A Life-cycle incomplete markets model for the Analysis of Superannuation in Australia

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RBA

"If we take a late retirement and an early death, we'll just squeak by."

Why such an analysis is relevant?

- Both households and policy makers are concerned whether we are saving enough for retirement
- Policy measures such as an increase in retirement age, increase in mandatory contributions, are being considered and implemented

Overview of the Australian Retirement System

- **Age-pension**: targeted income support for pension age retirees
  - The maximum basic rate is $1,358 per fortnight for a couple in 2021
  - The proportion of the population aged 65 and over receiving age pension has declined from 74% in 2001 to 62% in 2021
- **Superannuation**: mandatory contributions towards retirement savings
  - Superannuation Guarantee (SG) has increased from 3% in 1992 to 10% in 2022
  - Superannuation coverage has increased from 29% of employed persons in 1974 to 90% 2012
  - Superannuation assets totalled $3.5 trillion in 2021, around 150% of GDP
- **Voluntary savings**

Related literature

- Pay-as-you-go pension
  - Overlapping generations model: Auerbach and Kotlikof (1987)
  - Literature with income risk: Imrohoroglu, Imrohoroglu, and Joines (1995), Nishiyama and Smetters (2007), Imrohoroglu and Kitao (2009), Kitao (2014)
- Means tested age-pension and Superannuation in Australia
  - Kudrna and Woodland (2011), Hulley, McKibbin, Pedersen, and Thorp (2013), Chomik, Piggott, Woodland, Kudrna, and Kumru (2015)
  - Barrett and Tseng (2008), Connolly and Kohler (2004), Kudrna and Woodland (2010, 2013), Kingston and Thorp (2019), Chung, Kudrna, and Woodland (2018), MARIA (2017)

What we plan to do in this paper

- Construct a quantitative incomplete markets life-cycle model to evaluate changes in retirement policies and examine their distributional consequences
- Use SIH and ALife data for Australia to discipline our analysis
- Key features of our model
  - Households are heterogeneous due to life-cycle differences and idiosyncratic income uncertainty
  - Households work and endogenously choose when to retire
  - Three are three assets during working life, two liquid assets (bonds and equities) and a illiquid asset (superannuation). In retirement there are two liquid assets

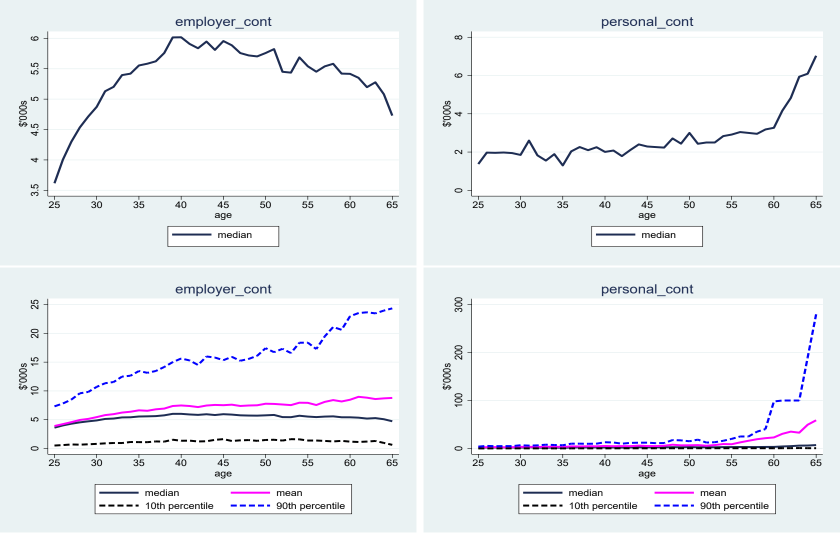
Data

Data

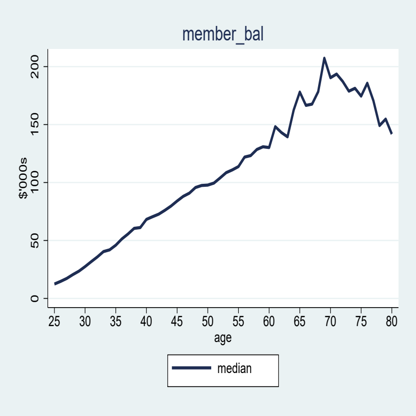
- ATO Longitudinal Information Files (ALife): Superannuation data from 1997-2018 and income data from 1991-2018

