent than the supply of labor. The greater relative decline in labor causes a rise in the capital labor ratio and results in a decline in the interest rate and a rise in wages. However, the increased need for precautionary saving quickly causes the capital decline to slow and for capital to eventually start increasing toward its new steady state value. The decline in the labor supply also dampens and hours worked then gradually increase toward the new steady state as well. Home hours, by comparison, increase initially and then decline as market hours start to recover due to the increase in after-tax wages.

After about 10 periods, home hours rise again as households' consumption of housing services increases raising the demand for home hours. Overall, home hours fluctuate within a much narrower range than market hours. Taken together, the capital labor ratio initially increases from its period one value and then declines toward steady state. This behavior accounts for the hump shape profile in interest rates and U-shaped wages along the transition path.

Although the qualitative behavior of aggregate variables is similar along the two economies' transition paths, there are some important quantitative differences. First, a significant fraction of the increase in assets in the home-production economy are used to fund a greater housing stock, while by definition all of the increase in assets goes into capital in the one-good economy. Further, because the precautionary motive is greater in the one-good economy, saving increases by more, and the new steady-state interest rate is lower and the wage is higher. Finally, in the benchmark low productivity workers substitute market work with home work. As a result, labor supply in efficiency units are higher for the benchmark than for the one-good economy.

The welfare consequences along the transition are depicted in Figure 7. In the one-good economy, all of the existing agents are worse off and the middle-aged are particularly hard hit. They have lost a sizable amount of future Social Security payments without having a substantial amount of time to accumulate additional assets. Also, the wage rate does not increase sufficiently over their life span to compensate for the loss in Social Security benefits. Those in retirement and close to retirement are little affected as their Social Security benefits are either unchanged or little changed. The small welfare decline is due to a fall in the interest rate. The current young lose a bit, because the tax rate they initially pay is being used to fund current retirees, and the young will not benefit from Social Security. Also, it takes more than one generation for the capital stock and the productive capacity of the economy to increase by a large enough extent to more than compensate for loss of the Social Security annuity.

In the home-production economy, the welfare profiles are similar, but the losses for all but the retirees are more pronounced. Retirees actually benefit, because the decline in the interest rate allows them to rent bigger houses and produce more at home. Further, the decline in the interest rate is not as great as in the one-good economy and retirees therefore do not lose as much interest income from their accumulated savings. On net, the gain, however, is small. The larger welfare loss for other current generation agents occurs in part because a higher tax rate on labor is needed to finance the remaining Social Security obligations. The higher tax rate arises from the fact that the labor supply elasticity in this economy is much larger than in the one-good economy, and the greater reduction in hours worked requires a higher tax rate in order to generate the necessary revenue. The larger elasticity of labor implies that taxes are more distortionary in the presence of home production. Additionally, households in the one-good economy have higher wages and therefore, can accumulate precautionary savings and reduce the negative consequences of the borrowing constraint implying a lower proportional welfare loss. However, as the bottom panel in Figure 7 shows, new born agents become better off sooner in the home production economy. As the after-tax wage rises along the transition path, the combination of a more elastic labor supply as well as the addtional means of self insurance afforded by home production in the presence of a larger housing stock are the primary contributors to future generations benefiting from Social Security reform at a slightly faster pace.

7 Conclusion

We study the aggregate economic and welfare effects of Social Security reform in an environment with home production and multiple consumption goods. We show that abolishing Social Security improves steady-state welfare as well as differentially affecting the demand for various goods depending on the degree of substitutability between home production and market work for each particular good. Importantly, the steady-state gains are more than twice as large as those in a standard one-good economy model that is used in the extensive literature devoted to the study of possible reform of the Social Security system.

Our results indicated that abstracting from the key role that home production plays over the life cycle may result in a significant understatement of the costs of Social Security. Further, the presence of home production can have consequences for the transitional dynamics associated with reforms of Social Security. For the particular reform we examine, current generations are made significantly worse off relative to steady-state in the home-production economy than they are in the one-good economy. However, future generations enjoy the benefits of the reform somewhat sooner. We trace some of these differential welfare effects to the additional margins of substitution afforded to agents when they have access to a home-production technology. To summarize, because the home-production economy is better able to match life-cycle profiles and to jointly explain time use and the types of goods consumed over the life cyle, it may provide a better platform for analyzing the consequences of changes in government policies that impact household behavior.

Appendix A. Definition of the Stationary Equilibrium

We focus on the stationary equilibrium of the economy where factor prices and agent distribution over the 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_s the aggregate investment on housing, I_k the aggregate investment on physical capital.

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; price of rental housing η; 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, $\upsilon(x)$, such that the following conditions hold:

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

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

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

$$r = F_1^m(K, L) - \delta^k,$$
$$w = F_2^m(K, L).$$

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

$$\int b\upsilon(dx) + \int_{t=0} (a(1+r))\upsilon(dx) = \int (1-\lambda_t)[(1+r)a']\upsilon(dx).$$

(v) No arbitrage condition holds

$$\eta = r + \delta^s.$$

(vi) Government budget is balanced at each period

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

(vii) All markets clear

$$S = \int s\upsilon(dx),$$
$$D = \int d\upsilon(dx),$$
$$K = \int a\upsilon(dx) - S,$$
$$C_m = \int c_m \upsilon(dx),$$
$$L = \int \varepsilon e_t n_m \upsilon(dx),$$
$$I_k = K' - (1-\delta^k)K,$$
$$I_s = S' - (1-\delta^s)S$$
$$F^m(K,L) = C_m + D + I_k + I_s.$$

Appendix B: Computation of the Model

To compute the steady state of our model, we first discretize the income process into five points. The state space for average lifetime earnings and asset holdings is 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 market clearing conditions and government budget constraint. If both hold, an equilibrium is found. If not, go to step 1 and update the initial guess.

