Mobility, social security, savings, and inequality with two-sided altruism and uncertain earnings ability

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Abstract

We examine the effects of falling intergenerational mobility and rising social security on savings and distributions of wealth and income in a dynastic model with two-sided altruism and uncertain earnings ability. When mobility declines, high (low) earning households reduce (raise) savings. When social security expands, households experiencing upward (downward) mobility tend to reduce (raise) savings. Both life-cycle features and two-sided altruism improve the fitting of wealth distribution to data. Falling mobility and rising social security explain a large proportion of the fall in the gross saving rate and the rises of wealth and income inequality from 1980 to 2000.

1 Introduction

In the last two decades of the twentieth century, the U.S. personal saving rate declined sharply from 11% to 4%, and both wealth and income inequality increased. The top decile wealth and income shares increased from 67.2% to 69.7% and from 37.5% to 46.9% respectively (Piketty and Saez, 2014). Over the same period, the social security program expanded by more than one fifth and intergenerational mobility declined (Levine and Mazumder, 2002, 2007; Nam, 2004; Aaronson and Mazumder, 2008; Beller, 2009)[1]. According to empirical findings by Maki and Palumbo (2001), saving rates over the 1990s declined for households in the top two income quintiles yet rose for those in the bottom two quintiles, when the intergenerational elasticity of earnings (IGE) rose from 0.464 to 0.571 as shown in Aaronson and Mazumder (2008). It is of interest to ask: How do households with different wealth and earnings respond to changes in social security and intergenerational mobility in terms of saving and intergenerational transfer decisions? Can these responses account for the trends in aggregate savings and wealth and income distributions in data?

Such questions are typically approached in life-cycle models or dynastic models with downward altruism. In this paper we attempt to explore answers in a dynastic family model with two-sided altruism among two overlapping generations, working and retired, and with uncertain earnings ability. They make collective decisions on consumption, savings and transfers either from old parents to adult children or the other way around. Each working-aged agent draws a level of labor efficiency (earnings ability) from a given distribution, which is positively correlated with the ability of the parent. Intergenerational transfers motivated by two-sided altruism play a role of "family insurance", since they are made after the earning ability levels of children are realized. Savings, on the other hand, are made ex-ante during the working age, depending on the conditional expectation of the next generation's earnings given the worker's own earnings. This correlation of earnings across generations links the responses of savings and intergenerational transfers to changes in social security and intergenerational earnings mobility together and differentiates the responses by earnings and by wealth.

[1] There are also some empirical studies that find no significant trends of mobility over this period, such as Lee and Solon (2009) and Hertz (2007). However, the literature has on average found mobility declining over this period. A recent study by Chetty et al. (2014) finds that rank-based measures of mobility have remained stable for children born between 1971 and 1993, but most of them haven't reached age 30 by 2001.

We find several results as follows. First, the responses of households to a rise in social security differ by earnings across the overlapping generations. Households whose increases in the social security contribution from the young are not fully compensated by the increases in the social security benefits to the old decrease their savings, and the remaining households increase their savings. This result is different to the Ricardian equivalence in conventional dynastic family models (Barro, 1974). At the same time, the response of private transfers from the old to the young is always positive as in a typical dynastic model for all households, but the response depends not only on the expectation of the earnings of the unborn generation but also on the realized earnings of the overlapping old and young agents. Without consideration of the elderly in a typical dynastic model, young parents would only leave more bequests to the unborn children to counteract the expected increased future tax burden of the greater government debt or PAYG social security contribution on children. When private transfers also occur between overlapping old parents and adult children in the present model, they compare the social security contribution from adult children with the benefits to old parents. Thus, the effect of social security on aggregate savings interacts with mobility when earnings across generations are correlated.

The responses of savings to a rise in the intergenerational elasticity of earnings or a decline in intergenerational mobility also differ across households. Those with high-earning adult children decrease their savings but the rest reacts oppositely. The intuition is that the higher persistence of earnings across generations is a blessing to the current high-earning households but a curse to the rest. Expecting a higher likelihood of a continued success (poverty trap) for future generations, the incentive to save decreases (increases) for households currently receiving high (low) earnings. This is consistent with the aforementioned finding by Maki and Palumbo (2001) during a time with a rising intergenerational elasticity of earnings. Intergenerational transfers move along the same direction as savings, and the magnitude is always smaller than that of savings, as old parents share the "blessing" or "curse" with the young, and therefore they transfer more (less) to their children if the latter has to save more (less).

Calibrated to match a relatively small set of moments for the U.S. economy in 2000, the model generates a wealth distribution that is much more concentrated than the labor earnings distribution, which in turn is more concentrated than the income distribution. Comparing among the models, the life-cycle features improve the fitting of the wealth distribution to data, and the two-sided altruism does a better job than one-sided altruism from parents to children only. The expansion of social security from 1980 to 2000 decreases aggregate savings by 11%, and increases the Gini coefficient for wealth from .766 to .780. An economy with the same earnings distribution as in 2000 but higher mobility as in 1980 has 38% higher aggregate savings and a more equal wealth distribution. Roughly half of the effect on wealth inequality is due to a direct accumulation effect and the rest is attributed to the household saving response to mobility. Calibrated to match the earnings distributions, social security and mobility in 1980 and 2000, the model can explain more than half of the fall in the saving rate and the rises of wealth and income inequality in data.

1.1 Contributions with respect to the literature

The pioneer work by Becker and Tomes (1979) demonstrates the important role of inheritable genetic and cultural endowment between generations on the intergenerational income correlation and cross-sectional income distribution, through the channel of parents' decisions of investing on children's human capital. Later, in their 1986's work, ex-ante bequest decisions are incorporated into the model, and they explain the highly concentrated bequests of assets by showing that lower- and middle-income parents "bequeath" mainly in the form of human capital investment. Over time, average school years of the population steadily increase beyond the secondary level towards the college level with substantial fees. The increasing portion of youth paying for college education certainly strengthens the earnings correlation across generations or weakens intergenerational earnings mobility. The 1980s revenue-neutral tax reform that reduced the number of tax brackets to flatten marginal tax rates is another factor for the decline in intergenerational earnings mobility.

The present paper complements the study of family decisions and intergenerational mobility in the literature by examining the saving and transfer decisions during the working age and after retirement, as opposed to the focus on childhood education.[2] The present model provides another explanation of the highly concentrated bequests through the channels of the two-sided altruism and the regress-to-the-mean earnings process. The different timing for ex-ante saving

[2] See, among others, Galor and Tsiddon (1997), Owen and Weil (1998), Fernandez and Rogerson (1998), Maoz and Moav (1999), Hassler and Rodriguez Mora (2000), Benabou (2001), Solon (2004), Hassler et al. (2007), and Arawatari and Ono (2013).

and ex-post transferring is carefully studied, as Becker and Tomes (1979) point out: "parents may have to commit most of their investments before they know a great deal about their children's market luck". Also, the present work attempts to study the effects of mobility on aggregate savings and wealth/income distributions through ex-ante savings during the working age and ex-post transfers in the old age of altruistic agents in dynastic families.

The two-sided full altruism in our model follows Laitner (1992), in which, however, labor efficiency is i.i.d. between generations in the same family. We consider the persistence of labor efficiency within the family and examine its effect on savings and inequality. Though a positive IGE is also incorporated in Fuster et al. (2003, 2007) into a Laitner-type household's problem, their focus is on the reasons for the elimination of social security.

There is an extensive literature on wealth distribution, using dynastic models (see, e.g., Aiyagari, 1994; Krusell and Smith, 1998; Quadrini, 2000), life-cycle models (see, e.g., Davies, 1982; Huggett, 1996; De Nardi, 2004), or dynastic models with life-cycle features (see, e.g., Laitner, 2001; Nishiyama, 2002; Castaneda et al., 2003). A review of the literature can be found in Cagetti and De Nardi (2008). Complementing the literature, the present paper shows that full two-sided altruism for ex-post private intergenerational transfers can also generate a wealth distribution close to data, without specific assumptions on preference heterogeneity or entrepreneurial choices. In particular, it demonstrates the roles of life-cycles and two-sided transfers in generating a more unequal wealth distribution, compared with a pure dynastic model without life-cycle features that restricts transfers from parents to children only.

The two-sided altruism between generations is supported by empirical findings. On the one hand, parental support of young adult sons is responsive to children's current and anticipated earnings (e.g. Tomes, 1981; Rosenzweig and Wolpin, 1993; Laitner and Juster, 1996; Altonji et al., 1997). On the other hand, adult children's support to old parents is positively related to their own education or income but negatively related to the social-economic status of old parents (e.g. Hogan et al., 1993; Lee et al., 1994; Sun, 2002).

