Does Privatizing Social Security Produce Efficiency Gains?

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Introduction

- The current Social Security system
  - provides insurance against uncertain life spans and working ability shocks;
  - generates labor market distortions induced by the payroll tax.
- Privatization of Social Security could lead to efficiency gains or losses
- This paper *quantitatively* analyzes the macroeconomic and efficiency effects of Social Security privatization.
- Develops a heterogeneous-agent OLG model with elastic labor supply and idiosyncratic shocks to wages and lifetime uncertainty.

Motivation

- A fiscal policy change is not *in general* Pareto improving. Some households (or generations) will gain from the policy change at the expense of the others.
  - Social Security privatization would possibly improve the welfare of future generations at the expense of current generations (because of transition costs).
  - Privatization would possibly improve the welfare of high working ability workers at the expense of low working ability workers (because of a *reduction* in redistribution).
- We construct a proper measure of the net *efficiency* gain (or loss) that compensates households that would otherwise lose from reform;
  - Takes entire transition path into account;
  - Valid in general equilibrium.

Summary of the Results

- This paper considers a stylized partial (50 percent) and phased-in (40 years) Social Security privatization plan under different assumptions.
  - The transition cost is financed with a consumption tax (currently being modified in revision)
- In a representative-agent OLG economy without wage shocks, the partial privatization plan generates efficiency gains [+$21,900 per future household].
- In a heterogeneous-agent OLG economy with idiosyncratic working ability shocks, the privatization plan generates efficiency losses [-$5,600 per future household].

Summary of the Results (2)

- Surprisingly, in heterogeneous OLG economy with working ability shocks, efficiency losses from the privatization *increase* if
  - a small open economy is assumed (i.e., capital can move freely across the border);
  - perfect annuity markets are introduced to the economy (so that households can insure their longevity shocks).
- Efficiency losses from the privatization *decrease* if
  - the government introduces a modest matching (financed by the income tax increase) to low income households;
    - but too much matching actually hurts
  - the traditional benefit schedule is made more progressive (financed by the consumption tax increase).
- Privatization with a sizable increase in the benefit progressivity actually generates efficiency gains.

Base Model

- A heterogeneous-agent overlapping generations model with uninsurable idiosyncratic working ability shocks.
  - Aiyagari (QJE 1994)
  - Huggett (JME 1996)
  - Huggett and Ventura (RED 1999)
  - Conesa and Krueger (RED 1999)

- No aggregate productivity shocks
- No intergenerational altruism
- With lifetime uncertainty

Individual State: $\mathbf{s}_i = (i, e_i, a_i, b_i)$

i	Age $i \in \{20, ..., 109\}$
e_i	Working Ability $e_i \in \{e_i^1, e_i^2, ..., e_i^8\}$
a_i	Wealth $a_i \in [a_{\min}, a_{\max}]$
b_i	Average Historical Earnings (AIME$\times$12) per Worker

State of the Economy: $\mathbf{S}_t = (x_t(\mathbf{s}_i), W_{LS,t}, W_{G,t})$

$x_t(\mathbf{s}_i)$	Distribution of Households
$W_{LS,t}$	Lump-Sum Redistribution Authority Wealth
$W_{G,t}$	Rest of the Government Wealth

Policy Schedule: $\Psi_t = \{W_{LS,s+1}, W_{G,s+1}, C_{G,s}, \tau_{I,s}(.), \tau_{P,s}(.), \tau_{C,s}, tr_{SS,s}(\mathbf{s}_i), tr_{LS,s}(\mathbf{s}_i)\}_{s=t}^{\infty}$

$\tau_{I,s}(.)$	Progressive Income Tax Function
$\tau_{P,s}(.)$	Payroll Tax Function for OASDI
$\tau_{C,s}$	Consumption Tax Rate
$tr_{SS,s}(\mathbf{s}_i)$	OASDI Benefit Function
$tr_{LS,s}(\mathbf{s}_i)$	Lump-Sum Redistribution Authority Transfer

Household Decision Rules: $\mathbf{d}(\mathbf{s}_i, \mathbf{S}_t; \Psi_t)$

$c_i(\mathbf{s}_i, .; .)$	Consumption
$h_i(\mathbf{s}_i, .; .)$	Working Hours per Couple
$a_{i+1}(\mathbf{s}_i, .; .)$	End-of-period wealth