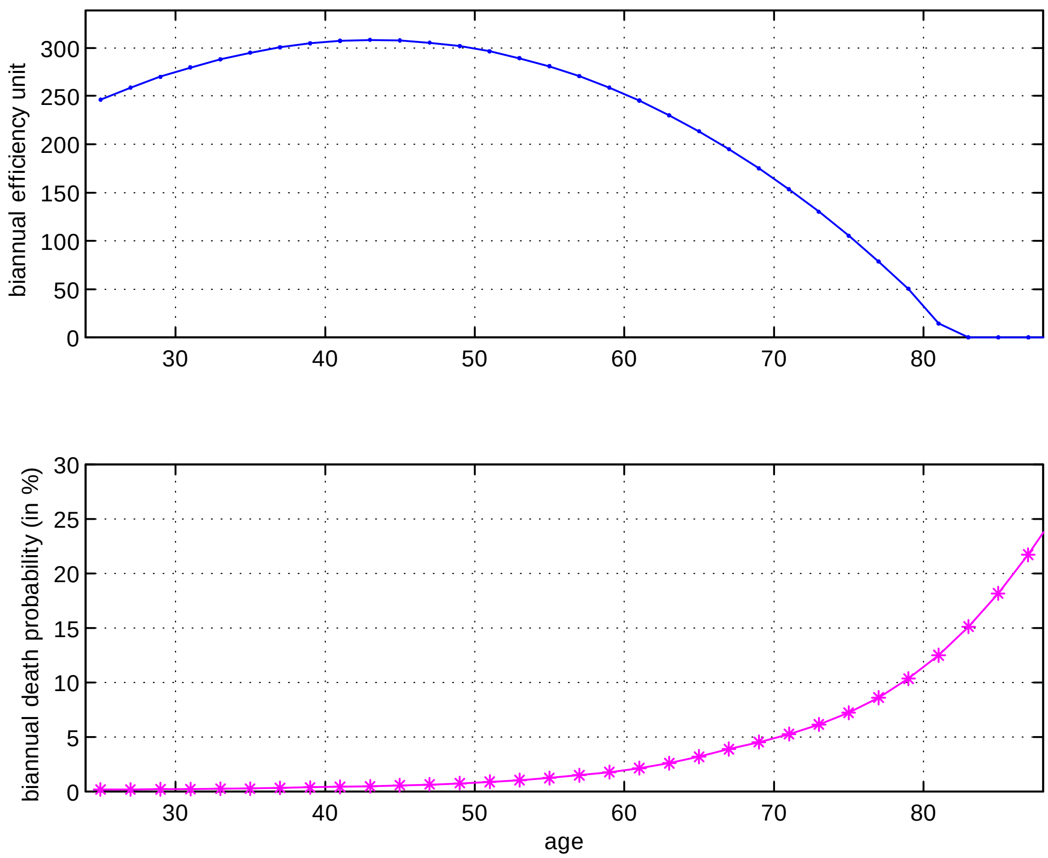


Figure 1. Life-Cycle Profiles

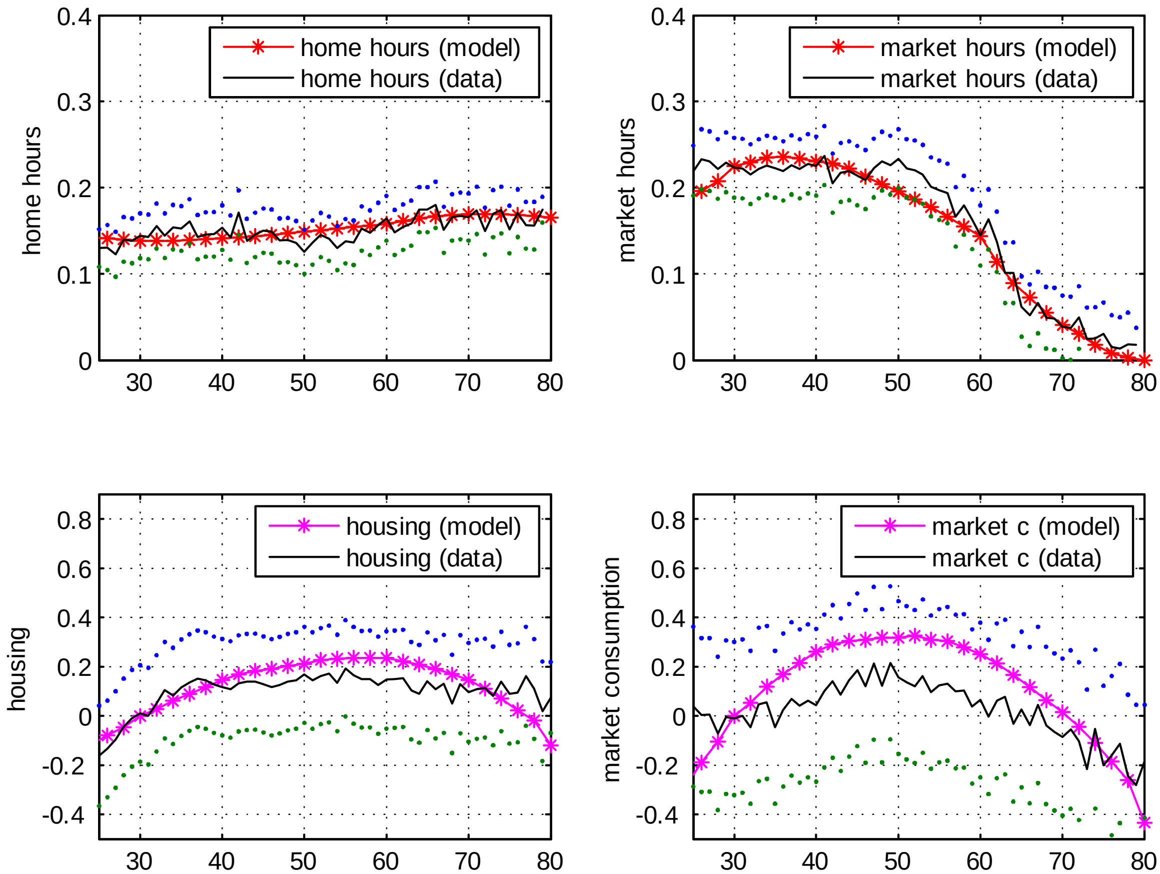


Figure 2. Life-cycle Labor Supply and Consumption Profiles — Benchmark without Home Production (the dotted lines represent the two-standard-deviation error band)