The rest of the paper is organized as follows. Section 2 describes the model and examines household responses to changes in state variables analytically. Section 3 calibrates the model and presents the simulation results. Section 4 conducts counter-factual experiments. The last section concludes the paper.

2 The model

The economy consists of households and firms in an infinite horizon with discrete periods.

2.1 Households

There is a unit mass of families with overlapping young (working) and old (retired) agents in each period. At the end of each period, the young agent turns old and a new young agent enters the family. The old-age longevity is $0 < T \leq 1$, so the total lifetime is $1+T$ for all agents. In the young period, an agent receives an idiosyncratic labor efficiency shock which determines his labor income (earnings); in the old period, he receives social security benefits, which are financed by a uniform PAYG labor income tax.

The budget constraint of an old agent in period t with his asset a_t and his labor efficiency when young l_{t-1}^y is

$$Td_t + b_t = (1+r_t)a_t + T \cdot \mathrm{Tr}(w_{t-1}l_{t-1}^y), \tag{1}$$

where d_t is the old agent's consumption per unit time; $\mathrm{Tr}(w_{t-1}l_{t-1}^y)$ is the social security benefits for the old agent per unit time which depends on his earnings when young; w_t and r_t are the wage and interest rates, respectively; a positive (negative) b_t refers to the transfer from the parent to the child (from the child to the parent).

His adult child's budget constraint with the transfer from the old b_t and the child's labor efficiency l_t^y is

$$c_t + a_{t+1} = (1-\tau_{ss})w_t l_t^y + b_t, \tag{2}$$

where c_t is the young agent's consumption per unit time, $a_{t+1} \equiv s_t$ is his saving this period which is also his asset next period, τ_{ss} is the PAYG social security contribution (tax) rate.

The two generations in a family are mutually fully altruistic and share the dynastic welfare[3]:

$$V(a_t, l_{t-1}, l_t) = \max_{c_t, d_t. b_t, a_{t+1}} \left\{ \alpha T u(d_t) + u(c_t) + \beta E_t \left[V(a_{t+1}, l_t, l_{t+1}) \mid l_t \right] \right\}, \tag{3}$$

[3]Superscripts over labor efficiency are dropped as it does not cause confusion.

subject to (1), (2), $c_t \geq 0$, $d_t \geq 0$, and $a_{t+1} \geq 0$, where $\alpha > 0$ and $0 < \beta < 1$ are relative taste parameters. It is assumed here that there is a borrowing constraint: households cannot hold negative net assets in any period.

We can also combine the two budget constraints as

$$c_t + Td_t + a_{t+1} = (1 + r_t)a_t + T \cdot \mathrm{Tr}(w_{t-1}l_{t-1}) + (1 - \tau_{ss})w_t l_t. \tag{4}$$

A household's total resources available are the sum of the household's asset (after interest), the old agent's social security benefits and the young agent's after-tax earnings. The resources can be pooled by the overlapping agents in the family and connected to future generations through transfers.

2.2 Household responses to changes in state variables

Define Ω_t a vector of all the household's state variables outside a_t. The recursive household's problem is formulated as

$$\begin{aligned} V(a_t, \Omega_t) \quad = \quad & \max_{a_{t+1}, b_t} \{\alpha T u \left(\left[(1 + r_t)a_t + T \cdot \mathrm{Tr}(w_{t-1}l_{t-1}) - b_t \right] / T \right) + \\ & u \left(b_t + (1 - \tau_{ss})w_t l_t - a_{t+1} \right) + \beta E \left[V(a_{t+1}, \Omega_{t+1}) \mid l_t \right] \} \end{aligned} \tag{5}$$

for non-negative assets a_{t+1} and consumption for the young and the old agents.

The first-order conditions are:

$$a_{t+1}: \; a_{t+1} \left\{ u' \left(b_t + (1 - \tau_{ss})w_t l_t - a_{t+1} \right) - \beta E \left[V_a(a_{t+1}, \Omega_{t+1}) | l_t \right] \right\} = 0, \tag{6}$$

$$a_{t+1} \geq 0, \; u' \left(b_t + (1 - \tau_{ss})w_t l_t - a_{t+1} \right) \geq \beta E \left[V_a(a_{t+1}, \Omega_{t+1}) | l_t \right];$$

$$b_t: \; u' \left(b_t + (1 - \tau_{ss})w_t l_t - a_{t+1} \right) = \alpha u' \left(\left[(1 + r_t)a_t + T \cdot \mathrm{Tr}(w_{t-1}l_{t-1}) - b_t \right] / T \right), \tag{7}$$

and the subsequent binding Euler equation is

$$u'(c_t) = \beta(1 + r_{t+1}) E \left[u'(c_{t+1}) | l_t \right]. \tag{8}$$

The weighted marginal utility of consumption should be equal for the co-existing young and old agents, and the marginal cost of savings should be equal to the discounted expected marginal benefit from the next period.

The binding first-order conditions in (6) and (7) can be used to find the responses of savings and transfers to changes in state variables. Our analytical approach will yield more general results than the numerical investigations in existing dynastic models, particularly with two-sided altruism. The first-order conditions implicitly determine policy functions $b_t = b(a_t, \Omega_t)$ and $a_{t+1} = g(a_t, \Omega_t)$. The envelope theorem determines $V_a(a_t, \Omega_t) = \alpha(1 + r_t)u'(d_t) > 0$ and $V_{aa}(a_t, \Omega_t) = \alpha(1 + r_t)^2 u''(d_t)/T < 0$.

2.2.1 Responses to a rise in assets

The effects of a rise in a_t on savings and intergenerational transfers are determined by differentiating the binding first-order conditions with respect to a_t:

$$\mathrm{H}\begin{bmatrix} g_a(a_t, \Omega_t) \\ b_a(a_t, \Omega_t) \end{bmatrix} = \begin{bmatrix} 0 \\ \alpha(1 + r_t)u''(d_t)T^{-1} \end{bmatrix},$$

where H is the Hessian matrix

$$\mathrm{H} = \begin{bmatrix} u''(c_t) + \beta E\left[V_{aa}(a_{t+1}, \Omega_{t+1})|l_t\right] & -u''(c_t) \\ -u''(c_t) & u''(c_t) + \alpha u''(d_t)T^{-1} \end{bmatrix}.$$

Then $\det(\mathrm{H}) = \alpha u''(c_t)u''(d_t)T^{-1} + \beta E\left[V_{aa}(a_{t+1}, \Omega_{t+1})|l_t\right]\left[u''(c_t) + \alpha u''(d_t)T^{-1}\right] > 0$, and a dynastic family with more asset a_t to begin with saves more and transfers more to the child:

$$g_a(a_t, \Omega_t) = \frac{1}{\det(\mathrm{H})} \det \begin{bmatrix} 0 & -u''(c_t) \\ \alpha(1 + r_t)u''(d_t)T^{-1} & u''(c_t) + \alpha u''(d_t)T^{-1} \end{bmatrix} > 0,$$

$$b_a(a_t, \Omega_t) = \frac{1}{\det(\mathrm{H})} \det \begin{bmatrix} u''(c_t) + \beta E\left[V_{aa}(a_{t+1}, \Omega_{t+1})|l_t\right] & 0 \\ -u''(c_t) & \alpha(1 + r_t)u''(d_t)T^{-1} \end{bmatrix} > 0.$$

This result is intuitive and useful for comparisons of savings and transfers across households with different levels of assets. Holding the social security contribution rate constant, the effects of an exogenous increase of social security benefits $\mathrm{Tr}(w_{t-1}l_{t-1})$ on savings and transfers share the same signs as those of a rise in a_t, as households do not distinguish between funds available from assets and social security benefits when they make decisions.

