Intergenerational Long Term Effects of Preschool –Estimates from a Structural Dynamic Programming Model

Lakshmi K. Raut, Economist, Social Security Administration
and Visiting Fellow, University of Chicago
(paper jointly with James Heckman, University of Chicago)

In last few minutes I will briefly present this 2007 WEA conference paper.

Mortality and Disability Risk Sharing under the OASDI Program in a Stochastic Overlapping Generations Framework

Will not have time to present.

- Exits from the disability insurance rolls: estimates from a competing-risks model (forthcoming: Social Security Bulletin August 2017 issue)
- Economic Incentives and Social Security Disability Entitlements in a Counting Process Model (An earlier draft presented at 2010 WEA Meeting)
- Pathways to Disability using HRS data

Summary

- Economic Issues:
  - Skills such as social, motivational and cognitive skills are important for school and labor market success and are important determinants of income inequality and social mobility
  - Where are they produced? → Home, neighborhood, schools? → role of preschool inputs.
  - Children of poor SES lack these skills, resulting in lack of demand for higher education.
- Methodology:
  - Equilibrium Markov Process arising from an altruistic model of parental preschool investment within a structural dynamic programming framework, incorporating stochastic production processes of various skills.
- Policy: Estimate the effects of a publicly provided preschool program to disadvantaged children as a "social contract" for every generation.
  - Within generation effects: educational and labor market achievements, earnings distribution.
  - Intergenerational effects: social mobility and schooling mobility.
  - Estimate general equilibrium tax burden of such a social contract policy.

Findings

- Preschool has significantly positive effects on production of social, motivational and cognitive skills.
- These skills have significantly positive effects on school and labor market outcomes.
- The conventional estimate of the rate of returns to schooling without including the non-cognitive skills overestimates it by around one percent.
- The gains to the society exceed the cost of such a policy.
- The positive effects on social mobility, college mobility and income inequality are not dramatic but significant. The estimates are based on the qualities of preschools in the sixties. Higher economy-wide returns are expected from better quality preschool programs such as Perry preschool and Abecedarian preschool programs.

Outline

- Present evidence of inequality at birth—in terms of development in health, and human capital including cognitive and non-cognitive skills—has significant long-term effects in inequalities in school and labor market outcomes.
- Formulate stochastic production process of these skills and parental input choices in an altruistic dynamic programming framework.
- Derive an econometric estimation method for individual choices to recover structural parameters and controlled Markov Process driving the aggregate economy. Introduce publicly provided preschool program for children of poor SES. Use NLSY79 survey data for estimation of the model and
- Point out future extensions, especially incorporating macro feedback effects.

Important Skills: Cognitive and Personality traits

Evidence of importance of early intervention

- Neuroscience research on brain development using fMRI techniques, see Noble et al (2012). Study the importance of intervention between ages, 0-8.
- Bowlby's affect dysregulation theory: importance during ages 0-2.
- Stanford Marshmallow Test (see Walter Mischel, 2014 book)
- Perry Preschool (see Schweinhart, 2002,Online Res. Bulletin)
- U.S.Census Bureau interviewed 3,000 employers (1 to 5 very important): skill credentials - 3.2, years of schooling - 2.9, scores on employer given test and academic performance- each 2.5, **attitude - 4.6 and communication - 4.2.**(see Bowles et al (2001, JEL)
- The Mind Tools Program (see Diamond et al, 2007**)**
- Evidence from NLSY79, I present the findings from our paper, Heckman and Raut [2016] and my earlier paper Raut[2003].

An altruistic Model of parental preschool investment, Raut[2003] and Heckman and Raut[2016]

- **Life cycle**: [0,5) preschool, [6-17) schooling, [17-26) number of years of schooling, [26-]: labor market participation
- **Observable states** (measured cognitive and non-cognitive skills) of an individual:
- x = (τ, σ, μ, η, φ, s)
  - τ : *talent,*
  - σ : *socialization,*
  - μ : *motivation,*
  - η : *Self-esteem (Rosenberg measure),*
  - φ : *Internal self-control (Perlin measure)*
  - *s : Schooling level*
- z = (x, ε), ε : *taste shifter and random factors affecting permanent income, school outcomes given observable inputs.*

Structural Dynamic Programming Model

- Parent of type: $(x, \varepsilon), x: \text{ observed m discrete types }, \varepsilon: \text{ unobserved}$
- Earns $w(x,\varepsilon)$, decides preschool investment *a in A(x).*
- Consumption: $c \equiv w(x,\varepsilon) - a(\theta)$ utility: $u_\theta\left(x, \varepsilon, a\right)$
- Transition probability : $p\left(dx', d\varepsilon' \mid x, \varepsilon, a\right)$
- Bellman equation of the choice problem:

$$V\left(x,\varepsilon\right) = \max_{a \in A\left(x\right)} u_\theta\left(x,\varepsilon,a\right) + \beta \int V\left(x',\varepsilon'\right) p\left(dx', d\varepsilon' \mid x, \varepsilon, a\right)$$

- *Structural Parameters:* $\xi = \{u_\theta(.), \xi_p, \beta\}$ *where* ξ_p : parameters characterizing transition probabilities
- *Optimal solution:* $a(x,\varepsilon)$
- Data: $\{(x_i, x_i^{'}), a_i\}_{i=1}^n$ cannot recover structural parameters **NEED** simplification

Simplifications

Assumptions: (originally made by Rust to convert this to McFadden's random utility framework)

A1: $u(x,\varepsilon,a) = u(x,a) + \varepsilon(a), \varepsilon(a)$ continous variable

A2: $p(x',\varepsilon' \mid x,\varepsilon,a) = g(\varepsilon' \mid x')f(x' \mid x,a)$

A3: ϵ's are i.i.d. as extreme value distribution with parameters– location 0 and scale 1.