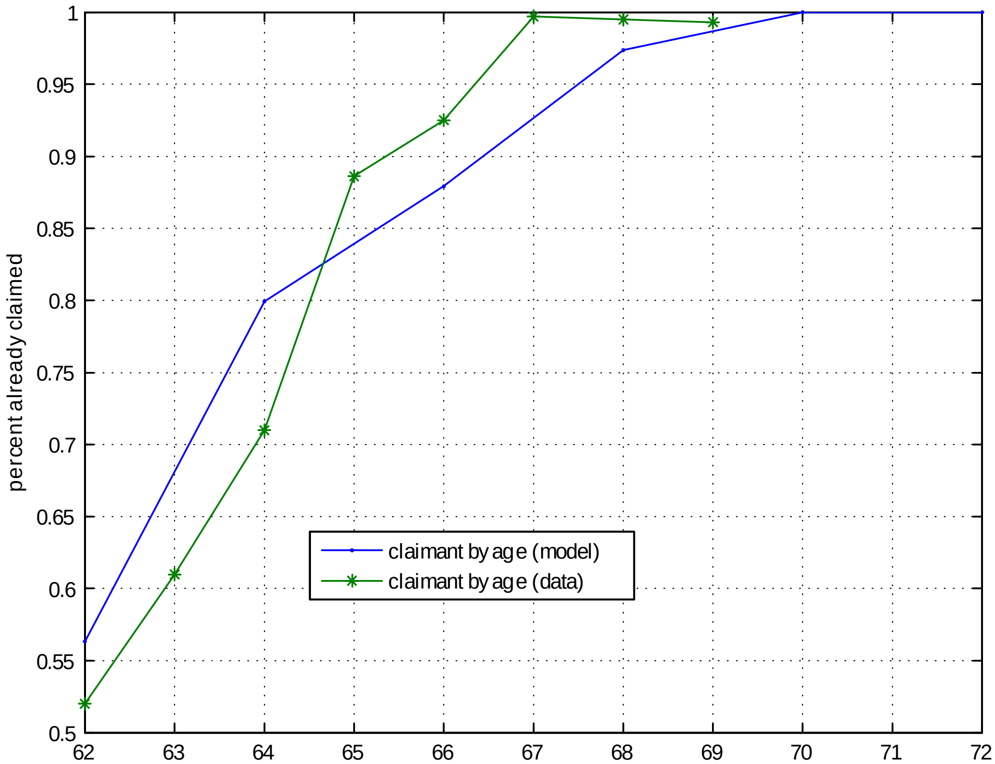


Figure 3. Social Security Claims by Age

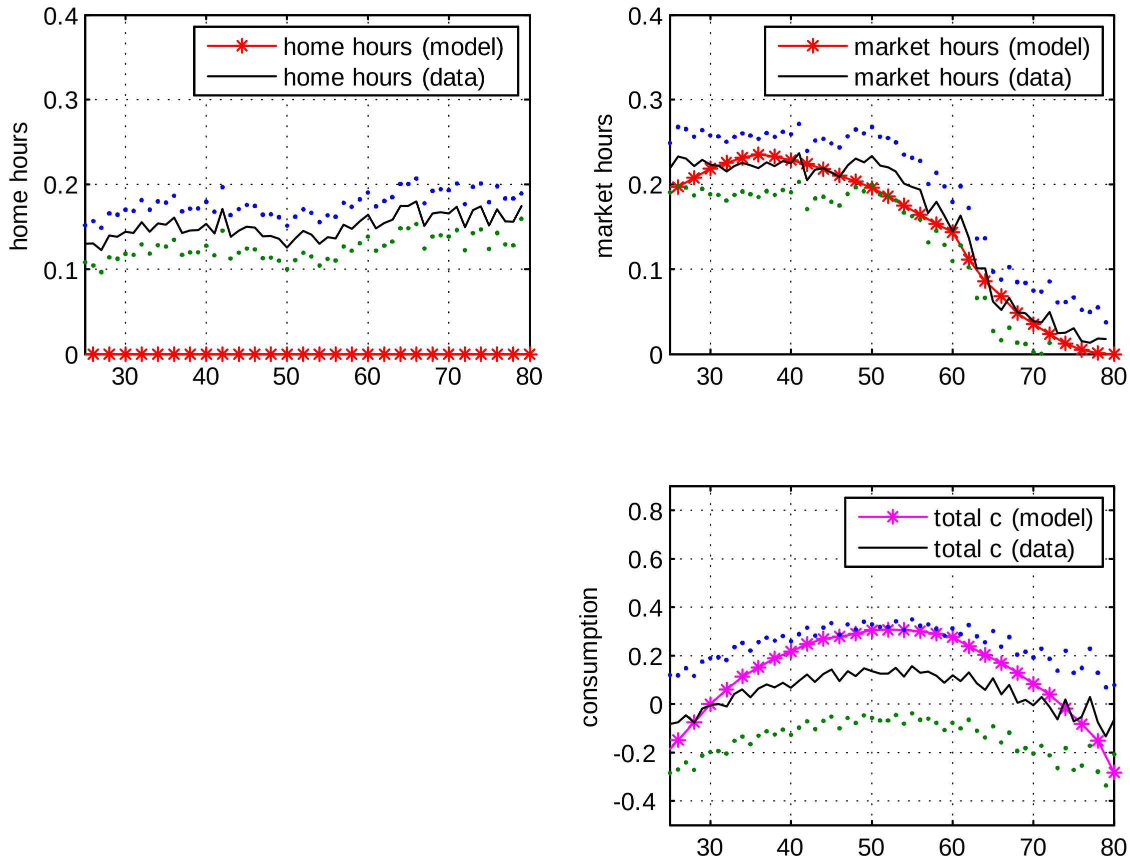


Figure 4. Life-cycle Profiles of Labor Supply and Consumption in the One-good Economy (the dotted lines represent the two-standard-deviation error band)