2.2.2 Responses to a rise in the wage rate

The effects of a rise in the wage rate w_t on savings and transfers are determined by differentiating the first-order conditions with respect to w_t:

$$\mathrm{H}\begin{bmatrix} g_{w_t}(a_t,\Omega_t) \\ b_{w_t}(a_t,\Omega_t) \end{bmatrix} = \begin{bmatrix} (1-\tau_{ss})l_t u''(c_t) \\ -(1-\tau_{ss})l_t u''(c_t) + \alpha u''(d_t)\partial \mathrm{Tr}(w_{t-1}l_{t-1})/\partial w_t \end{bmatrix},$$

where $\partial \mathrm{Tr}(w_{t-1}l_{t-1})/\partial w_t > 0$ as social security benefits increase when contributors' wage increases given the same contribution rate, which leads to

$$\begin{aligned} g_{w_t}(a_t,\Omega_t) &= \frac{\alpha(1-\tau_{ss})l_t u''(d_t)u''(c_t) + \alpha T u''(d_t)u''(c_t)\partial \mathrm{Tr}(w_{t-1}l_{t-1})/\partial w_t}{T\det(\mathrm{H})} > 0 \\ b_{w_t}(a_t,\Omega_t) &= \frac{1}{\det(\mathrm{H})}\left\{\alpha u''(d_t)u''(c_t)\partial \mathrm{Tr}(w_{t-1}l_{t-1})/\partial w_t + \right. \\ &\quad \left. \beta E\left[V_{aa}(a_{t+1},\Omega_{t+1})|l_t\right]\left[-(1-\tau_{ss})l_t u''(c_t) + \alpha u''(d_t)\partial \mathrm{Tr}(w_{t-1}l_{t-1})/\partial w_t\right]\right\}. \end{aligned}$$

The positive response of savings is straightforward, as increases in both the young agent's after-tax earnings and the old agent's social security benefits strengthen the incentive to save for future generations. However, the response of the transfers is not so clear-cut. On the one hand, the rise in the young agent's after-tax earnings suppresses the old agent's motive for transfers to the young. On the other hand, the simultaneous rise in the old agent's social security benefits strengthens the motive for transfers to the future generations. Therefore, transfers to the young are more likely to decline if the rise in the after-tax income for the young is much larger than the rise in the benefits for the elderly. However, transfers to the young may actually increase if the economy runs a large social security program but the young agent has a very low level of labor efficiency, because in this case the increase in the social security benefits dominates.

2.2.3 Responses to a rise in the interest rate

The effects of a rise in the interest rate r_{t+1} are determined by differentiating the first-order conditions with respect to r_{t+1}:

$$\mathrm{H}\begin{bmatrix} g_{r_{t+1}}(a_t,\Omega_t) \\ b_{r_{t+1}}(a_t,\Omega_t) \end{bmatrix} = \begin{bmatrix} -\beta\alpha E\left[u'(d_{t+1}) + (1+r_{t+1})u''(d_{t+1})a_{t+1}T^{-1} \mid l_t\right] \\ 0 \end{bmatrix},$$

which leads to

$$\begin{aligned} g_{r_{t+1}}(a_t,\Omega_t) &= \frac{-\beta\alpha E\left[u'(d_{t+1}) + (1+r_{t+1})u''(d_{t+1})a_{t+1}T^{-1} \mid l_t\right]\left[u''(c_t)T + \alpha u''(d_t)\right]}{T\det(\mathrm{H})} \\ b_{r_{t+1}}(a_t,\Omega_t) &= \frac{-\beta\alpha E\left[u'(d_{t+1}) + (1+r_{t+1})u''(d_{t+1})a_{t+1}T^{-1} \mid l_t\right]u''(c_t)}{\det(\mathrm{H})}. \end{aligned}$$

Both responses depend on the sign of the term $E\left[u'(d_{t+1}) + (1+r_{t+1})u''(d_{t+1})a_{t+1}T^{-1} \mid l_t\right]$, consisting of the expected substitution effect and income effect. The former effect strengthens the incentive to save as the return to savings increases, whereas the latter stimulates more consumption this period and hence weakens the incentive to save. Intergenerational transfers co-move with savings, as parents share the decrease (increase) of the current period consumption with their children if savings are to be increased (decreased). Therefore, the present model generates a unique channel connecting intergenerational transfers with the interest rate.

2.2.4 Responses to a rise in old-age longevity

The effects of a rise in T (for the current old generation) are determined by differentiating the first-order conditions with respect to T:

$$\mathrm{H}\begin{bmatrix} g_T(a_t,\Omega_t) \\ b_T(a_t,\Omega_t) \end{bmatrix} = \begin{bmatrix} 0 \\ -\alpha u''(d_t)T^{-2}\left[(1+r_t)a_t - T^2\partial\mathrm{Tr}(w_{t-1}l_{t-1})/\partial T - b_t\right] \end{bmatrix}$$

From this, if $a_t(1+r_t) > T^2\partial Tr(w_{t-1}l_{t-1})/\partial T + b_t$, then

$$
\begin{aligned}
g_T(a_t,\Omega_t) &= \frac{-\alpha u''(d_t)u''(c_t)\left[(1+r_t)a_t - T^2\partial Tr(w_{t-1}l_{t-1})/\partial T - b_t\right]}{T^2 \det(\mathrm{H})} < 0, \\
b_T(a_t,\Omega_t) &= \frac{-\alpha u''(d_t)\left[(1+r_t)a_t - T^2\partial Tr(w_{t-1}l_{t-1})/\partial T - b_t\right]}{T^2 \det(\mathrm{H})} \\
&\quad \cdot \left\{u''(c_t) + \beta E\left[V_{aa}(a_{t+1},\Omega_{t+1})|l_t\right]\right\} < 0.
\end{aligned}
$$

Otherwise, $g_T(a_t,\Omega_t) > 0$ and $b_T(a_t,\Omega_t) > 0$. Here, $\partial\mathrm{Tr}(w_{t-1}l_{t-1})/\partial T < 0$ because social security annuity for longer retirement time has to fall given the same contribution rate τ_{ss}. Intuitively, a rise in longevity induces the family to spend more resources for the elderly through reducing savings and transfers, unless a family starts from very little assets and leaves bequests out of social security income. In these asset-poor families leaving bequests, the young agent must be of very low labor income according to (7), and thus the asset-poor elderly with longer life leaves more bequests to the young. These results are different from those in the literature where transfer decisions are made ex-ante.

2.2.5 Responses to a rise in the social security contribution

The effects of a rise in the social security contribution rate τ_{ss}, which also raises social security annuity $\partial\mathrm{Tr}(w_{t-1}l_{t-1})/\partial\tau_{ss} > 0$, are determined below:

$$
\mathrm{H}\begin{bmatrix} g_{\tau_{ss}}(a_t,\Omega_t) \\ b_{\tau_{ss}}(a_t,\Omega_t) \end{bmatrix} = \begin{bmatrix} -u''(c_t)w_t l_t \\ u''(c_t)w_t l_t + \alpha u''(d_t)\partial\mathrm{Tr}(w_{t-1}l_{t-1})/\partial\tau_{ss} \end{bmatrix},
$$

which leads to

$$
\begin{aligned}
g_{\tau_{ss}}(a_t,\Omega_t) &= \frac{\alpha u''(d_t)u''(c_t)[T\partial\mathrm{Tr}(w_{t-1}l_{t-1})/\partial\tau_{ss} - w_t l_t]}{T \det(\mathrm{H})}, \\
b_{\tau_{ss}}(a_t,\Omega_t) &= \frac{1}{\det(\mathrm{H})}\left\{\alpha u''(d_t)u''(c_t)\partial\mathrm{Tr}(w_{t-1}l_{t-1})/\partial\tau_{ss} + \right. \\
&\quad \left. \beta E\left[V_{aa}(a_{t+1},\Omega_{t+1})|l_t\right]\left[u''(c_t)w_t l_t + \alpha u''(d_t)\partial\mathrm{Tr}(w_{t-1}l_{t-1})/\partial\tau_{ss}\right]\right\} > 0.
\end{aligned}
$$

The response of savings to a rise in the social security contribution differs among households. It is signed by the marginal gain of social security benefits to the elderly minus the marginal loss of after-tax earnings to the young. Therefore, controlling an old agent's labor efficiency, households with high-earning young agents are likely to reduce their savings, while those with low-earning young agents are likely to increase their savings. On average, if we assume a uniform social security benefit $\bar{\text{Tr}}$ for all old agents, making use of the budget balance of the social security program, then $T\partial\bar{\text{Tr}}/\partial\tau_{ss} - w_t l_t = w_t \bar{l} - w_t l_t$ implies that households earning less (more) than average save more (less) in response to a rise in the social security contribution rate. In general, the response depends on the combination of the parent's and the child's labor efficiency: Households experiencing an upward mobility are more likely to reduce their savings, as the current young generation contributes more to social security than what their old parents receive. Therefore, the change of mobility may have an impact on the effect of social security on aggregate savings, as mobility determines the likelihoods of different labor efficiency combinations across old parents and children, which will be shown numerically in Section 4.2.

This mixed savings effect of social security and government debt differs not only from the typical Ricardian equivalence hypothesis in a standard dynastic model with downward altruism (Barro, 1974), but also from the negative saving effect of social security in a life-cycle model, in which the young, who does not care for the elderly parent's welfare, only recognizes a shift of income from the young to the old age in the life-cycle. At the same time, the response of transfers from the old to the young is always positive as in a dynastic model. However, without the consideration of the elderly, it is the young parent in a typical dynastic model who leaves more bequests to counteract the expected increased future tax burden of greater government debt or a greater PAYG social security contribution on the child. In the current model, it is the old parent who transfers more to the young adult when the latter's increased tax or social security burden is realized.