Households' Problem

$$v\left(\mathbf{s}_i, \mathbf{S}_t; \Psi_t\right) = \max_{c_i, h_i} u\left(c_i, h_i\right) + \beta\left(1+\mu\right)^{\alpha(1-\gamma)} \phi_i E\left[v\left(\mathbf{s}_{i+1}, \mathbf{S}_{t+1}; \Psi_{t+1}\right) | e_i\right]$$

subject to

$$\begin{aligned} a_{i+1} = & \frac{1}{1+\mu}\left\{w_t e_i h_i + (1+r_t)(a_i + tr_{LS,t}(\mathbf{s}_i))\right. \\ & - \tau_{I,t}\left(w_t e_i h_i, r_t(a_i + tr_{LS,t}(\mathbf{s}_i)), tr_{SS,t}\left(\mathbf{s}_i\right)\right) \\ & \left. -\tau_{P,t}\left(w_t e_i h_i\right) + tr_{SS,t}\left(\mathbf{s}_i\right) - (1+\tau_{C,t})c_i\right\} \geq a^{\min}_{i+1,t}(\mathbf{s}_i), \end{aligned}$$

$$a_{20} = 0, \text{ and } a_{i\in\{65,\dots,110\}} \geq 0,$$

$$b_{i+1} = \begin{cases} 0 & \text{if } i \leq 24 \\ \frac{1}{i-24}\{(i-25)b_i \frac{w_t}{w_{t-1}} + \min\left(w_t e_i h_i/2, weh^{\max}_t\right)\} & \text{if } 25 \leq i \leq 59 \\ (1+\mu)^{-1} b_i & \text{if } i \geq 60, \end{cases}$$

where $weh^{\max}_t$ is payroll tax cap and μ is a long-run growth rate.

- 8 x 8 transition matrix, indexed by age
- Survival function for ϕ_i

The Measure of Households

$x_t(\mathbf{s})$ = measure of households, adjusted by pop. growth rate, ν

$X_t(\mathbf{s})$ = corresponding cumulative measure.

The population of age 20 households is normalized to unity:

$$\int_E \mathrm{d}X_t(20, e, 0, 0) = 1.$$

Law of motion of the measure of households

$$x_{t+1}(\mathbf{s}') = \frac{\phi_i}{1+\nu} \int_{E \times A \times B} \mathbf{1}_{[a'=a'(\mathbf{s},\mathbf{S}_t;\Psi_t)+q_t]} \mathbf{1}_{[b'=b'(w_t e h(\mathbf{s},\mathbf{S}_t;\Psi),b)]} \pi_{i,i+1}(e'|e$$

where $\pi_{i,i+1}$ denotes the transition probability of working ability from age i to age $i+1$.

Distribution of Bequests

- *Aggregate* value of accidental bequests deterministic
- Could be distributed equally across surviving households:
  - But anticipated with certainty, artificially reducing savings
  - Inequal bequests needed for realistic wealth inequality
- We distribute bequests randomly to surviving working-age households.
  - Each household receives a bequest q_t with constant probability η:

$$q_t = \frac{\sum_{i=20}^{109}(1-\phi_i)\int_{E\times A\times B} a'(\mathbf{s},\mathbf{S}_t;\Psi_t)\mathrm{d}X_t(\mathbf{s})}{\sum_{i=20}^{109}(1-\phi_i)\int_{E\times A\times B}\mathrm{d}X_t(\mathbf{s})},$$

$$\eta = \frac{\sum_{i=20}^{109}(1-\phi_i)\int_{E\times A\times B}\mathrm{d}X_t(\mathbf{s})}{\sum_{i=20}^{64}\phi_i\int_{E\times A\times B}\mathrm{d}X_t(\mathbf{s})}.$$