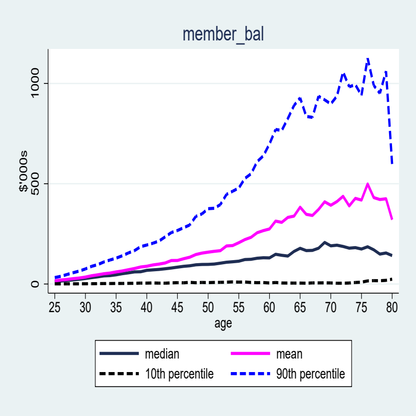
- Survey of Income and Housing (SIH) 2017-18: Information on other assets
  - Bonds include bonds, debentures and accounts held with financial institutions (excl. offset accounts)
  - Equities include net value of financial and non-housing assets such as shares, public and private trusts, own businesses
  - The share of bonds in total wealth (net of housing) is 11% and the share of equity is 48% in 2018

Contributions to Super - ALife 2018

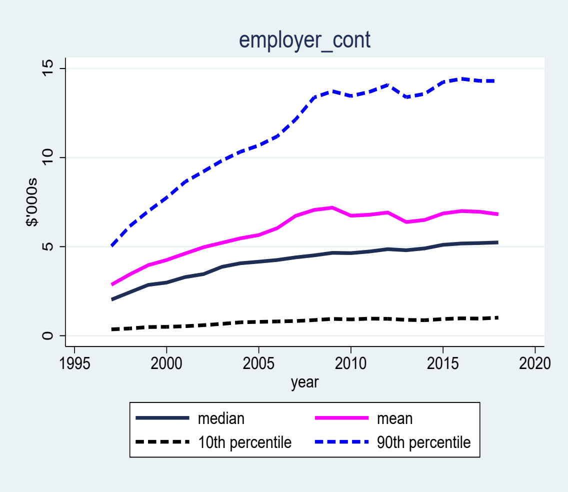


Superannuation balances - ALife 2018

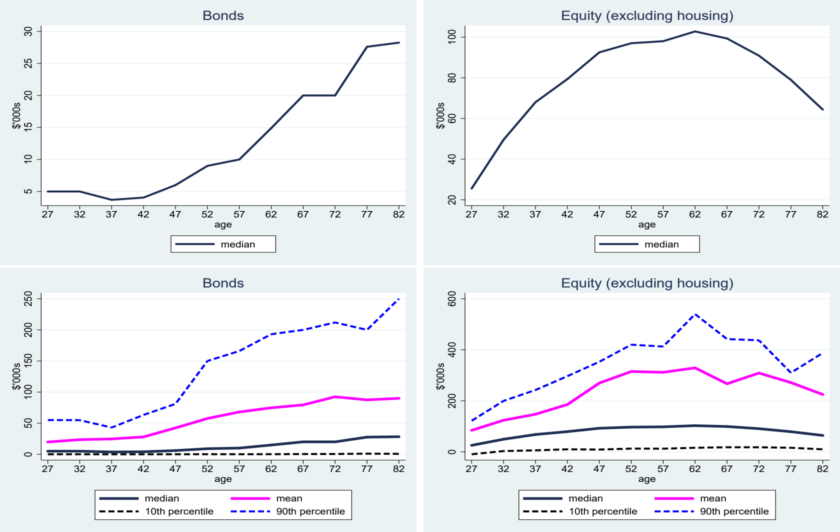




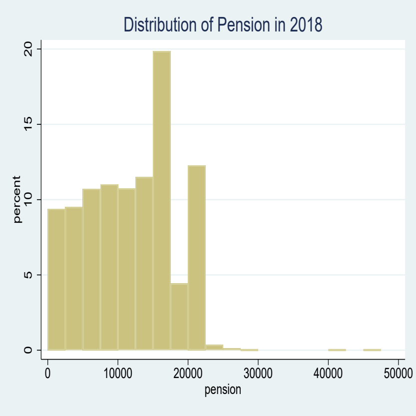
Contributions to Super have increased over time - ALife 2018