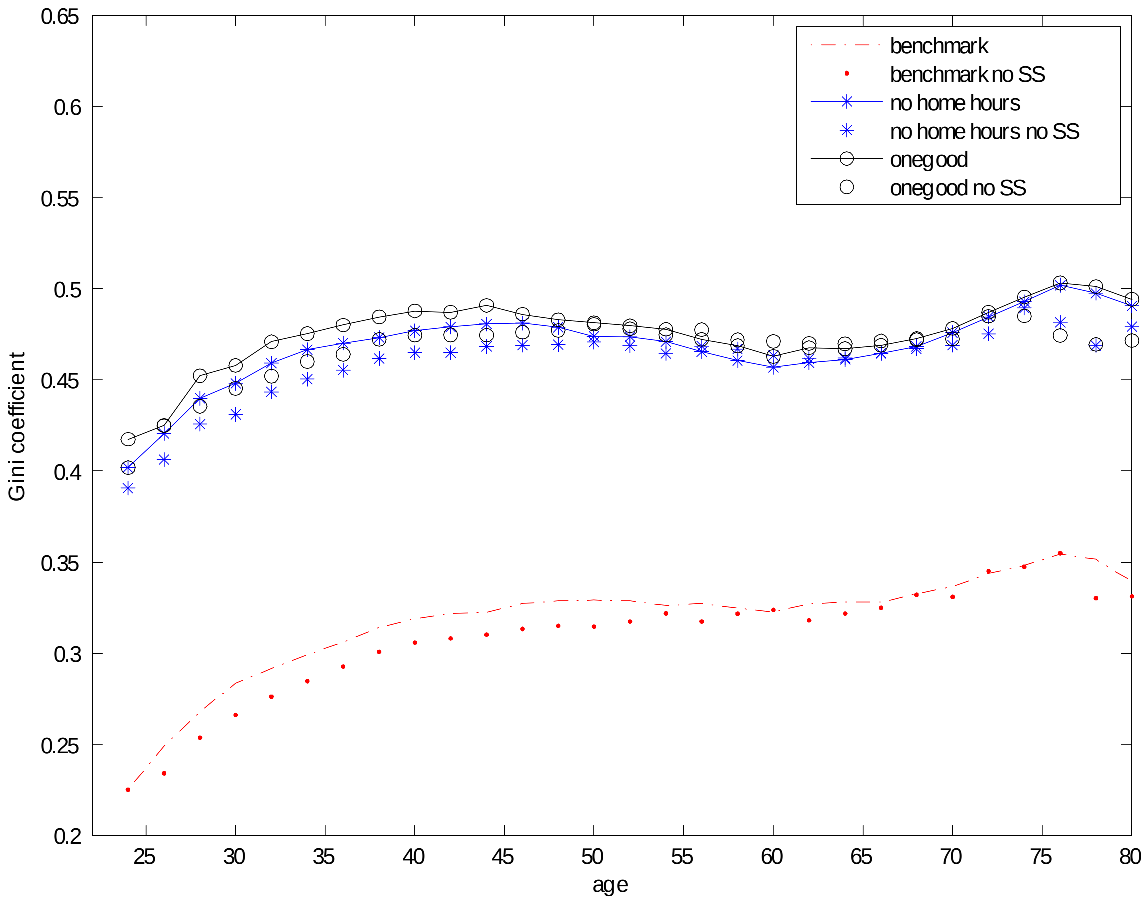


Figure 5. Consumption Gini Coefficients