2.2.6 Responses to a rise in the young agent's labor efficiency

Here onwards, we make the following assumption on the labor efficiency:

Assumption 1. ***The logarithm of the labor efficiency shock follows an*** $AR(1)$ ***process between generations,*** $\ln(l_t) = \lambda \ln(l_{t-1}) + \epsilon_t$, $\epsilon_t \sim N(0,\ \sigma_\epsilon^2)$.

Here, λ is the intergenerational elasticity of earnings (IGE). Then, the effects of higher labor efficiency l_t on savings and transfers are determined by

$$\mathrm{H}\begin{bmatrix} g_{l_t}(a_t,\Omega_t) \\ b_{l_t}(a_t,\Omega_t) \end{bmatrix} = \begin{bmatrix} u''(c_t)(1-\tau_{ss})w_t - \beta E\left[V_{al_t}(a_{t+1},\Omega_{t+1}) + V_{al_{t+1}}(a_{t+1},\Omega_{t+1})\frac{\lambda l_{t+1}}{l_t}|l_t\right] \\ -u''(c_t)(1-\tau_{ss})w_t \end{bmatrix},$$

where $V_{al_t}(a_{t+1},\Omega_{t+1}) = \alpha(1+r_{t+1})u''(d_{t+1})\partial \mathrm{Tr}(w_t l_t)/\partial l_t < 0$ is a negative effect of higher labor efficiency on the marginal benefit of savings through increased social security benefits, and $V_{al_{t+1}}(a_{t+1},\Omega_{t+1}) = (1+r_{t+1})u''(c_{t+1})(1-\tau_{ss})w_{t+1} < 0$ is a negative effect of expecting higher labor efficiency of children on the marginal benefit of savings through intergenerational earnings correlations. In addition, there is a positive income effect of higher labor efficiency on savings through $-u''(c_t)(1-\tau_{ss})w_t$. Higher labor efficiency for the young also weakens the incentive for transfers from the old.

The net effects of higher labor efficiency l_t on savings and transfers are

$$\begin{aligned} g_{l_t}(a_t,\Omega_t) &= \frac{1}{T\det(\mathrm{H})}\Big\{\alpha(1-\tau_{ss})w_t u''(d_t)u''(c_t) - \beta\left[u''(c_t)T + \alpha u''(d_t)\right] \\ &\quad \times E\left[V_{al_t}(a_{t+1},\Omega_{t+1}) + V_{al_{t+1}}(a_{t+1},\Omega_{t+1})\frac{\lambda l_{t+1}}{l_t}|l_t\right]\Big\}, \\ b_{l_t}(a_t,\Omega_t) &= \frac{-\beta u''(c_t)}{\det(\mathrm{H})}E\Big[(1-\tau_{ss})w_t V_{aa}(a_{t+1},\Omega_{t+1}) + V_{al_t}(a_{t+1},\Omega_{t+1}) + \\ &\quad V_{al_{t+1}}(a_{t+1},\Omega_{t+1})\frac{\lambda l_{t+1}}{l_t}|l_t\Big] < 0. \end{aligned}$$

The net effect on savings is only positive when the income effect of higher labor efficiency dominates. This result differs from that of a dynastic model with i.i.d. labor efficiency for each generation ($\lambda = 0$) or if social security benefits are uniform. The negative effect of higher labor efficiency l_t for the young on transfers from the old is intuitive and is also related to the IGE.

2.2.7 Responses to higher intergenerational elasticity of earnings

The effects of higher IGE λ on savings and transfers are determined by

$$\mathrm{H}\begin{bmatrix} g_{\lambda}(a_t,\Omega_t) \\ b_{\lambda}(a_t,\Omega_t) \end{bmatrix} = \begin{bmatrix} -\beta(\ln l_t)E\left[V_{al_{t+1}}(a_{t+1},\Omega_{t+1})l_{t+1}|l_t\right] \\ 0 \end{bmatrix},$$

which implies that

$$
\begin{aligned}
g_\lambda(a_t, \Omega_t) &= \frac{-\beta\left[u''(c_t)T + \alpha u''(d_t)\right](\ln l_t)E\left[V_{al_{t+1}}(a_{t+1}, \Omega_{t+1})l_{t+1} \mid l_t\right]}{T\det(H)}, \\
b_\lambda(a_t, \Omega_t) &= \frac{-\beta u''(c_t)(\ln l_t)E\left[V_{al_{t+1}}(a_{t+1}, \Omega_{t+1})l_{t+1} \mid l_t\right]}{\det(H)}.
\end{aligned}
$$

As the responses of both savings and transfers depend on the sign of $-\ln l_t$, both of them increase (decrease) for households whose young agents earn less (more) than the median earner, as $\ln l_t = \lambda \ln l_{t-1} + \epsilon_t$, $\epsilon_t \sim N(0,\ \sigma_\epsilon^2)$ implies that the stationary distribution of earnings is log-normal: $\ln l_\infty \sim N\left(0,\ \sigma_\epsilon^2/(1-\lambda^2)\right)$. Higher persistence of earnings along generations is a blessing to high-earning households but a curse to the rest. High-earning households choose to save less than before, as the conditional expectation of their next generation's labor earnings increases. However, the opposite is true to low-earning households. Unlike the effect of social security on savings, the effect of a higher IGE on savings only depends on the current young generation's efficiency, which solely determines whether this change is a blessing or a curse to the family. Transfers from the old to the young move along the same direction as savings and the magnitude is always smaller than that of savings, as old agents share the "blessing" or "curse" with the young agent and they transfer more (less) to young agents if the latter has to save more (less).

2.3 Firms

There is just one type of good produced in the economy, according to a Cobb-Douglas production function $F(K,\ L) = AK^\theta L^{1-\theta}$, where K is the aggregate capital and L is the aggregate labor efficiency. The capital market is open, and thus competitive firms can borrow at an exogenous international interest rate r. However, the labor market is closed. Capital depreciates fully in one period. As a result, the capital-labor ratio K/L is exogenously determined and so is the wage rate w:

$$1 + r = \theta A(K/L)^{\theta-1}, \tag{9}$$

$$w = (1-\theta)A(K/L)^\theta. \tag{10}$$

This is supported by the stylized fact that the capital-output ratio is roughly constant over long periods of time (Kaldor, 1961), and consistent with the fact that, though the personal saving rate declines sharply from 1980 to 2000, gross capital formation and the real interest rate remain stable in countries like the United States; meanwhile, the international debt position rises significantly over the period, as illustrated in Figure 1.

2.4 The stationary equilibrium

A stationary equilibrium is a collection of prices $\{r,\ w\}$, a value function $V(\cdot)$, household policy rules $\{g(\cdot),\ b(\cdot)\}$, a measure $\Psi(\cdot)$ on household states $(a_t,\ l_{t-1},\ l_t)$, and the social security tax rate τ_{ss} and transfer scheme $\mathrm{Tr}(\cdot)$, such that:

1. Given $\{r,\ w,\ \tau_{ss},\ \mathrm{Tr}(\cdot)\}$, $\{g(\cdot),\ b(\cdot)\}$ and $V(\cdot)$ solve the household's dynamic programming problem in (5);

2. Given r, the capital-labor ratio K/L and the wage rate w are determined by the firm's profit maximization conditions in (9)-(10);

3. The labor market clears very period:

$$L = \int_0^{+\infty} l\Psi_l(l)dl,$$

where Ψ_l is the marginal distribution of l.

4. The social security program is budget balanced:

$$\tau_{ss} wL = T \int_0^{+\infty} \mathrm{Tr}(wl)\Psi_l(l)dl$$

5. The households measure $\Psi(a_t,\ l_{t-1},\ l_t)$ is invariant, when households evolve according to their policy rules and the transition of efficiency shocks.

3 Simulations

3.1 Calibration

The stationary equilibrium is calibrated to the U.S. economy in 2000. We assume that each period in the model is 40 years: the young period represents 25-64 years of age and the old period is after 65 years old. As life expectancy at age 65 is 17.6 years in year 2000 (the National Center for Health Statistics), we set T=17.6/40=0.44. The social security tax rate is 12.4% in year 2000 (the Social Security Administration), so we set $\tau_{ss} = 0.124$. Following Fuster et al. (2007), the social security transfer scheme Tr(·) is calibrated to match the marginal replacement rates listed in their paper, and we rescale the benefits so that the program is self-financing.