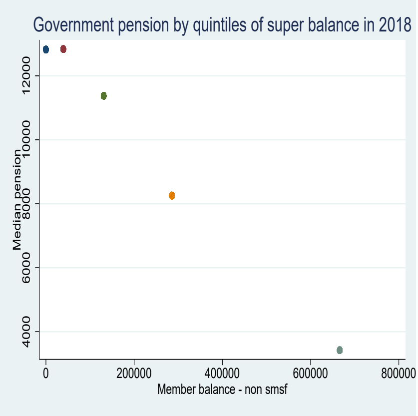


Other Assets - SIH 2017/18



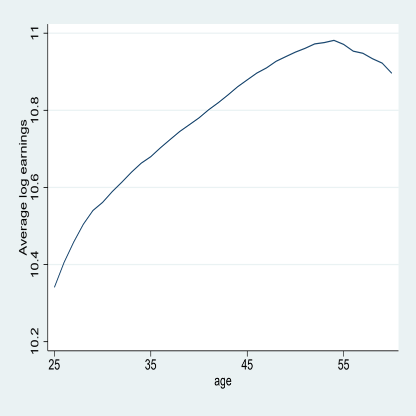
Age-pension from ALife 2018





Earnings process from ALife 1996-2018

- Predictable age profile of labour income, 25-60



- The persistent-transitory earnings process will be estimated by simulated method of moments using ALife data

Model

Model: Overview

- Incomplete markets life-cycle partial equilibrium model with endogenous retirement

- Time is continuous

- There is a continuum of households indexed by age, their holdings of liquid assets x , illiquid assets a , and their idiosyncratic labor productivity z which follows an exogenous Markov process

- Three assets to capture the unintended consequences of tax advantages to Super.

Assets over the life-cycle

- Before retirement households save in *two* liquid and *one* illiquid asset
  - Liquid wealth, x, has bonds and equities, where p is a portfolio decision

$$b = px$$
$$e = (1 - p)x$$
$$x = b + e$$

  - Illiquid wealth
    - Mandatory: A fraction of labour income, ξ, is automatically deposited into a
    - Voluntary: at rate δ, get opportunity to adjust between liquid, x and illiquid wealth, a. If choose to adjust, must pay a fixed cost κ

- After retirement super becomes liquid and households save in two liquid assets

$$b = ps$$
$$e = (1 - p)s$$
$$s = x + a$$

Optimization problem

$$\max_{T^*,\{c_t,p_t\}_{t\geq 0}} \mathbb{E}_0 \left[\int_0^{T^*} e^{-\rho t} u(c_t, b_t) dt + \int_{T^*}^{T} e^{-\rho t} u(c_t, b_t) dt \right]$$

Optimization problem

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for $t < T^*$

$$\dot{x}_t = (1-\tau)[(1-\xi) w z_t + r^b p_t x_t + r^e (1-p_t) x_t] - c_t$$
$$\dot{a}_t = (1-\tau_s)(r^a a_t + \xi w_t z_t)$$
$$a_t \geq 0 \text{ and } x_t \geq 0$$

Optimization problem

$$\max_{T^*,\{c_t,p_t\}_{t\geq 0}} \mathbb{E}_0 \left[\int_0^{T^*} e^{-\rho t} u(c_t, b_t) dt + \int_{T^*}^{T} e^{-\rho t} u(c_t, b_t) dt \right]$$

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for $t \geq T^*$

$$\begin{aligned} s_{T^*} &= x_{T^*} + a_{T^*} \\ \dot{s}_t &= (1-\tau_s)\left[r^b p_t s_t + r^e (1-p_t) s_t\right] + pen_t - c_t \\ s_t &\geq 0 \end{aligned}$$

Optimization problem

$$\max_{T^*,\{c_t,p_t\}_{t\geq 0}} \mathbb{E}_0 \left[\int_0^{T^*} e^{-\rho t} u(c_t, b_t) dt + \int_{T^*}^{T} e^{-\rho t} u(c_t, b_t) dt \right]$$

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$$\begin{aligned} \dot{x}_t &= (1-\tau)[(1-\xi)wz_t + r^b p_t x_t + r^e (1-p_t) x_t] - c_t \\ \dot{a}_t &= (1-\tau_s)(r^a a_t + \xi w_t z_t) \\ a_t &\geq 0 \text{ and } x_t \geq 0 \end{aligned}$$

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- where $z_t \in \{z_1, ..., z_J\}$ is the exogenous discrete-state Poisson process for productivity with hazard rate $\lambda_{j,j'}$