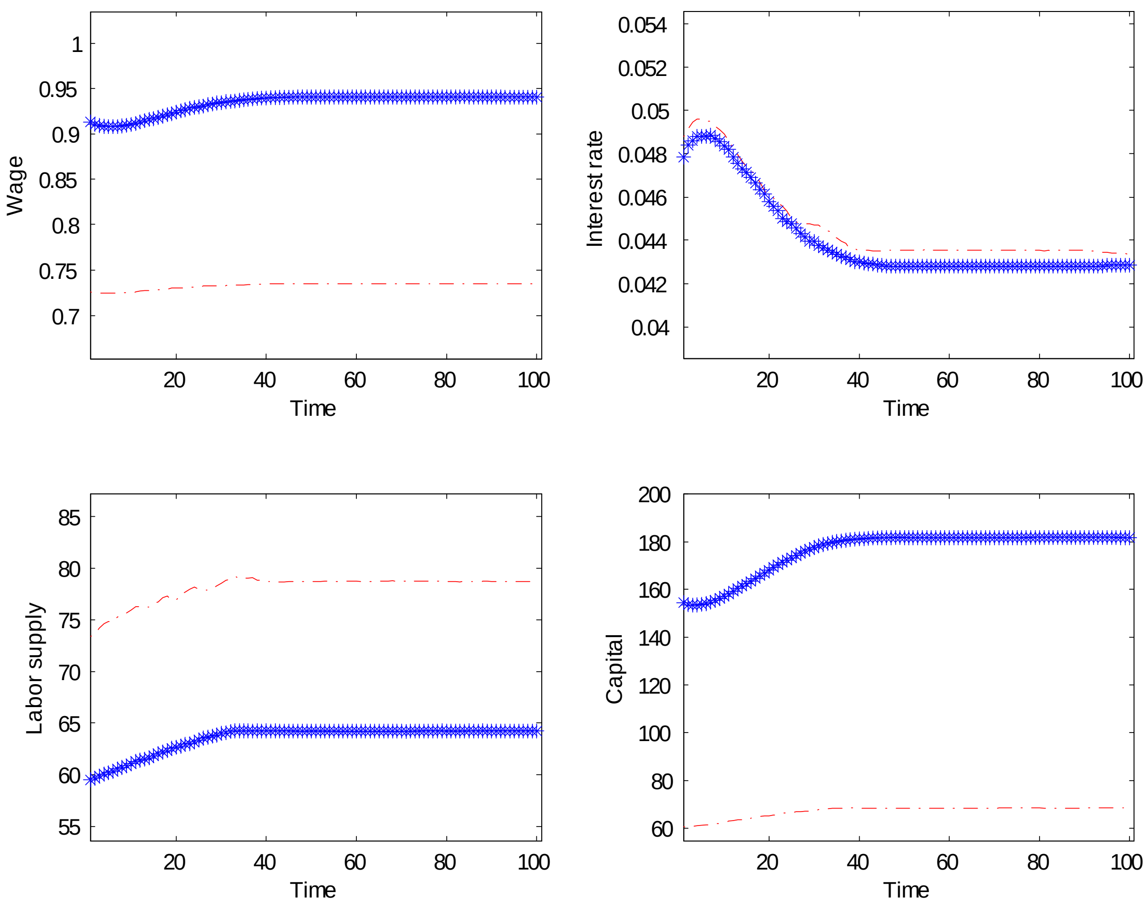
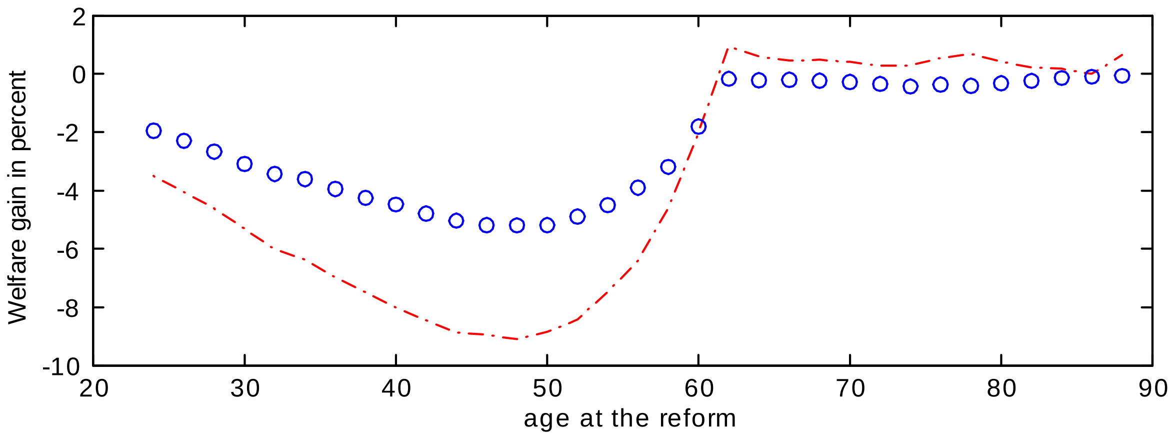