Government

$$T_{I,t} = \sum_{i=20}^{109} \int_{E \times A \times B} \tau_{I,t} \left(w_t e h(\mathbf{s}, \mathbf{S}_t; \Psi_t), r_t \left(a + tr_{LS,t} \left(\mathbf{s} \right) \right), tr_{SS,t} \left(\mathbf{s} \right) \right) \mathrm{d}X_t \, (\mathbf{s}$$

$$T_{P,t} = \sum_{i=20}^{109} \int_{E \times A \times B} \tau_{P,t} \left(w_t e h(\mathbf{s}, \mathbf{S}_t; \Psi_t) \right) \mathrm{d}X_t \left(\mathbf{s} \right).$$

$$Tr_{SS,t} = \sum_{i=20}^{109} \int_{E \times A \times B} tr_{SS,t} \left(\mathbf{s} \right) \mathrm{d}X_t \left(\mathbf{s} \right).$$

$$W_{G,t+1} = \frac{1}{\left(1+\mu\right)\left(1+\nu\right)} \left\{ (1+r_t) W_{G,t} + T_{I,t} + T_{P,t} - Tr_{SS,t} - C_{G,t} \right\},$$

Table 1: Marginal Individual Income Tax Rates in 2001 (Married Household, Filed Jointly)

Taxable Income			Marginal Income Tax Rate (%)
\$0	–	\$45,200	$15.0 \times \varphi_I$
\$45,200	–	\$109,250	$28.0 \times \varphi_I$
\$109,250	–	\$166,500	$31.0 \times \varphi_I$
\$166,500	–	\$297,350	$36.0 \times \varphi_I$
\$297,350	–		$39.6 \times \varphi_I$

Table 2: Marginal Payroll Tax Rates in 2001

Taxable Labor Income per Worker			Marginal Tax Rate (%)	
			OASDI	HI
\$0	–	\$80,400	$12.4 \times \varphi_P$	2.9
\$80,400	–		$0.0 \times \varphi_P$	2.9

Note: The payroll tax adjustment factor φ_P equals 1.0 in. the baseline economy.

Table 3: OASDI Replacement Rates in 2001

AIME (b/12)			Marginal Replacement Rate (%)
\$0	–	\$561	$90.0 \times \varphi_{SS}$
\$561	–	\$3,381	$32.0 \times \varphi_{SS}$
\$3,381	–		$15.0 \times \varphi_{SS}$

Note: The OASDI benefit adjustment factor φ_{SS} is set so that the OASDI is pay-as-you-go in the baseline economies.

Lump-Sum Redistribution Authority (LSRA)

- LSRA is a *tool* to calculate Hicksian efficiency gains
- Rebates or taxes (1) all current households at the time of the policy change ($t = 1$) and (2) all new households when they enter the economy ($t \geq 2$) to make those households as better off as the pre-reform economy.
- If the net discounted value of LSRA transfers is negative [positive], LSRA makes additional transfers [tax] Δtr (uniform, growth-adjusted) to all future households.
- That is, Δtr shows the overall *efficiency gain* ($\Delta tr > 0$) or *loss* ($\Delta tr < 0$).

$$tr_{R,t}(\mathbf{s}_i) = \begin{cases} tr_{CV,t}(\mathbf{s}_i) & \text{if } t = 1 \\ tr_{CV,t}(\mathbf{s}_i) + \Delta tr, & \text{if } t > 1 \text{ and } i = 20 \\ 0 & \text{otherwise} \end{cases} .$$

$$W_{LS,t+1} = \frac{1}{(1+\mu)(1+\nu)}(1 + r_t)(W_{LS,t} - Tr_{LS,t}),$$

Other Standard Procedures of a Bewley Model

- The production technology is Cobb-Douglas.
- Aggregation in a closed economy

$$K_t = W_t = \sum_{i=20}^{109} \int_{E\times A\times B} a_i \mathrm{d}X_t\left(\mathbf{s}_i\right) + W_{LS,t} + W_{G,t}$$

$$L_t = \sum_{i=20}^{109} \int_{E\times A\times B} e_i\, h_i(\mathbf{s}_i, \mathbf{S}_t; \Psi_t)\mathrm{d}X_t\left(\mathbf{s}_i\right).$$