Recursive form - Hamilton Jacobi Bellman equation

- Working life

$$
\begin{aligned}
\rho V_t^w(x,a,z) = & \max_{\{c,p\}} \; u(c,px) \\
& + \frac{\partial V_t^w}{\partial x}\dot{x}_t + \frac{\partial V_t^w}{\partial a}\dot{a}_t \\
& + \sum_{j' \neq j} \lambda_{j,j'} \left[V_t^w\left(x,a,z_{j'}\right) - V_t^w\left(x,a,z_j\right) \right] \\
& + \delta \left[V_t^*\left(x,a,z\right) - V_t^w\left(x,a,z\right) \right] \\
& + \frac{\partial V_t^w}{\partial t}
\end{aligned}
$$

Recursive form - Hamilton Jacobi Bellman equation

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\begin{aligned}
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& + \delta \left[V_t^*\left(x,a,z\right) - V_t^w\left(x,a,z\right) \right] \\
& + \frac{\partial V_t^w}{\partial t}
\end{aligned}
$$

- Retired life

$$
\rho V_t^r\left(s\right) = \max_{\{c,p\}} \; u(c,ps) + \frac{\partial V_t^r}{\partial s}\dot{s}_t + \frac{\partial V_t^r}{\partial t}
$$

Recursive form (cont'd)

- Decision to retire at $T^* \in [\underline{T}, \overline{T}]$ depends on

$$\max\{V_t^w(x, a, z), V_t^r(x + a)\}$$

  Retire if $V_t^r > V_t^w$.

Recursive form (cont'd)

- Decision to retire at $T^* \in [\underline{T}, \overline{T}]$ depends on

$$\max\{V_t^w(x,a,z), V_t^r(x+a)\}$$

  Retire if $V_t^r > V_t^w$.

- Decision to adjust between liquid and illiquid assets

$$\begin{aligned} V_t^*(x,a,z) &= \max\{W_t(x,a,z), V_t^w(x,a,z)\} \\ W_t(x,a,z) &= \max_{x',a'} V_t^w(x',a',z) \end{aligned}$$

$$a' = \begin{cases} a - \frac{x'-x}{1-\tau_{con}} - \kappa & \text{if} \quad \frac{x'-x}{(1-\tau_{con})} \geq -(d_{con}^{max} - \xi wz) \\ a - (x'-x) + \tau_{con}\left(d_{con}^{max} - \xi wz\right) - \kappa & \text{if} \quad \frac{x'-x}{(1-\tau_{con})} < -\left(d_{con}^{max} - \xi wz\right) \end{cases}$$

$$x' \leq x$$

Solution method

- Requires solving PDEs: Hamilton-Jacobi-Bellman equation for individual choices and Kolmogorov Forward equation for evolution of distribution (Kaplan, Moll and Violante, 2018)
- New aspects: life-cycle model, three-assets and endogenous retirement
- Solution to the HJB are value functions $V_t^w(x, a, z)$, $V_t^r(s)$, policy functions $c_t^w(x, a, z)$, $c_t^r(s)$, $p_t^w(x, a, z)$, and $p_t^r(s)$
- Solution to the KFE are stationary distributions $g_t(x, a, z)$ and $g_t(s)$

Numerical experiments

Functional forms

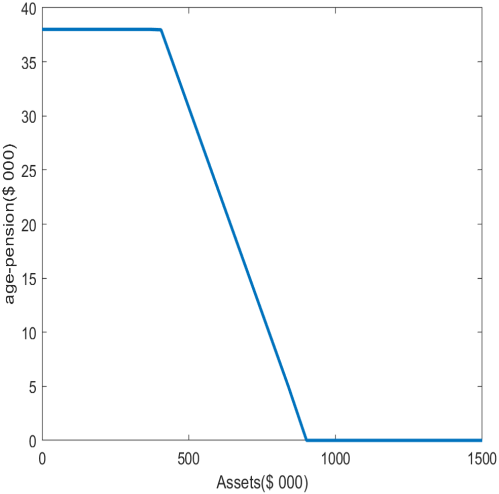
- The utility function

$$u(c_t, b_t) = \frac{c_t^{1-\sigma} - 1}{1-\sigma} + \psi^b \frac{b_t^{1-\sigma^b}}{1-\sigma^b},$$