Figure 6. Transitional Dynamics (dashed line: benchmark economy; solid line: one-good economy)



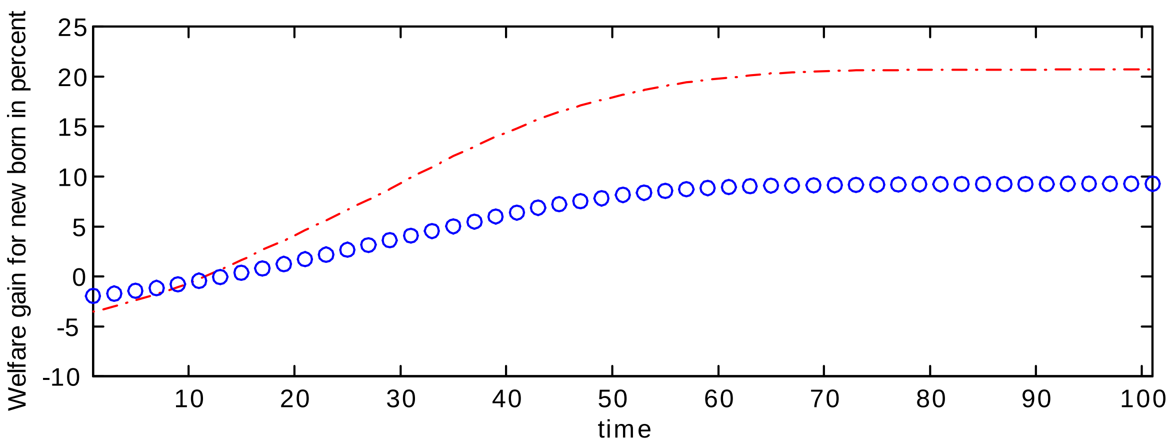


Figure 7. Welfare Along the Transition Path (dashed line: benchmark economy; solid line: one-good economy)

Table 1. Calibration According to the Data and the Literature

Parameters		Value	Source
Demographics			
T	maximum life span	90	
λ_t	survival probability	Fig. 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^s	annual depreciation rate of housing	0.010	authors' calculation
Endowment			
e_t	age-efficiency profile	Fig. 1	French (2005)
ρ_ε	AR(1) coefficient of income process	0.96	Huggett (1996)
σ_ε^2	innovation of income process	0.045	Huggett (1996)
σ_1^2	variance of income process at age 1	0.38	Huggett (1996)
Government policy			
$pen(t_r,y)$	Social Security benefit		see text
home production			
ζ_1	sub. betw. d and h	1.588	Dotsey, Li and Yang (forthcoming)
Preference			
γ	risk aversion coefficient	1.500	Attanasio, et al. (1999), Gourinchas and Parker (2002)

Table 2. Calibration Results

Parameters (9)		Value
β	discount factor	0.954
τ	Social Security tax rate	0.102
ω_1	weight on durable	0.754
ζ_2	sub. betw. d and h composite and n_h	0.800
ω_2	weight on d and h composition	0.758
ζ_3	sub. betw. market and home goods	2.186
ω_3	weight on market goods	0.130
ζ_4	sub. betw. consumption and leisure	1.522
ω_4	weight on consumption	0.225

Table 3. Calibration to Match Data Moments

Moments	Model	Data
capital output ratio (K/Y)	1.714	1.714
Social Security budget balance	0.000	0.000
home input/housing	0.102	0.102
The Young (between ages 24 and 49)		
average expenditure on home input goods/income	0.281	0.303
average share of home hours	0.141	0.145
average share of market hours	0.222	0.205
The Old (between ages 50 and 80)		
average expenditure on home input goods/income	0.310	0.292
average share of home hours	0.160	0.158
average share of market hours	0.112	0.118

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

Variable	SS Benefits	No SS Benefits (relative changes)	No SS Benefits – Fixed Prices (relative changes)
SS tax rate (τ)	0.102	0.000 (-100%)	0.000 (-100%)
interest rate (r)	0.050	0.044 (-12.902%)	0.050 (0.000%)
wage (w)	0.724	0.735 (1.501%)	0.724 (0.000%)
capital output ratio (K/Y)	1.714	1.797 (4.832%)	1.714 (0.000%)
aggregate capital (K)	62.475	68.376 (9.446%)	62.126 (-0.559%)
aggregate labor (L)	76.540	78.727 (2.857%)	76.113 (-0.559%)
aggregate wealth	153.799	178.119 (15.820%)	207.701 (35.056%)
total housing/income	2.505	3.009 (20.108%)	2.621 (4.635%)
home input/income	0.255	0.256 (0.255%)	0.267 (4.634%)
market cons./income	0.523	0.541 (3.364%)	0.560 (6.998%)
market hours	0.165	0.174 (5.655%)	0.165 (-0.080%)
home hours	0.150	0.151 (0.903%)	0.151 (0.901%)
leisure	0.685	0.675 (-1.556%)	0.684 (-0.178%)