We take θ, the capital's share of output, to be 0.36 according to Cooley and Prescott (1995). We calibrate output and capital to match the GDP per capita and the investment-output ratio. Moreover, total factor productivity A can be determined from the production technology, after the aggregate labor input is calculated from the stationary distribution of labor efficiency. Instantaneous utility is assumed to follow a CRRA form: $u(c) = (c^{1-\sigma} - 1)/(1 - \sigma)$. We take the relative risk aversion coefficient σ to be 2, which falls in the range commonly used in the literature. The weight of the old agent in the household's problem, α, is calibrated by the first-order condition in (7) to match the ratio between the annual consumption of people aged 25-64 and over 65 (the U.S. Census). The time discount rate β is calibrated to match the average household net worth (the U.S. Census).

Labor efficiency across generations follows an $AR(1)$ process: $\ln l_t = \lambda \ln l_{t-1} + \epsilon_t$, $\epsilon_t \sim N(0,\ \sigma_\epsilon^2)$ as in Assumption 1. Using the method introduced in Tauchen (1986), we discretize the distribution into five states, from the lowest to the highest are l_1 to l_5 and l_3 is the median, and calculate the transition probability between them. As λ is the IGE, it is set to 0.571, according to the estimate for year 2000 in Aaronson and Mazumder (2008). σ_ϵ is calibrated to match the Gini coefficient of long-term earnings for year 1999 in Kopczuk et al. (2010). In summary, parameters are calibrated according to Table 1.

3.2 The benchmark simulation

The value function and the policy functions for savings and transfers in (5) are found by discretizing the asset space and updating the value and policy functions by the Bellman equation, until the differences between iterations are small enough. We make use of the first-order condition in (7) to reduce the control variables of the maximization in each iteration to just a_{t+1}, which significantly improves the robustness and speed of finding the maximizer numerically in each iteration. After value and policy functions are found, a large number of dynastic families are simulated. Starting with the same asset and labor efficiency, household assets and labor efficiency are updated each period according to the policy function for savings and the $AR(1)$ process aforementioned respectively, until the wealth distribution in the economy gets stationary, indicated by the moments of the distribution close enough between iterations.

From the household's problem, the difference between funds from assets and from social security benefits does not play a role in the transfer and saving decisions. Therefore, we can present the value function and the policy functions more conveniently by combining the first two state variables in (3) and replace them with $m_t \equiv (1+r)a_t + T \cdot \mathrm{Tr}(wl_{t-1})$, which are the total resources available for the old agent in the household. Solving the model numerically, the value function (as in Figure 2) and the policy functions (as in Figure 3 and Figure 4) can be found. The value function is strictly increasing and concave for each efficiency state. Those with higher efficiency have higher values for several reasons. Young agents with higher efficiency receive more labor earnings when young and enjoy more social security benefits when old. Also, as labor efficiency is positively correlated across generations, the chance of drawing relatively high efficiency is higher for the next generation, given that the current generation draws a high efficiency shock.

Consistent with the findings in Section 2.2.1 and 2.2.6, transfers to children are larger for wealthier households or if children's labor efficiency is low. These results are consistent with the empirical finding that parental support of young adult sons is positively related to parents' income or net worth and negatively related to children's current and anticipated earnings (e.g. Tomes, 1981; Rosenzweig and Wolpin, 1993; Laitner and Juster, 1996; Altonji et al., 1997). Note that transfers to children could be negative for those old agents who have saved little in the young period but their children happen to have very high earnings, in which case altruistic adult children find it rational to provide net financial support to old parents. This is consistent with the empirical finding that adult children's support to old parents is positively related to adult children's education or income but negatively related to the social-economic status of old parents, such as in Hogan et al. (1993) and Lee et al. (1994).

Wealthier households save more controlling earnings of young agents. Consistent with the analysis in Section 2.2.6, we find that households with higher-earnings for young agents do not necessarily save more. In particular, households with the lowest-earning young agents in fact save more than those with higher-earning young agents. One reason of this is that as social security's marginal replacement rate is the highest for the lowest earners, it is more likely that the negative effect on savings due to higher social security benefits when old dominates for those households.

In spite of a relatively small set of aggregate moments matched to, the simulation produces wealth and income distributions close to data in general. The wealth and income distributions from the simulation are compared with data in Table 2. Consistent with empirical findings, the simulation generates a distribution of wealth more concentrated than that of labor earnings, which is in turn more concentrated than that of household income. However, as Table 2 shows, the simulation over-estimates the number of households with zero assets but we find that increasing the number of grids on the state space alleviates this problem. The simulation also generates an extremely unequal distribution of transfers, from which we find that 42% of households experience negative transfers to the young (adult children provide net financial support to old parents). This is consistent with the estimate by Hurd and Smith (2002) that more than 40% of children receive nothing from deceased parents, if we assume that old parents receiving net financial support from adult children leave no bequests.

We compare the simulated wealth distribution of our model with those of other models in Table 3. Using the IGE found from data, a pure dynastic model without life-cycle features (as in Appendix) generates a wealth distribution much more unequal than the Aiyagari (1994) model. However, in such models savings are all transferred to the next generation, which requires the bequest (transfer) distribution to be the same as the wealth distribution, which is not consistent with the empirical finding that the bequest distribution is even more unequal than the wealth distribution (Hurd and Smith, 2002). Incorporating life-cycle features but only one-sided transfers from parents to children improves the fitting of the simulated wealth distribution to data. The fitting improves further once we allow for two-sided transfers: the wealth distribution is more skewed as low-earning agents can partially rely on their descendants to finance their expenditures when old.

4 Counter-factual experiments

4.1 The effects of social security

To examine social security's effects on aggregate savings and wealth/income distributions, we decrease the social security tax rate from 12.4% in 2000 to 10.16% in 1980, and find that aggregate savings are 12% higher and the Gini coefficient for wealth decrease from 0.780 to 0.766. In other words, as social security expands from 1980 to 2000, aggregate savings decrease by 11% and the wealth Gini rises from 0.766 to 0.780 (Table 4). Relative to the small change of the social security tax rate, the changes of aggregate savings and wealth inequality are obvious.

However, the result here arises not through the channel of life-cycle savings. As it can be found from the combined budget constraint in (4), without the heterogeneity of labor efficiency, social security would have no effect on aggregate savings in the present model, as parents who receive more social security benefits give more bequests immediately to children who now contribute more to the program. As analyzed in Section 2.2.5, household responses to the expansion of social security are heterogeneous: controlling the old agent's efficiency, households with high-earning young agents are likely to reduce their savings, while those with low-earning young agents are likely to increase their savings; however, the responses of transfers to the young are positive for all households (Figure 5).

Distribution wise, we compare the average wealth by quintiles in the two scenarios, and find that the relative decrease of wealth is largest for the 3rd quintile and much milder for the top quintile, though the top quintile is the largest contributor to the decrease of aggregate savings (Table 5), which causes a more unequal wealth distribution. Though social security is re-distributional with a uniform tax rate but a decreasing marginal replacement rate, it does not reduce the inequality of before-tax or after-tax income distribution. Rather, it raises them through the more unequal wealth and therefore capital income channel (Table 4).

To investigate the effect of social security on savings under different mobility environments, we conduct the same experiment under a perfectly mobile economy (IGE=0). We find that the absolute decrease of aggregate savings is 5% larger in a highly mobile society than in the U.S. economy in 2000. The intuition is related to the household responses to a larger social security contribution rate in Section 2.2.5. High-earning young agents are now more likely to be sons of medium- or low-earning parents. We have seen that the increase in the social security contribution is likely to dominate the increase in benefits in such households, therefore their savings decrease. Although the opposite is true to low-earning households, high-earning households are the heavy savers and therefore their impact on aggregate savings is likely to dominate.

4.2 The effects of intergenerational immobility

To examine the effects of immobility on aggregate savings and wealth distribution, we reduce the IGE from 0.571 in 2000 to 0.318 in 1980 as found by Aaronson and Mazumder (2008), keeping the stationary earnings distribution the same as before. We can achieve this by reducing λ in the AR(1) process of the log earnings, while adjusting σ_ϵ accordingly such that the variance of the stationary distribution of log earnings, which equals $\sigma_\epsilon^2/(1-\lambda^2)$, remains the same as before. Therefore, this is a counter-factual experiment to compare with an economy that is identical to the U.S. economy in 2000 except for a lower IGE at the 1980's level.

We find that aggregate savings are 38% higher in the economy with mobility at the 1980's level and the Gini coefficient of wealth decreases from 0.780 to 0.721. In other words, as mobility decreases from the 1980's level to the 2000's level, aggregate savings decrease by 28% and the wealth Gini rises from 0.721 to 0.780 (Table 4). Consistent with the analysis of household responses in Section 2.2.7, savings increase (decrease) for young agents who earn less (more) than the median earner, and transfers from the old to the young move in the same direction as savings (Figure 6 where $l_t = l_3$ is the median labor efficiency), as the economy's mobility decreases. It can also be found from the figure that the absolute change of the high earners clearly dominates that of the low earners. On aggregate, the decrease from high-earning households dominates the increase from low-earning households and the net effect is a decrease of aggregate savings. As shown in Table 6, the contribution to the decrease of aggregate savings rises with wealth quintiles, though the relative decrease of wealth are actually the largest for the second and third quintiles.