Denote $v(x) \equiv \int V(x,\varepsilon)g(d\varepsilon \mid x)$ and $P(a \mid x) = \int_{\Omega(x,a)} g(d\varepsilon \mid x)$, where

$\Omega(x,a) = \{\varepsilon \mid a \text{ is optimal for agent } (x,\varepsilon)\}$

Then we have $v = (I - \beta\overline{F})^{-1}(\overline{u} + \overline{e})$ and $P(a \mid x) = \dfrac{e^{\tilde{v}(x,a)}}{\sum_{a' \in D} \tilde{v}(x,a')}$, where

$\tilde{v}(x,a) = u_\theta(x,a) + \beta F(x,a)[I_m - \beta\overline{F}]^{-1}[\overline{u}_\theta + \overline{e}]$

$\Pi(x,x') = \sum_{a \in A(x)} f(x' \mid x,a) * P(a \mid x;\tau)$

Notation:

$e(x,a) \equiv (\lambda - \ln P(a \mid x))$, where $\lambda = 0.57721566$, and

$F(x,a) = [(f(x_1' \mid x,a),\ldots f(x_m' \mid x,a)]$, an m-dimensional row vector

$$v = \begin{bmatrix} v(x_1) \\ \ldots \\ v(x_m) \end{bmatrix}, \text{ an } m\text{-dimensional column vector}$$

$\overline{w}(x) = \sum_{a \in A(x)} w(x,a)P(a \mid x)$ for any scalar or vector function $w(x,a)$

Estimation Algorithm

parametrize the utility function $u_\theta(x,a)$, where $\theta \in \Re^k$ and follow these steps:

1. Start with an initial $J \times 1$ vector of probabilities $P_0 \in \triangle$.

2. First compute the

$$P(a|x,\theta) = \frac{e^{\tilde{v}(x,a;\theta)}}{\sum_{a\in D(x)} e^{\tilde{v}(x,a';\theta)}}, \text{ where}$$
$$\tilde{v}(x,a) = u_\theta(x,a) + \beta F(x,a)\left[I_m - \beta \bar{F}\right]^{-1}\left[\bar{u}_\theta + \bar{e}\right]$$

   and then maximize the likelihood $L(\theta,\beta) = \prod_{i=1}^{n} P(a_i|x_i,\theta)$ which is a non-linear conditional logit model.

3. Given θ^*, β^* in step 2, compute $P_1 = (P(a|x,\theta^*), x \in X, a \in A) \in \triangle$ from the above formula.

4. If $||P_1 - P_0|| < \varepsilon$ STOP, else set $P_0 = P_1$ go to step 2.

Table 4: Maximum likelihood parameter estimates of $\xi = (\theta, \beta)$ and other derivd macroeconomic parameters, given two different estimates of $f_\gamma(x'|x,a)$

	Given estimates of $f_\gamma(x'\|x,a)$ with	
	only significant x	all x
Cost ($\hat{\theta}$) of preschool (in '000 dollars)	1.222***	1.224***
Degree of altruism: $\hat{\beta}$	0.443**	0.486***
Long-run Equibrium Tax Rate: τ (in percent)	5.94	5.83
Percent of population in poor SES:		
Before the policy introduction ($\tau = 0$)	36.22	35.71
After the policy introduction	29.64	29.14
Per capita after tax annual earnings:		
Before the policy introduction ($\tau = 0$)	5621.85	5640.08
After the policy introduction	5734.93	5759.38
gains in per capita income	113.09	119.30
log-likelihood	-7424.97	-7429.575

Note: Parameter estimates with *, **, and *** are significant at $p \leq 0.10$, $p \leq 0.05$ and $p \leq 0.01$ respectively.

Intergenerational Effects of Free preschool to children of poor SES

- From estimated optimal transition probability matrix *p(x'|x,a(x))*, x in X, calculated intergenerational <u>mobility measure</u>: $1-\lambda_{max}$ and invariant population distribution
- **<u>College Mobility</u>**:
  - Before:

$$Q_b^s = \begin{bmatrix} 0.93287 & 0.06713 \\ 0.59380 & 0.40620 \end{bmatrix}, p_b^s = \begin{bmatrix} 0.8984 & 0.1016 \end{bmatrix}, 1-\lambda_{\max,b}^s = 0.6609$$

  - After Policy:

$$Q_a^s = \begin{bmatrix} 0.90553 & 0.09447 \\ 0.59184 & 0.40816 \end{bmatrix}, p_a^s = \begin{bmatrix} 0.8624 & 0.1376 \end{bmatrix}, 1-\lambda_{\max,a}^s = 0.6863$$

- **<u>Social mobility</u>**:
  - before the policy: 0.5945
  - After the policy: 0.6465
- **<u>Income Inequality (Gini Coefficient):</u>**
  - Before the policy:0.2363, percent in poor SES: 36 , w = 5622
  - After the policy: 0.2335, percent in poor SES: 30, w = 5735
- **<u>Tax Burden of the Social Contract</u>**

Per capita gain in average after tax earnings == $113

Thank you...