Table 5. Consumption and Labor Supply with/without Social Security Benefits – Benchmark

age	housing		home input		market con.		market hour		home hour	
	SS	No SS	SS	No SS	SS	No SS	SS	No SS	SS	No SS
24	2.300	3.016	0.234	0.256	0.401	0.468	0.185	0.178	0.143	0.149
34	2.743	3.455	0.279	0.294	0.602	0.659	0.235	0.231	0.138	0.143
44	3.100	3.720	0.316	0.316	0.726	0.752	0.222	0.232	0.144	0.145
54	3.256	3.798	0.332	0.323	0.729	0.733	0.177	0.196	0.153	0.152
64	3.180	3.607	0.324	0.307	0.632	0.603	0.089	0.125	0.165	0.161
74	2.768	3.093	0.282	0.263	0.480	0.439	0.018	0.040	0.169	0.166
84	1.828	1.970	0.186	0.167	0.214	0.202	0.000	0.000	0.161	0.154

Table 6. Welfare Gain (%) – Benchmark

		Initial Productivity				
	all	1st	2nd	3rd	4th	5th
No SS Benefits	20.752	43.407	32.836	22.290	13.634	4.476
No SS Benefits–Fixed Prices	20.034	38.031	28.958	14.842	14.368	8.508

Table 7. Calibration to Match Data Moments – One-good Economy

Parameters (4)		One-good Economy
β	discount factor	0.955
τ	Social Security tax	0.103
ζ_4	sub. betw. consumption and leisure	1.521
ω_4	weight on consumption	0.069

Table 8. Aggregate Effects of Eliminating Social Security Benefits

Variable	relative changes after the reform benchmark	one-good
interest rate (r)	-12.902%	-14.561%
wage (w)	1.501%	4.300%
capital output ratio (K/Y)	4.832%	8.768%
aggregate capital	9.446%	18.309%
aggregate labor	2.857%	4.541%
total housing	20.108%	
home input	0.255%	
market consumption	3.364%	7.081%
market hours	5.655%	7.989%
home hours	0.903%	
leisure	-1.556%	-1.549%

Table 9. Consumption and Labor Supply with/without Social Security Benefits – One-good Economy

age	market consumption		market hour	
	SS	No SS	SS	No SS
24	0.751	0.898	0.180	0.173
34	1.049	1.183	0.232	0.229
44	1.227	1.342	0.218	0.228
54	1.273	1.320	0.175	0.189
64	1.148	1.136	0.086	0.135
74	0.920	0.873	0.013	0.030
84	0.492	0.435	0.000	0.000

Table 10. Welfare Gain (%) – One-good Economy

		Initial Productivity				
	all	1st	2nd	3rd	4th	5th
No SS Benefits	9.253	13.419	11.846	9.935	7.510	3.805

References

[1] Abbott, Michael, and Orley Ashenfelter 1976. “Labor Supply, Commodity Demand, and the Allocation of Time,” *Review of Economic Studies* 43, 395–412.

[2] Aguira, Mark, and Erik Hurst 2007. “Lifecycle Prices and Production,” *American Economic Review* 97(5), 1533–59.

[3] Aguiar, Mark, and Erik Hurst forthcoming. “Deconstructing Lifecycle Expenditure,” *Journal of Political Economy.*

[4] Attanasio, Orazio, James Banks, Costas Meghir, and Guglielmo Weber 1999. “Humps and Bumps in Lifetime Consumption,” *Journal of Business and Economic Statistics* 17, 22–35.

[5] Barnett, William 1979. “The Joint Allocation of Leisure and Goods Expenditure,” *Econometrica* 47, 539–563.

[6] Baxter, Marianne, and Dana Rotz 2009. “Detecting Household Production,” University of Boston, manuscript.

[7] Baxter, Marianne and Urban J. Jermann. 1997. “The International Diversification Puzzle Is Worse Than You Think,” *American Economic Review*, 170–180.

[8] Becker, Gary. 1965. “A Theory of the Allocation of Time.” *The Economic Journal* 75, 493–517.

[9] Benhabib, Jess, Richard Rogerson, and Randall Wright 1991. “Homework in Macroeconomics: Household Production and Aggregate Fluctuations,” *Journal of Political Economy* 99, 1166–1187.

[10] Chang, Yongsung 2000. “Comovement, Excess volatility, and Home production,” *Journal of Monetary Economics* 46, 385–96.

[11] Chen, Kaiji 2010. “A Life-cycle Analysis of Social Security with Housing,” *Review of Economic Dynamics* 13(3), 597–615.

[12] Cooley, Thomas, and Jorge Soares 1999. “A Positive Theory of Social Security Based on Reputation,” *Journal of Political Economy* 107(1), 135–60.