The effect on wealth inequality is two-fold. There is a direct effect: lower mobility raises the chance of consecutive generations of low (high) earnings and therefore the likelihood of extreme low (high) wealth. There is also an indirect effect: the change of saving decisions alters the wealth distribution as well. To separate out the direct effect, we conduct another sub-experiment: we reduce the IGE to the 1980's level while keeping the household's policy functions the same as in 2000. We find that the direct effect reduces the Gini coefficient from 0.780 to 0.753. Therefore, the indirect effect reduces the Gini coefficient further from 0.753 to 0.721 (Table 4). This means that if we estimate the effect of intergenerational mobility on the wealth distributions without modeling the response of saving behaviors, using a "warm glow" bequest motive for instance, then we could have under-estimated the effect by more than one half in this case. Moreover, the direct effect predicts an opposite direction of the change of aggregate savings.

4.3 A comparison of the U.S. economy in 1980 and 2000

Finally, we simulate the model with the 1980's IGE, social security, earnings distribution, and life expectancy at age 65, and compare it with the U.S. economy in 2000. Major indicators are summarized in Table 7. Over the twenty years, the model finds several results: Aggregate savings shrink by 15.9% and the gross saving rate falls from 14.5% to 11.9%; wealth inequality rises and the top wealth quintile share rises from 74% to 81%; income inequality also rises and the top income quintile share rises from 48.6% to 52.0%. Compared with data, they are consistent with the trends of the gross saving rate and the wealth/income distributions. While the model explains largely the change of wealth inequality, the extent of the rise of income inequality is still much smaller than in data, which suggests that there are other factors besides the wealth distribution contributing to the rise of income inequality.

Aggregate savings decrease as high-earning households, who are the heavy savers, decrease their savings in response to the decrease in mobility and the expansion of social security (Figure 7). However, there is also a positive effect on aggregate savings from the rise of earnings inequality. As the variability of earnings gets larger, the proportion of super high earners increases, who are also the large contributors to aggregate savings. This explains why the negative effect on aggregate savings is smaller than in Section 4.2, where the earnings distribution is kept the same.

Wealth becomes more unequally distributed since the relative decrease of wealth is largest for the second and third quintiles, though the largest contributors to the aggregate change are the top two quintiles (Table 8). The rises of both labor earnings and wealth inequality contribute to the rise of income inequality, and they dominate the reallocation effect of a larger social security program.

5 Conclusion

The results in the present paper shed some lights on the effects of lower intergenerational mobility and larger social security on aggregate savings and wealth/income inequality in a dynastic model with two-sided full altruism. Analytically, the responses of savings and transfers differ among households with different labor efficiency combinations from the old and the young, which are consistent with some empirical evidence in the literature. Numerically, the results can largely explain the actual changes in the U.S. economy since 1980.

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Appendix

A pure dynastic model

If we ignore the life-cycle and overlapping-generation features of the benchmark model, and assume savings are all bequeathed to children at the end of life, then the recursive problem of a dynastic family with inheritance b_t and labor efficiency l_t for the current generation is:

$$\begin{aligned} W(b_t, l_t) &= \max_{c_t, b_{t+1}} \{(1+T)u(c_t) + \beta \left[W(b_{t+1}, l_{t+1}) \mid l_t\right]\} \\ \text{s.t.} \quad (1+T)c_t &= (1+r_t)b_t + (1-\tau_{ss})w_t l_t + T \cdot \text{Tr}(w_t l_t) - b_{t+1}, \\ c_t &\geq 0, \ b_{t+1} \geq 0, \end{aligned}$$

which is quite similar to the agent's problem in Aiyagari (1994), except that each period here is one generation in the family dynasty. The firm's problem and the economic environment are the same as in the benchmark model.

Tables and figures

	Description	Value or moment to match
T	Longevity in the old period	0.44
τ_{ss}	Social security tax rate	0.124
Tr	Social security transfer per unit time	Replacement rates in Fuster et al. (2007)
θ	Capital share	0.36
A	Total factor productivity	GDP per capita
σ	Constant relative risk aversion	2
α	Weight of old agent in household	Ratio of consumption for 25-64 and 65+
β	Subjective discount factor	Average household net worth
λ	Intergenerational earning elasticity	0.571
σ_ϵ^2	Variance in AR(1) process of $\ln(l_t)$	Gini coefficient of earnings
P	Transition probability of efficiency	Following Tauchen (1986)'s method

Table 1: Calibration of parameters

Gini	% of total wealth/income/transfers				
	Q1	Q2	Q3	Q4	Q5
US wealth data					
.803	-.3	1.3	5.0	12.2	81.7
Wealth distribution from simulation					
.780	0	0	2.8	15.7	81.5
US income data					
.462	3.6	8.9	14.8	23.0	49.8
Income distribution from simulation					
.482	3.8	8.5	12.1	23.6	52.0
Transfers distribution from simulation					
1.497	-38.1	-5.0	3.0	18.6	121.5

Table 2: Wealth, income and transfer distributions from data and simulation

Gini	% of total wealth				
	Q1	Q2	Q3	Q4	Q5
US Data					
.803	-.3	1.3	5.0	12.2	81.7
Aiyagari (1994)					
.380	-	-	-	-	41.0
Without life-cycle features					
.722	0	1.4	4.5	20.6	73.5
One-sided transfers only					
.757	0	0.4	3.8	18.4	77.8
Our model					
.780	0	0	2.8	15.7	81.5

Table 3: Comparison of simulated wealth distributions from different models

	Agg. savings	Wealth Gini	Income Gini	After-tax income Gini
2000's US economy	Calibrated	.780	.482	.476
1980's social security	12% higher	.766	.484	.486
1980's mobility	38% higher	.721	.462	-
Mobility's direct effect only	6.3% lower	.753	.467	-

Table 4: The effects of social security or mobility on aggregate savings and inequality

	Q1	Q2	Q3	Q4	Q5
Average wealth (80)	0	0	721	3557	17076
Average wealth (00)	0	0	536	2987	15496
Absolute change	0	0	-185	-570	-1580
% change	-	-	-25.7%	-16.0%	-9.3%
Contribution to decrease of agg. savings	0.0%	0.0%	7.9%	24.4%	67.7%

Table 5: Comparison of economies with 1980's social security and 2000's social security by quintiles

	Q1	Q2	Q3	Q4	Q5
Average wealth (80)	0	74	1595	4917	19184
Average wealth (00)	0	0	536	2987	15496
Absolute change	0	-74	-1059	-1930	-3688
% change	-	-100.0%	-66.4%	-39.3%	-19.2%
Contribution to decrease of agg. savings	0.0%	1.1%	15.7%	28.6%	54.6%

Table 6: Comparison of economies with 1980's IGE (low) and 2000's IGE (high) by quintiles

	Year	Aggregate savings	Wealth Gini	Q5 wealth share	Income Gini	Q5 income share	Gross saving rate
Data	1980	-	.72	74.7%	.403	44.1%	22.9%*
	2000	-	.803	81.7%	.462	49.8%	19.8%
	Change	-	+.083	+7.0%	+.059	+5.7%	-3.1%
Simulation	1980	4529	.718	73.9%	.442	48.6%	14.5%
	2000	3809	.78	81.5%	.482	52.0%	11.9%
	Change	-15.9%	+.062	+7.6%	+.040	+3.4%	-2.6%

Table 7: Comparison of the economy in 1980 and 2000

*We calculate the 5-year averages of gross savings (% of GNI) from World Development Index, for 1980 and 2000.