Mortality and Disability Risk Sharing under the OASDI Program in a Stochastic Overlapping Generations Framework

Lakshmi K. Raut

Presented at the 2007 WEA Meeting

Motivation

Disability and Mortality Risks over the life cycle:

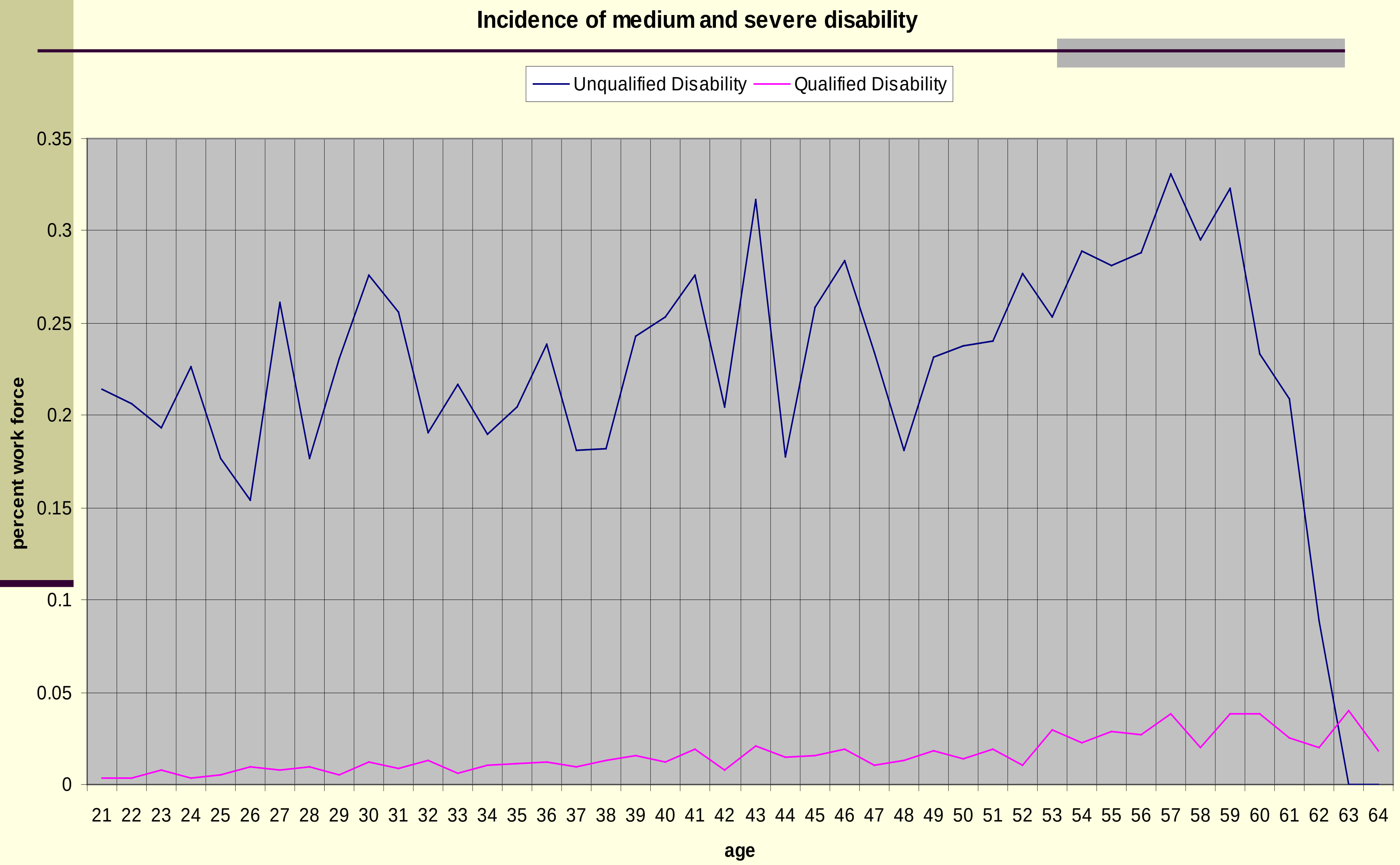
Individuals develop adverse health conditions as they get older, which limit their earnings, resources, and well-being. Workers also face uncertainty about their life spans, which affect their savings and consumption decisions. Many well-known economic characteristics (known as moral hazard and adverse selection) of these risks prevent private markets from pooling these risks adequately. Pay-as-you-go social insurance programs—by levying payroll taxes on workers and paying benefits to disabled workers, retirees, and survivors—can substitute for these missing markets.

We examine the effects of a program similar to the OASDI (Old-Age, Survivors and Disability Insurance) program on these two types of risk-sharing.