[13] Dotsey, Michael, Wenli Li, and Fang Yang forthcoming. “Consumption and Time Use over the Life Cycle,” *International Economic Review.*

[14] Fisher, Jonas 1997. "Relative Prices, Complementarities and Comovement Among Components of Aggregate Expenditures," *Journal of Monetary Economics* 39, 449–74.

[15] French, Eric 2005. "The Effects of Health, Wealth and Wages on Labor Supply and Retirement Behavior," *Review of Economic Studies* 72(2), 395–427.

[16] Fuster, Luisa 1999. "Is Altruism Important for Understanding the Long-run Effects of Social Security ?" *Review of Economic Dynamics* 2(3), 616-637.

[17] Fuster, Luisa, Ayse Imrohoroglu and Selahattin Imrohoroglu 2003. "A Welfare Analysis of Social Security in a Dynastic Framework," *International Economic Review* 44(4), 1247–1274.

[18] Fuster, Luisa, Ayse Imrohoroglu, and Selahattin Imrohoroglu 2007. "Elimination of Social Security in a Dynastic Framework," *Review of Economic Studies* 74(1), 113–145.

[19] Gervais, Martin 2002. "Housing Taxation and Capital Accumulation," *Journal of Monetary Economics* 49, 1461–1489.

[20] Gomme, Paul, Finn Kydland, and Peter Rupert 2001. "Home Production Meets Time to Build," *Journal of Political Economy* 109(5), 1115–1131.

[21] Gomme, Paul, and Peter Rupert 2007. "Theory, Measurement and Calibration of Macroeconomic Models," *Journal of Monetary Economics* 54(2), 460–497.

[22] Gourinchas, Pierre-Olivier, and Jonathan A. Parker 2002. "Consumption over the Life Cycle," *Econometrica* 70, 47-89.

[23] Greenwood, Jeremy, and Zvi Hercowitz 1991. "The Allocation of Capital and Time over the Business Cycle," *Journal of Political Economy* 99 (6), 1188–1214.

[24] Greenwood, Jeremy, Richard Rogerson, and Randall Wright 1995. "Household Production in Real Business Cycle Theory," in *Frontiers of Business Cycle Research.* Princeton, NJ: Princeton University Press. 157–74.

[25] Hornstein, Andreas and Praschnik, Jack 1997. "Intermediate Inputs and Sectoral Comovement in the Business Cycle," *Journal of Monetary Economics* 40, 573–95.

[26] Huggett, Mark 1996. "Wealth Distribution in Life-Cycle Economies," *Journal of Monetary Economics* 38(3), 469–494.

[27] Huggett, Mark, and Gustavo Ventura 2000. "On the Distributional Effects of Social Security Reform," *Review of Economic Dynamics* 2, 498–531.

[28] Hurst, Erik, and Paul Willen 2007. " Social Security and Unsecured Debt," *Journal of Public Economics* 91, 1273–1297.

[29] Imrohoroglu, Selahattin, and Kitao, Sagiri 2009. "Labor Supply Elasticity and Social Security Reform," *Journal of Public Economics* 93, 867–878.

[30] Imrohoroglu, Selahattin, and Kitao, Sagiri 2012. "Social Security , Benefit Claiming and Labor Force Participation and Long-Run Sustainability," *American Economic Journal: Macroeconomics* 4(3), 96–127.

[31] Laitner, John, and Dan Silverman 2012. "Consumption, Retirement and Social Security : Evaluating the Efficiency of Reform that Encourages Longer Careers," *Journal of Public Economics* 96(7-8), 615–634.

[32] McGrattan, Ellen, Richard Rogerson, and Randall Wright 1997. "An Equilibrium Model of the Business Cycle with Household Production and Fiscal Policy," *International Economic Review* 38(2), 267–290.

[33] Mincer, Jacob 1962. "On-the-Job Training: Costs, Returns and Some Implications," *Journal of Political Economy* 70(5)(2), 50–79.

[34] Nishiyama, Shinichi, and Kent Smetters 2007. "Does Social Security Privatization Produce Efficiency Gains?" *Quarterly Journal of Economics* 122(4), 1677–1719.

[35] Reid, Margaret G. 1934. Economics of Household Production, New York: John Wiley & Sons, Inc.

[36] Rogerson, Richard 2009. "Market Work, Home Work, and Taxes: A Cross-Country Analysis," *Review of International Economics* 17(3), 588–601.

[37] Rogerson, Richard, and Johanna Wallenius 2009. "Retirement in a Life Cycle Model of Labor Supply with Home Production," Working Paper, Arizona State University.

[38] Rupert, Peter, Richard Rogerson, and Randall Wright 2000. "Homework in Labor Economics: Household Production and Intertemporal Substitution," *Journal of Monetary Economics* 46, 557-579.

[39] Sato, K. 1967. "A Two-Level Constant-Elasticity-of-Substitution Production Function," *Review of Economic Studies* 34(2), 201–218.

[40] Storesletten, Kjetil, Chris Telmer, and Amir Yaron 1999. "The Risk Sharing Implications of Alternative Social Security Arrangements," *Carnegie-RochesterConference Series on Public Policy* 50, 213-260.

[41] Yang, Fang 2013. "Social Security Reform with Impure Intergenerational Altruism," *Journal of Economic Dynamics and Control* 37, 52-67