Recursive Competitive Equilibrium

Let $\mathbf{s}_i = (i, e_i, a_i, b_i)$ be the state of households, let $\mathbf{S}_t = (x_t(\mathbf{s}_i), W_{LS,t}, W_{G,t})$ be the state of the economy, and let Ψ_t be the government policy schedule known at the beginning of year t. A series of factor prices, accidental bequests, the policy variables, and the parameters $\boldsymbol{\varphi}$ of policy functions,

$$\Omega = \{r_s, w_s, q_s, W_{LS,s+1}, W_{G,s+1}, C_{G,s}, \tau_{C,s}, tr_{LS,s}(\mathbf{s}_i), \boldsymbol{\varphi}_s\}_{s=t}^{\infty},$$

the value function of households,$\{v\left(\mathbf{s}_i, \mathbf{S}_s; \Psi_s\right)\}_{s=t}^{\infty}$, the decision rule of households, $\{\mathbf{d}(\mathbf{s}_i, \mathbf{S}_s; \Psi_s)\}_{s=t}^{\infty}$, and the measure of households, $\{x_s(\mathbf{s}_i)\}_{s=t}^{\infty}$, are in a recursive competitive equilibrium if, in every period $s = t, ..., \infty$,

1. each household solves the utility maximization problem taking Ψ_t as given,

2. the firm solves the profit maximization problem, and the capital and labor markets clear,

3. the government policy schedule satisfies.

Solution Algorithm: Discretization of the State Space

Take factor prices and policy variables as given ("outer loop")

State of a household: $\mathbf{s}_i = (i, e_i, a_i, b_i) \in I \times E \times A \times B$

- $I = \{20, ..., 109\}$
- $E = [e^{\min}, e^{\max}]$
- $A = [a^{\min}, a^{\max}]$
- $B = [b^{\min}, b^{\max}]$.

Discretized as $\hat{\mathbf{s}}_i \in I \times \hat{E}_i \times \hat{A} \times \hat{B}$,

- $\hat{E}_i = \{e_i^1, e_i^2, ..., e_i^{N_e}\}, N_e = 8$ (1 in rep. agent model)
- $\hat{A} = \{a^1, a^2, ..., a^{N_a}\}, N_a = 57$ (61 in rep. agent)
- $\hat{B} = \{b^1, b^2, ..., b^{N_b}\}, N_b = 8$ (6 in rep. agent)
  - Experiment with # of nodes; reduce until has an impact

For all these discrete points, compute:

- Household decisions:

$$\mathbf{d}(\hat{\mathbf{s}}_i, \mathbf{S}_t; \Psi_t) = \left(c_i\left(.\right), h_i\left(.\right), a_{i+1}\left(.\right)\right) \in (0, c^{\max}] \times [0, h_i^{\max}] \times A$$

- Marginal values, $\frac{\partial}{\partial a} v(\hat{\mathbf{s}}_i, \mathbf{S}_t; \Psi_t)$ and $\frac{\partial}{\partial b} v(\hat{\mathbf{s}}_i, \mathbf{S}_t; \Psi_t)$
- Values $v(\hat{\mathbf{s}}_i, \mathbf{S}_t; \Psi_t)$

To find the optimal end-of-period wealth:

- Start with the Euler equation
- Bilinear interpolation (with respect to a and b) of marginal values next period.
  - Linear assumption normally induces saddle path
  - So we go linear in *marginal* value fct => quadratic in V
  - Also, we use log-linear rather than just linear
  - Experimenting with smooth functions but then must smooth policies
  - Shape preservation not possible in general in many dimensions

Solving for Steady-State Equilibrium (without LSRA)

Gov't policy: $\Psi = (W_{LS}, W_G, C_G, \tau_I(.), \tau_P(.), \tau_C, tr_{SS}(\hat{\mathbf{s}}_i), tr_{LS}(\hat{\mathbf{s}}_i))$.

1. Set the initial values of factor prices (r^0, w^0), accidental bequests q^0, the policy variables $(W_{LS}^0, C_G^0, \tau_C^0)$, and the parameters $\left(\varphi_I^0, \varphi_{SS}^0\right)$ of policy functions $(\tau_I(.),\ tr_{SS}(\hat{\mathbf{s}}_i))$ if determined endogenously.

2. Given $\Omega^0 = (r^0, w^0, q^0, W^0_{LS}, C^0_G, \tau^0_C, \varphi^0_I, \varphi^0_{SS})$, find the decision rule of a household $\mathbf{d}(\hat{\mathbf{s}}_i;\ \Psi, \Omega^0)$ for all $\hat{\mathbf{s}}_i \in I \times \hat{E}_i \times \hat{A} \times \hat{B}$.