Outline

- The value of the OASDI program to individuals: -- Annuity role of the OASI program and income smoothing role of the DI program.
  - Effect of the program on the mean and variance of asset holdings, earnings, and consumption over the life-cycle.
  - Effect of the program on the size of the representative individual's life-time welfare
  - Individual's willingness to pay for the protection.
  - Macroeconomic effects on capital accumulation and labor supply.
- How individuals in different groups—by sex, race, education level and occupation—protected by the program for the two types of risks. Which group benefits relatively more. (to be done)

Incidence of Disability



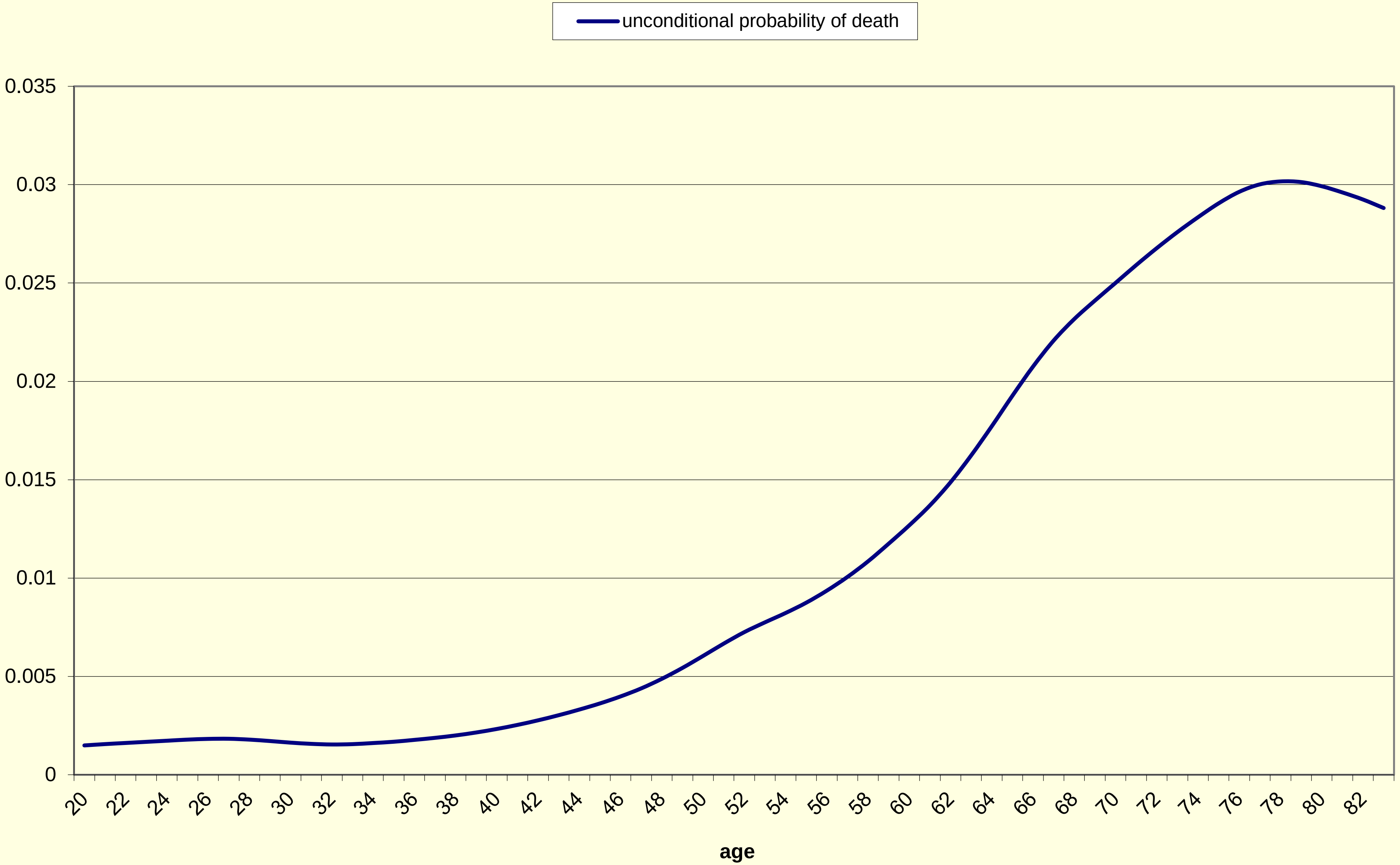
Transition Probability of disability Health Status

Table: Transition probabilities (in percent) for health status from one year to the next

Health status current year	Health status next year		
	Normal	Moderate	Disabled
Normal	90.90	7.36	1.74
Moderate	21.14	71.77	7.09
Disabled	18.35	55.06	26.59

Source: Estimated by the author from SIPP

Figure 1: Probability of dying at the end of an age



Structure of the Model Economy

Each person active life starts at age 21, his first period of life, and he lives a maximum of 65 periods, i.,e., up to age 85. We assume that at age 65, i.e. in period 45, he retires.

Notation:

- $\mathcal{S} = \{s_d, s_m, s_n\}$: $s_d =$ disabled and eligible for disability benefits, $s_m =$ somewhat disabled which lowers productivity but not qualified for disability benefits, and $s_n =$ normal health status.
- $g \in G$: group g in the set of groups G.
- $e(g, j, s), g \in G, j = 1...J, s \in \mathcal{S}$: a group member g's age-specific disability indexed productivity level,
- $\Gamma_j^g(s'|s), s \in \mathcal{S}, g \in G, j = 1, ...J-1$: a group member g's age-specific transition probability matrices are to be computed form SIPP data set.
- n : annual population growth rate.
- γ_b : annual growth rate of labor productivity growth.
- q : accidental inheritance.
- τ_o : Social Security pension tax rate.
- τ_d : Social Security disability tax rate.
- ψ_k^g : a group member g's probability of surviving to age k, from age $k-1$.