	Q1	Q2	Q3	Q4	Q5
Average wealth (80)	0	191	1278	4526	17002
Average wealth (00)	0	0	536	2987	15496
Absolute change	0	-191	-742	-1539	-1506
% change	-	-100.0%	-58.1%	-34.0%	-8.9%
Contribution to decrease of agg. savings	0.0%	4.8%	18.7%	38.7%	37.9%

Table 8: Comparison of the economy in 1980 and 2000 by quintiles

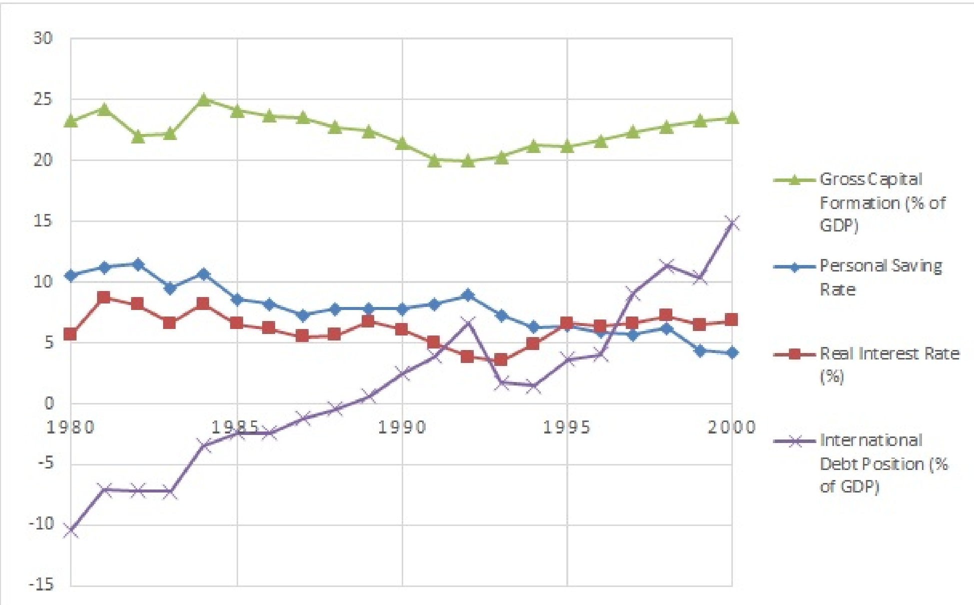


Figure 1: Investment, savings, real interest rate and foreign debt position, US, 1980-2000

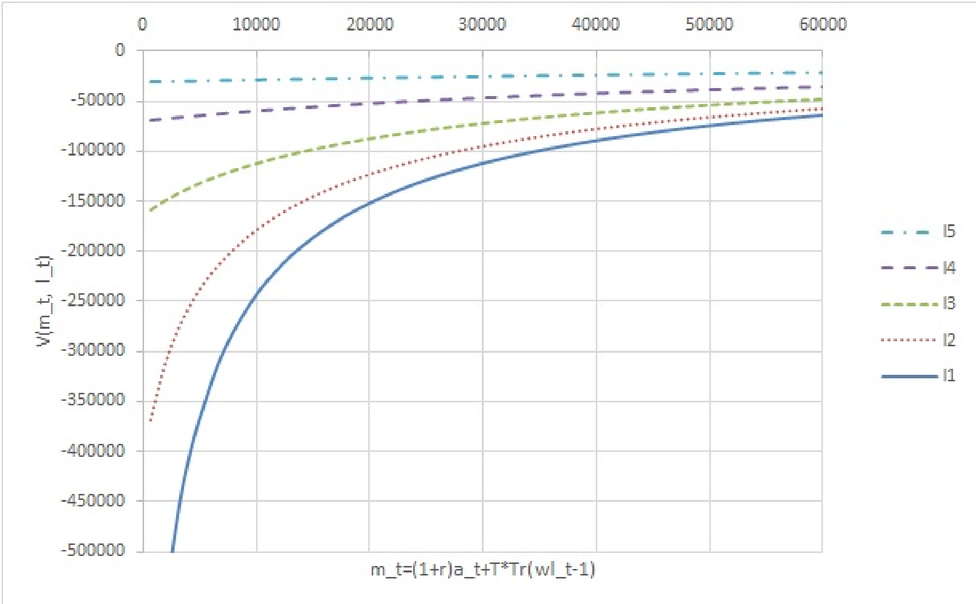


Figure 2: The household's value function $V(m_t, l_t)$ for the benchmark calibration

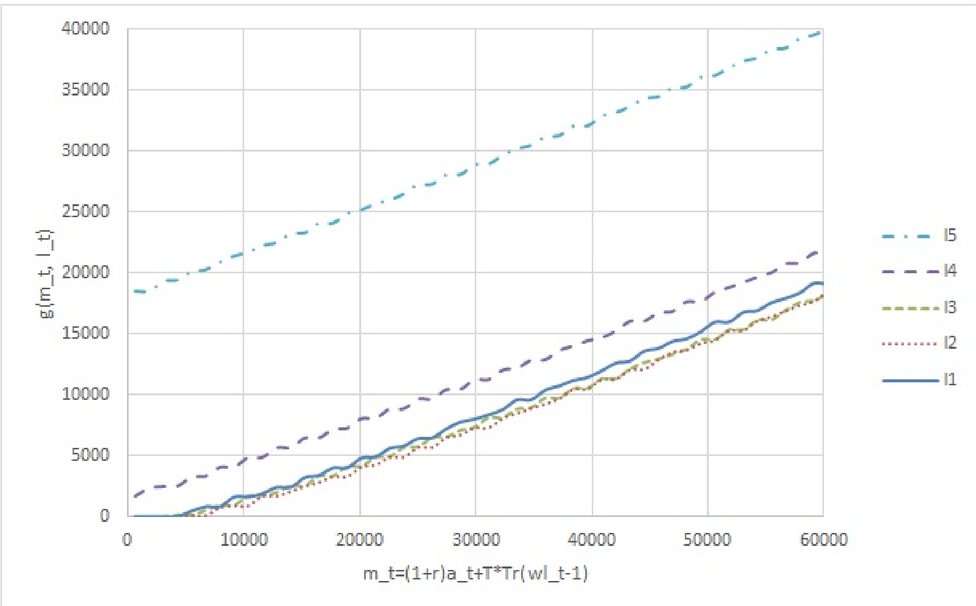


Figure 3: The household's saving policy $g(m_t, l_t)$ for the benchmark calibration

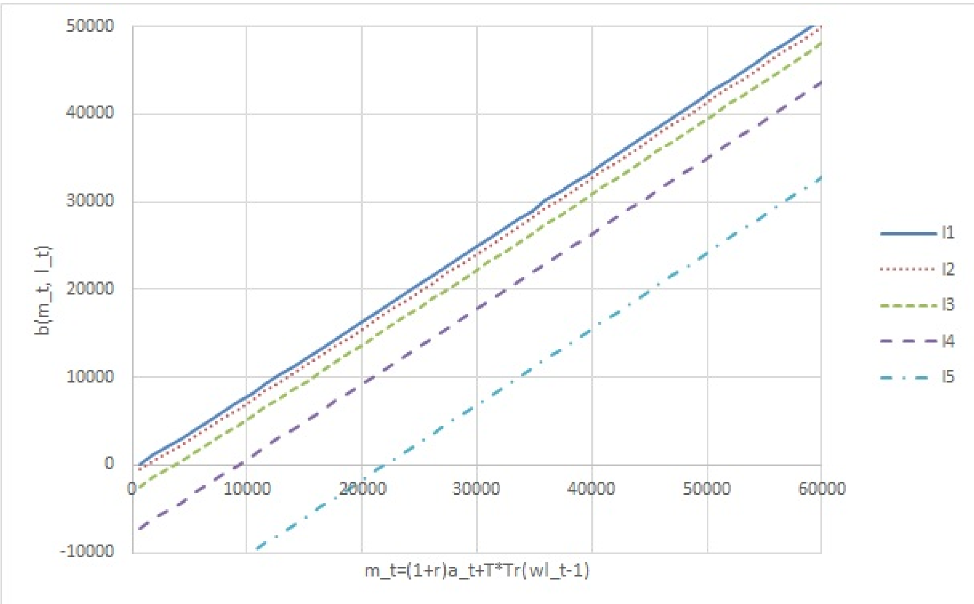
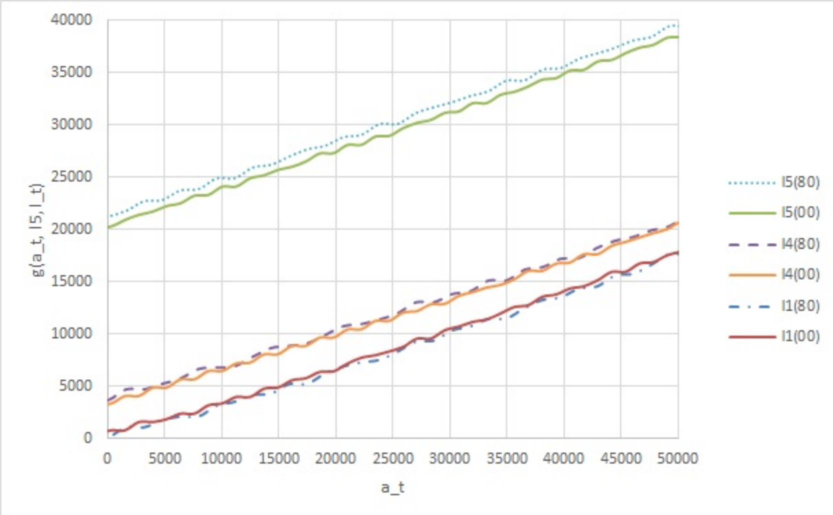
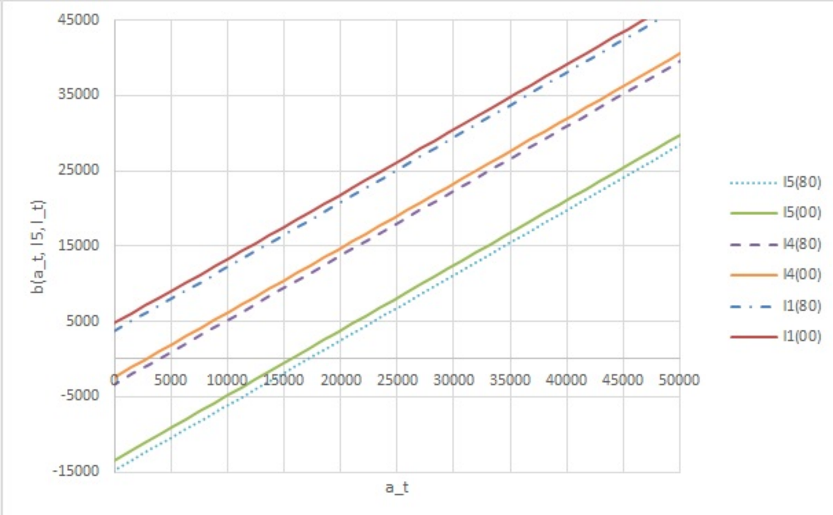