   (a) For age $i = 109$, find the decision rule $\mathbf{d}(\hat{\mathbf{s}}_{109}; \Psi, \Omega^0)$. Since the survival rate $\phi_{109} = 0$, the end-of-period wealth $a_{i+1}(\hat{\mathbf{s}}_{109}; .) = 0$ for all $\hat{\mathbf{s}}_{109}$. Compute consumption and working hours $(c_i(\hat{\mathbf{s}}_{109}; .), h_i(\hat{\mathbf{s}}_{109}; .))$ and, then, marginal values $\frac{\partial}{\partial a} v(\hat{\mathbf{s}}_{109}; \Psi, \Omega^0)$ and values $v(\hat{\mathbf{s}}_{109}; \Psi, \Omega^0)$ for all $\hat{\mathbf{s}}_{109}$.

   (b) For age $i = 108, ..., 20$, find the decision rule $\mathbf{d}(\hat{\mathbf{s}}_i; \Psi, \Omega^0)$, marginal values $\frac{\partial}{\partial a} v(\hat{\mathbf{s}}_i; \Psi, \Omega^0)$, and values $v(\hat{\mathbf{s}}_i; \Psi, \Omega^0)$ for all $\hat{\mathbf{s}}_i$, using $\frac{\partial}{\partial a} v(\hat{\mathbf{s}}_{i+1}; \Psi, \Omega^0)$ and $\frac{\partial}{\partial b} v(\hat{\mathbf{s}}_{i+1}; \Psi, \Omega^0)$ recursively.

      i. Set the initial guess of $a^0_{i+1}(\hat{\mathbf{s}}_i; .)$.

      ii. Given $a^0_{i+1}(\hat{\mathbf{s}}_i; .)$, compute $(c_i(\hat{\mathbf{s}}_i; .), h_i(\hat{\mathbf{s}}_i; .))$, using $\frac{\partial}{\partial b} v(\hat{\mathbf{s}}_{i+1}; \Psi, \Omega^0)$. Plug into the Euler eq'n with $\frac{\partial}{\partial a} v(\hat{\mathbf{s}}_{i+1}; \Psi, \Omega^0)$.

      iii. If the Euler error sufficiently small, stop. Otherwise, update $a^0_{i+1}(\hat{\mathbf{s}}_i; .)$ and return to Step ii.

3. Find the steady-state measure of households $x(\hat{\mathbf{s}}_i; \Omega^0)$ using the decision rule obtained in Step 2. This computation is done forward from age 20 to age 109. Repeat this step to iterate q for q^1.

4. Compute new factor prices (r^1, w^1), accidental bequests q^1, the policy variables $(W^1_{LS}, C^1_G, \tau^1_C)$, and the parameters $\left(\varphi^1_I, \varphi^1_{SS}\right)$ of policy functions.

5. Compare $\Omega^1 = (r^1, w^1, q^1, W^1_{LS}, C^1_G, \tau^1_C, \varphi^1_I, \varphi^1_{SS})$ with Ω^0. If the difference is sufficiently small, then stop. Otherwise, update Ω^0 and return to Step 2.

Solving for Transition Path (without LSRA)

Similar to steady-state solution except:

1. Solved for many cohorts over next T periods, at which point economy is in new steady state

2. For households alive at time of reform, must recompute their decisions conditional on their states alive at reform

See Appendix for precise details

Solving the Lump-Sum Redistribution Authority
If LSRA is operative, add the following steps to the iteration:

1. For period $t = T, T-1, ..., 2$, compute the lump-sum transfers to newborn households $tr_{CV}(\hat{\mathbf{s}}_{20}; \Psi_t, \Omega_t^0)$ to them as well off as under the pre-reform economy. See more details in Appendix.

2. For period $t = 1$, compute the lump-sum transfers to all current households $tr_{CV}(\hat{\mathbf{s}}_i; \Psi_t, \Omega_t^0)$ to make those households as much better off as the pre-reform economy. The procedure is similar to Step 1. Set the lump-sum transfers $tr_{LS,1}(\hat{\mathbf{s}}_i) = tr_{CV}(\hat{\mathbf{s}}_i; \Psi_t, \Omega_t^0)$.