Aggregate Production Function

$$\begin{aligned} Y_t &= F(K_t, b_t L_t), \quad \bar{k}_t = K_t/(b_t L_t), \quad f(k) \equiv F(k, 1), \\ r_t &= f'\left(\bar{k}_t\right) - \delta, \quad w_t = f\left(\bar{k}_t\right) - \bar{k}_t f'\left(\bar{k}_t\right), b_t = b_0 (1+\gamma_b)^t \end{aligned}$$

Felicity Index in each period

$$u(c,\ell)=\frac{\left[c^{\phi}\left(1-\ell\right)^{1-\phi}\right]^{1-\gamma}}{1-\gamma}$$

The Bellman equation of the choice problem

$$V_j^g\left(a,s\right)=\max_{c_j,\ell_j}u\left(c,1-\ell\right)+\tilde{\beta}\psi_{j+1}^g\sum_{s'}V_{j+1}^g\left(a',s'\right)\Gamma_{j+1}^g\left(s'|s\right)$$

where

$$\begin{aligned}
c+\left(1+\gamma_b\right)a' &= (1+r)a+(1-\tau_o-\tau_d)w(g,j,s)\ell+B_j+D_j\left(s\right)+q \\
w(g,j,s) &= w\cdot e\left(g,j,s\right) \\
B_j &= \begin{cases} 0 & \text{if } j<J_R \\ B & \text{if } j\geq J_R \end{cases} \\
D_j\left(s\right) &= \begin{cases} D & \text{if } j<J_R, s=s_d \\ 0 & \text{otherwise} \end{cases} \\
\tilde{\beta} &= \beta\left(1+g_b\right)^{\phi(1-\gamma)}
\end{aligned}$$

Optimal policy functions of the Bellman equation $a'=\alpha_j^g\left(a,s\right), \ell=\lambda_j^g\left(a,s\right)$.

The invariant population distributions $\left\{\pi_j^g\left(a,s\right)\right\}$ for aggregating these two compute macro variables and government budgets satisfies

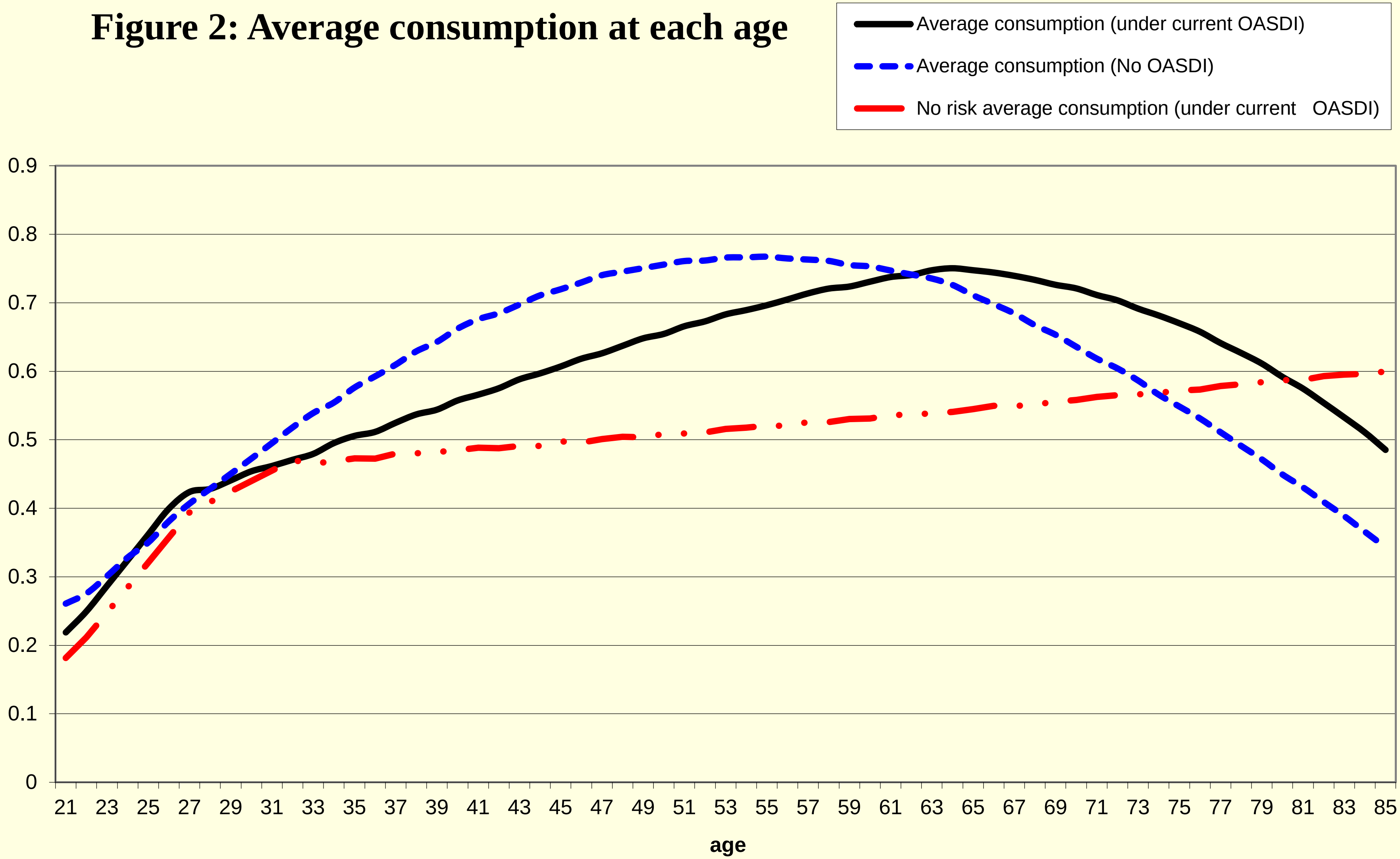
$$\pi_{j+1}^g\left(a',s'\right)=\frac{\psi_{j+1}^g}{(1+n)}\cdot\sum_{s\in S}\Gamma_{j+1}^g\left(s'|s\right)\sum_{a:\alpha_j(a,s)=a'}\pi_j^g\left(a,s\right), j=1,...J-1, g\in G$$