Figure 4: The household's transfer policy $b(m_t, l_t)$ for the benchmark calibration



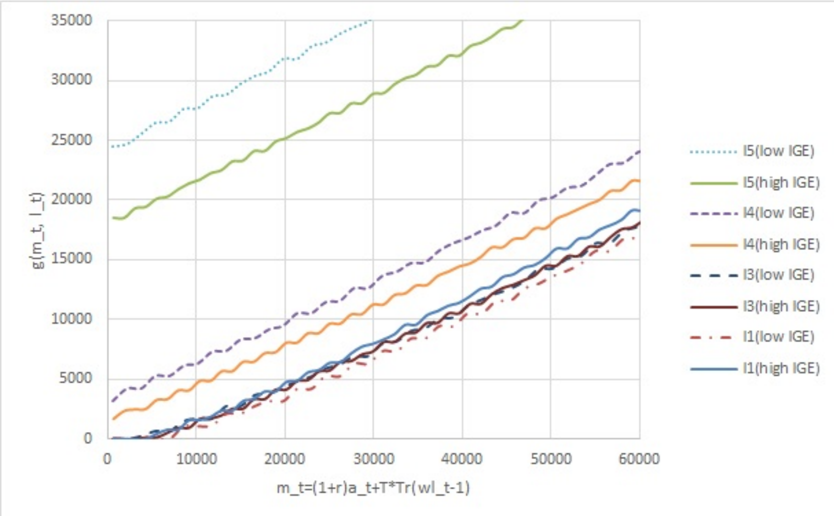
(a) The saving policy $g(a_t, l_{t-1}, l_t)$



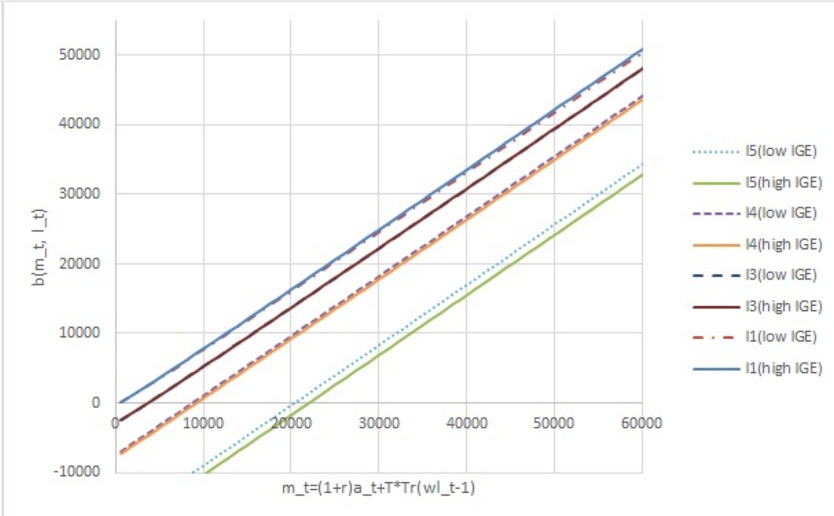
(b) The transfer policy $b(a_t, l_{t-1}, l_t)$

Figure 5: The comparison of the policy functions: 1980's vs. 2000's social security

We show the policies for $l_{t-1} = l_5$ only, as the responses are most obvious to see on diagrams in this case. Moreover, policies for $l_t = l_1, l_4 \text{or} l_5$ only are drawn on the diagrams, to keep the figures neat and clear as policies for $l_t = l_2 \text{or} l_3$ will look very close to $l_t = l_1$ on the diagrams.



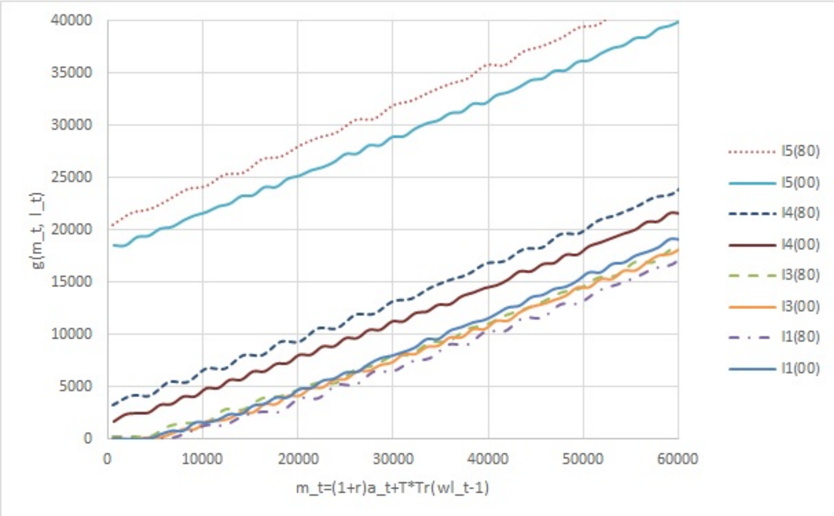
(a) The saving policy $g(a_t, l_{t-1}, l_t)$



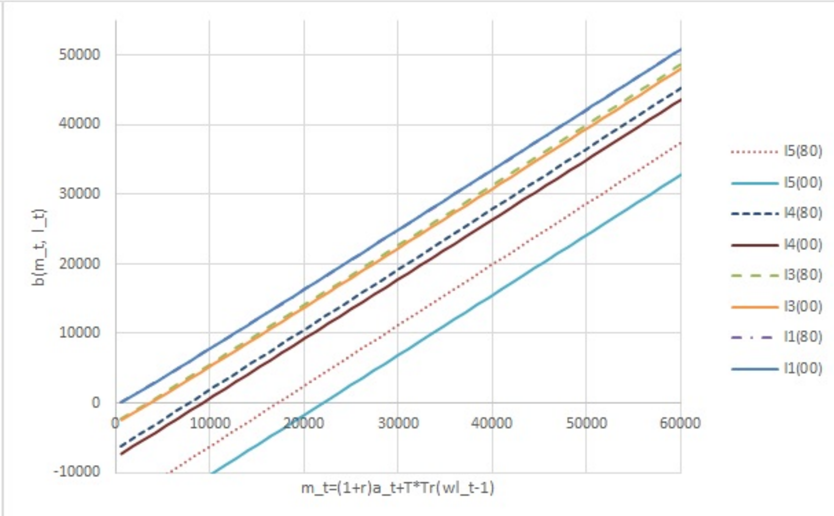
(b) The transfer policy $b(a_t, l_{t-1}, l_t)$

Figure 6: The comparison of the policy functions: 1980's (low) vs. 2000's (high) IGE

The policies for $l_t = l_1, l_3, l_4 or l_5$ only are drawn on the diagrams, to keep the figures neat and clear.



(a) The saving policy $g(a_t, l_{t-1}, l_t)$



(b) The transfer policy $b(a_t, l_{t-1}, l_t)$

Figure 7: The comparison of the policy functions: 1980's economy vs. 2000's economy

The policies for $l_t = l_1, l_3, l_4 \text{or} l_5$ only are drawn on the diagrams, to keep the figures neat and clear.