3. Compute an additional lump-sum transfer Δtr to newborn households so that the net present value of all transfers becomes zero. Compute the LSRA wealth, $\{W_{LS,t}^1\}_{t=1}^T$, which will be used to calculate national wealth. Recompute Δtr and $\{W_{LS,t}^1\}_{t=1}^T$ using new interest rates $\{r_t\}_{t=1}^T$.

Main Parameters (1)

Coefficient of relative risk aversion	γ	2.0
Capital share of output	θ	0.30
Depreciation rate of capital stock	δ	0.047
Long-term real growth rate	μ	0.018
Population growth rate	ν	0.010
Probability of receiving bequests	η	0.0161
Total factor productivity *	A	0.949

* Total factor productivity is chosen so that w equals 1.0.

Main Parameters (2)

		Representative-Agent Econ. w/o Wage Shocks	Heterogeneous-Agent Econ. w/ Wage Shocks		
				Lower Transitory Shocks to	
				1/2	1/5
Time preference *1	β	1.004	0.985	0.992	1.000
Share for consumption *2	α	0.436	0.466	0.456	0.450
Income tax adj. factor *3	φ_I	1.000	0.818	0.847	0.874
OASDI benefit adj. factor *4	φ_{SS}	1.232	1.385	1.388	1.388

*1. K/Y is targeted to be 2.74 without annuity markets.

*2. The average working hours are 3414 per married couple when $h_{\max}= 8760$.

*3. In a heterogeneous economy, the ratio of income tax revenue to GDP is 0.123.

*4. The OASDI budget is assumed to be balanced.

Policy Experiments

- A 50-percent "privatization" is introduced in year 1, that is, workers are allowed to "redirect" one half of their payroll tax to their "private accounts."
- Traditional benefits are reduced cohort by cohort in a phase-in manner from year 1 though year 40.
  - PIAs of 65-year-old households in year 1 are reduced by 1.25% (=50%/40), PIAs of 65-year-old households in year 2 are reduced by 2.5%, and so on. PIAs of workers aged 26 or younger in year 1 will be one half of their pre-reform PIAs.
- The transition cost is mainly financed with a consumption tax year by year, that is

$$\tau_{C,t} = (Tr_{SS,t} - T_{P,t})/C_t$$

  where C_t is aggregate consumption in year t. The rest of the government budget is adjusted by the proportional changes in marginal income tax rates.

- Private Accounts are assumed to be perfect substitutes of other private assets in terms of the rate of return, taxation, and liquidity.

Privatization Runs

1. Representative-agent economy without working ability shocks
2. Heterogeneous-agent economy with idiosyncratic working ability shocks
3. Run 2 in a small-open economy assumption
4. Run 2 with perfect annuity markets
5. Run 2 with contribution matching starting at 10% (linearly reduced to 0% at $60K household labor income)
6. Run 2 with contribution matching starting at 20%
7. Run 2 with more progressive S.S. bend points—120/32/10%
8. Run 2 with more progressive S.S. bend points—150/32/10%

Percent Change in Macro Variables from Baseline

(Without LSRA)

Run #	Year t	Y	K	L	r	w	φ_I^{*2}	τ_C
1	1	2.4	0.0	3.4	4.2	-1.0	-13.4	6.5
Representative	10	3.8	6.4	2.7	-4.3	1.1	-14.6	5.7
Agent without	20	5.4	10.9	3.1	-8.7	2.2	-16.6	4.3
Wage Shocks*1	40	8.3	17.6	4.6	-13.8	3.6	-20.1	1.1
	Long Run	9.3	20.7	4.8	-16.4	4.3	-21.2	-0.2
2	1	1.3	0.0	1.8	2.3	-0.5	-5.7	5.5
Heterogenous	10	2.5	4.3	1.7	-3.0	0.7	-6.6	4.8
Agents with	20	4.0	8.1	2.2	-6.7	1.7	-8.1	3.6
Wage Shocks*1	40	6.7	15.1	3.4	-12.7	3.3	-10.6	0.9
	Long Run	7.8	18.7	3.5	-16.0	4.2	-11.3	-0.2

*1. Closed economy, no private annuity markets, and LSRA is off.

*2. The proportional change in marginal tax rates across all households.