Main issues

- Compare **<u>three scenarios</u>**:
  - (a) Existing PAYGO system with OASI replacement rate 0.29 and DI Replacement Rate 0.29.
  - (b) No OASDI,
  - (c) No disability and mortality risks.

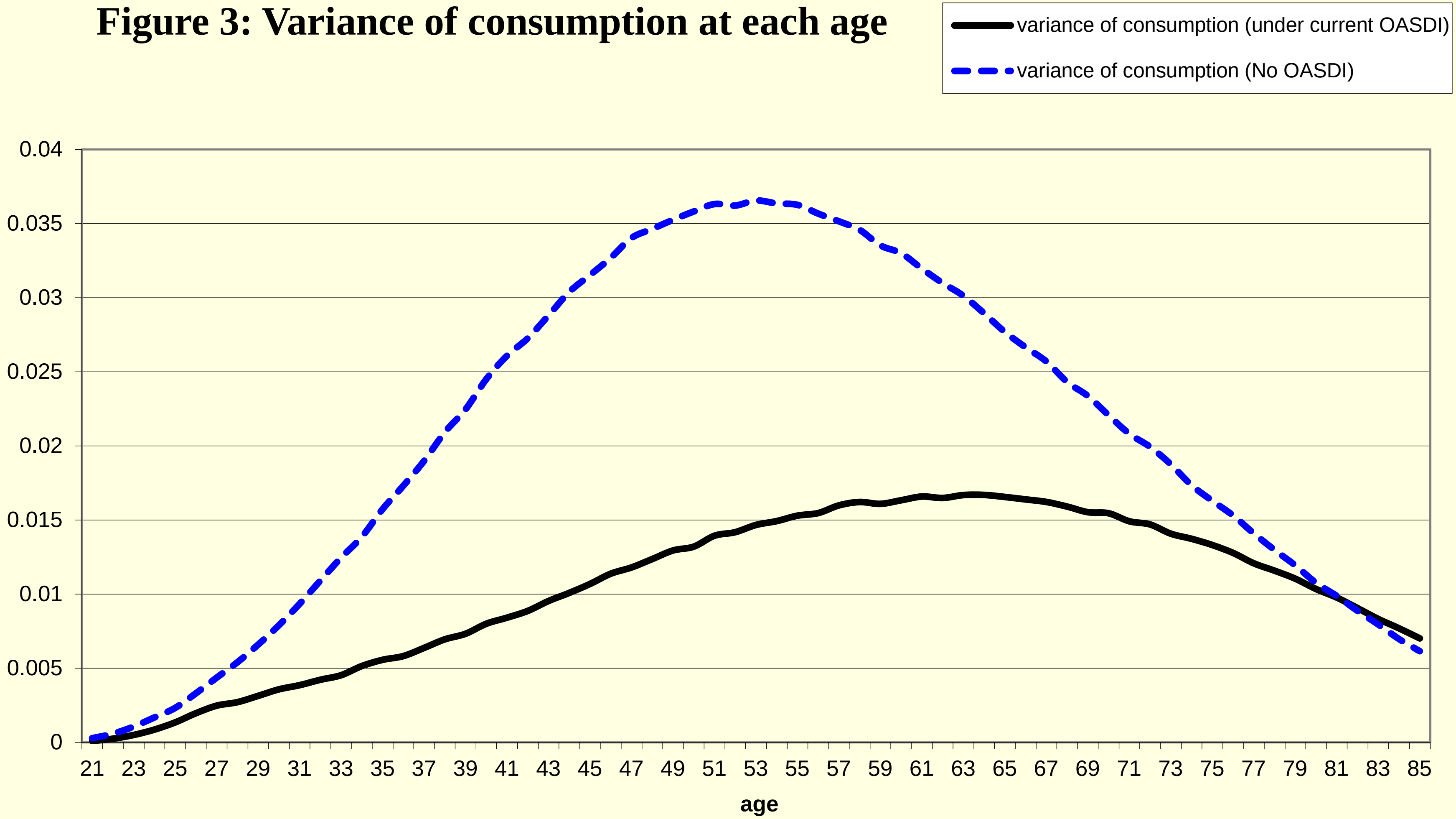
  Under these scenarios, going to do the following three things:
- Effect on mean and variance of consumption and asset holdings over the life-cycle.
- Effect on life time welfare and elderly poverty rates
- Value to individuals in terms of willingness to pay (under the veil of ignorance, or in private market willingness to pay at age 1, before knowing future health outcomes)