Change in Welfare per Household (1,000 dollars in 2001)

Run #	Age in Year 1	Without LSRA* Select Productivities e^1	e^3	e^5	e^8	With LSRA** For all Productivities
1	79	-	-7.5	-	-	0.0
Representative	60	-	-47.4	-	-	0.0
Agent Economy	40	-	-60.0	-	-	0.0
w/o Wage Shocks	20	-	-16.9	-	-	0.0
	0	-	24.6	-	-	21.9
	-20	-	47.1	-	-	21.9
2	79	-4.8	-5.7	-14.7	-79.3	0.0
Heterogeneous	60	-27.6	-43.5	-64.4	-361.8	0.0
Agent Economy	40	-18.7	-46.7	-76.4	-368.4	0.0
with Wage Shocks	20	2.2	-1.5	-5.2	-15.5	0.0
	0	32.8	33.7	36.1	43.4	-5.6
	-20	52.4	56.7	63.5	84.3	-5.6

* Standard equivalent variations measures. ** Value of Δtr.

Alternative Experiments (1)

(Heterogeneous Economy with Wage Shocks)

Run #	Without LSRA				With LSRA
	t	Y	K	L	Δtr
2. Closed Economy	10	2.5	4.3	1.7	
without Annuity Markets	20	4.0	8.1	2.2	
	Long Run	7.8	18.7	3.5	-5.6
3. Small Open Economy	10	3.6	7.3	2.0	
	20	5.6	14.5	1.8	
	Long Run	11.5	36.5	0.8	-6.6
4. Perfect Annuity Markets	10	2.3	4.2	1.5	
	20	3.5	7.4	1.9	
	Long Run	6.4	14.4	3.2	-7.2

Each run represents one change in assumption relative to Run 2, i.e., the changes are not cumulative.

Alternative Experiments (2)

(Heterogeneous Economy with Wage Shocks)

Run #	Without LSRA				With LSRA
	t	Y	K	L	Δtr
2. Closed Economy	10	2.5	4.3	1.7	
without Annuity Markets	20	4.0	8.1	2.2	
	Long Run	7.8	18.7	3.5	-5.6
5. Contribution Matching	10	0.7	2.2	0.1	
Starting at 10%	20	2.0	5.1	0.8	
	Long Run	5.9	15.1	2.1	-4.4
6. Contribution Matching	10	-1.5	-0.5	-2.0	
Starting at 20%	20	-0.5	1.2	-1.2	
	Long Run	3.4	11.0	0.3	-9.9
7. More Progressivity	10	1.3	2.2	0.8	
120 / 32 / 10%	20	2.6	5.3	1.5	
	Long Run	6.7	16.1	2.9	-0.1
8. More Progressivity	10	0.1	0.3	0.1	
150 / 32 / 10%	20	1.3	2.6	0.7	
	Long Run	5.5	13.4	2.3	+2.6

Each run represents one change in assumption relative to Run 2, i.e., the changes are not cumulative.

Lower Transitory Shocks and Higher Persistence

(Heterogeneous Economy with Wage Shocks)

Run #	Without LSRA				With LSRA
	t	Y	K	L	Δtr
2. Closed Economy	10	2.5	4.3	1.7	
without Annuity Markets	20	4.0	8.1	2.2	
	Long Run	7.8	18.7	3.5	-5.6
9. 1/2 Transitory Shocks	10	3.0	5.0	2.1	
	20	4.6	9.4	2.6	
	Long Run	8.7	20.4	4.0	-8.2
10. 1/5 Transitory Shocks	10	3.1	5.4	2.2	
	20	4.9	10.1	2.7	
	Long Run	9.1	21.4	4.2	-5.8

Each run represents one change in assumption relative to Run 2, i.e., the changes are not cumulative.

Concluding Remarks

- The policy implication in a simple (e.g., representative and deterministic) model is sometimes misleading. This paper showed that the insurance aspect of current Social Security is important.
  - The stylized partial privatization plan in this paper generates similar effects on macroeconomic variables in the representative-agent model without wage shocks and the heterogeneous-agent model with wage shocks.
  - However, the privatization generates sizable efficiency *gains* in the former and efficiency *losses* in the latter.
- Privatization with increased benefit progressivity can generate overall efficiency gains, according to our experiments.
- The efficiency implication in this paper is fairly robust for different sizes of transitory shocks.
- The model and procedure used in this paper are very useful to help policy makers choose the most efficient plan in several alternatives.