Effect on Consumption (mean)

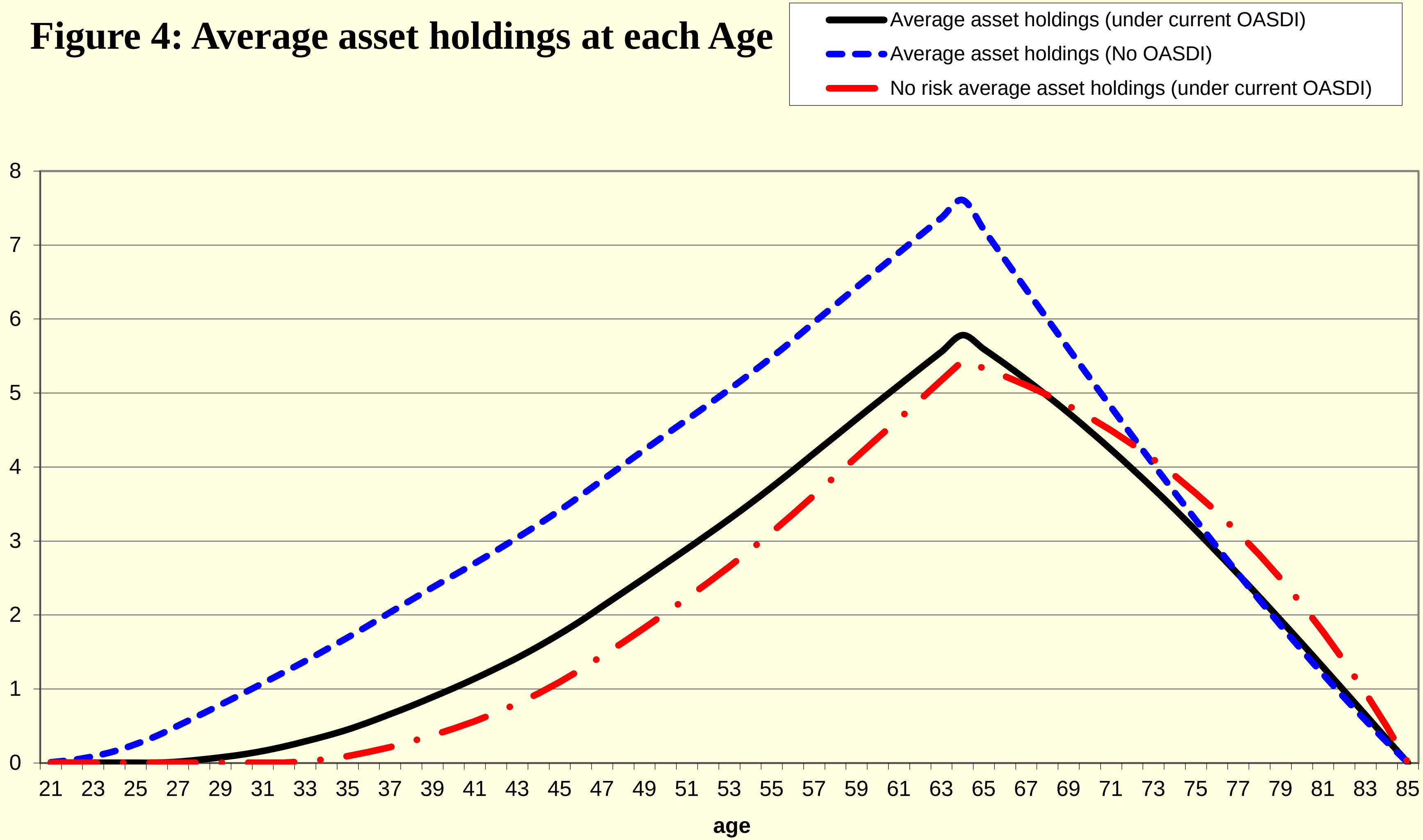


Effect on Consumption variance

Figure 3: Variance of consumption at each age

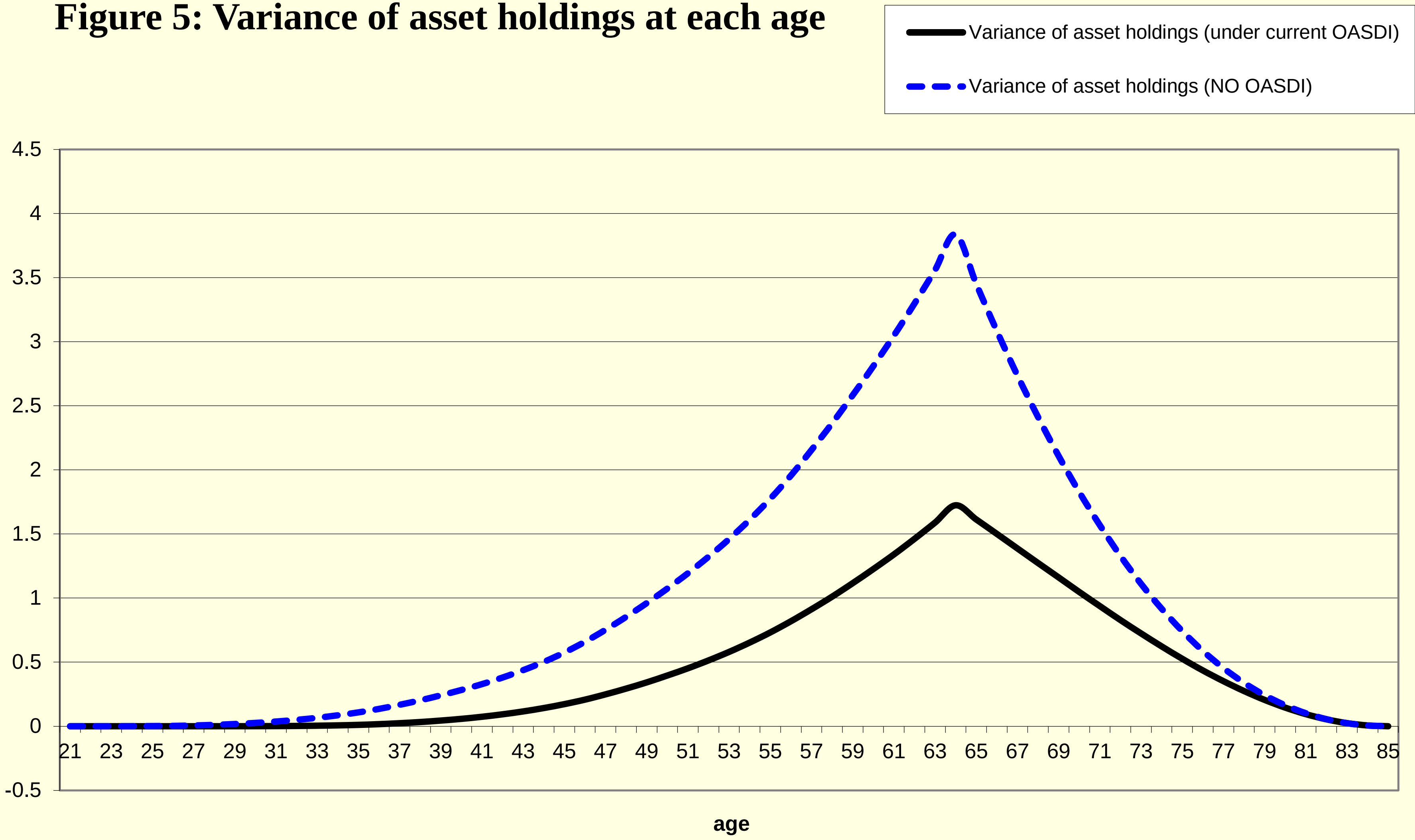


Effect on mean asset holdings



Effect on asset holdings variations

Figure 5: Variance of asset holdings at each age



Elderly Poverty Rates

Table 2: Elderly Poverty with and without the OASDI Program

Age Group	Percentage of population in poverty	
	Under the current OASDI Program	Without an OASDI Program
65	0.00	0.20
66	0.00	0.22
67	0.00	0.24
68	0.00	0.26
69	0.00	0.29
70	0.00	0.33
71	0.00	0.37
72	0.00	0.42
73	0.00	0.48
74	0.00	0.56
75	0.00	0.65
76	0.00	0.78
77	0.00	0.93
78	0.00	1.14
79	0.00	1.41
80	0.01	1.80
81	0.01	2.27
82	0.01	2.97
83	0.01	3.94
84	0.02	5.43
85	0.03	7.77

Table 1: Evaluation of Insurances Provided by the OASI and DI Programs

	In the Presence of Mortaility and Disability Risks				No Risks	
	Without publicly provided OASDI, i.e., replacement rates for OASI = 0, and DI = 0	Publicly provided OASDI with replacement rates for OASI = 0.29 and DI = 0.29	Publicly provided OASDI with replacement rates for OASI = 0 and DI = 0.29	Publicly provided OASDI with replacement rates for OASI = 0.29 and DI = 0	Without publicly provided OASDI with replacement rates for OASI = 0 and DI = 0	Publicly provided OASDI with replacement rates for OASI = 0.29 and DI = 0.29
Welfare						
β =0.967	66.27	74.10	77.35	61.74	78.46	73.73
β =1.011	49.49	80.75	78.81	56.60	82.53	83.27
Equivalent Variation						
β =0.967		10.56	14.33	-7.34	15.54	10.12
β =1.011		38.71	37.21	12.57	40.04	40.57
Per capita income						
In 2005 dollars	68,084.04	57,705.57	60,561.81	64,172.08	56,210.00	53,135.64
Interest Rate	5.03	8.29	7.24	6.09	6.71	7.89

Notes: 1) The equivalent variation is the percentage increase in bench mark consumption stream that makes him as well off at the benchmark situation as he is in the present situation.

Thank you …

Thanks for the invitation