- Age-pension

$$pen(s_t) = \begin{cases} p\bar{e}n - \phi_{pen}(s_t - \underline{s}) & \text{if} \quad \underline{s} \leq s_t < \bar{s} \\ 0 & \text{otherwise} \end{cases}$$

Age-pension function



Income process

- Idiosyncratic labour productivity is given by

$$\ln z_t = \ln z_{1,t} + \ln z_{2,t},$$

- Each component evolves according to a jump-drift process
- Jumps arrive at a Poisson rate λ
- Given a jump, a new productivity state $z' \sim N(0, \sigma^2)$
- Between jumps the stochastic process drifts back to zero at rate β

Calibrated values of the income process

		transitory	persistent
arrival rate	λ	0.080	0.007
mean reversion	β	0.762	0.009
standard deviation	σ	1.74	1.53

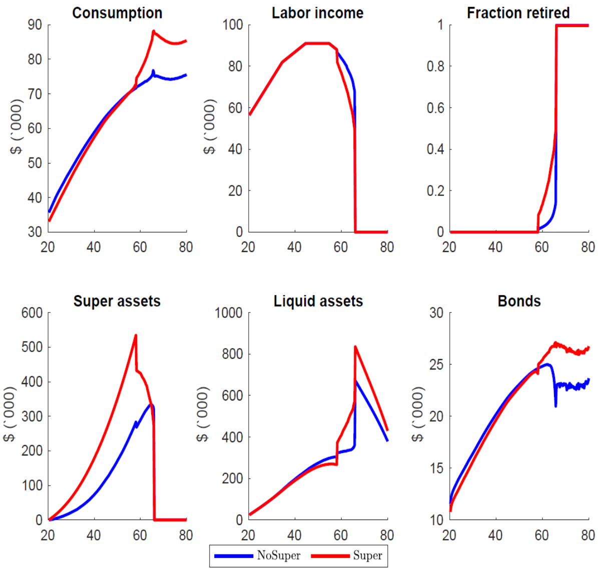
Parameters

CALIBRATED PARAMETER VALUES

Demographics and preferences		
$(\underline{T}, \bar{T}, T)$		$(58, 66, 80)$
$exp(-\rho)$	discount rate	0.97
σ^{-1}	IES	0.5
$\sigma^{b^{-1}}$	IES-bonds	0.5
ψ^b	weight on bonds	0.0025
Prices and adjustment cost		
r^a	return on super	0.05
r^e	return on equity	0.05
r^b	return on bonds	0.02
τ	tax on earnings	0.30
Superannuation and age-pension		
τ_s	tax on super contr.	0.15
ξ	SG rate	0.10
δ	adjust. rate	0.10
κ	adjust. cost	0.00
ϕ_{pen}	taper rate	0.076
$p\bar{e}n$	max. pension	$38,000$
$(\underline{s}, \bar{s})$	pension thresholds	$(405,000 - 901,500)$

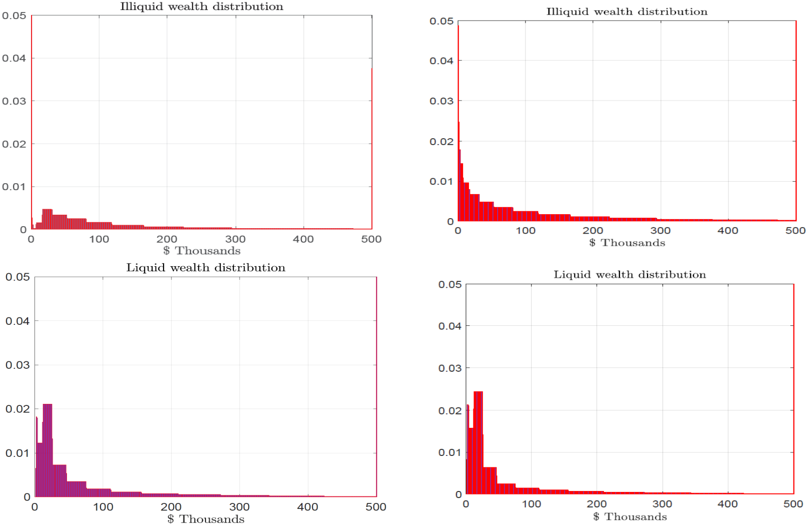
No Super and Super

Plots by age (means): No Super and Super



Distribution of assets during working life

- No Super (left panel) and Super (right panel)



Plots by age

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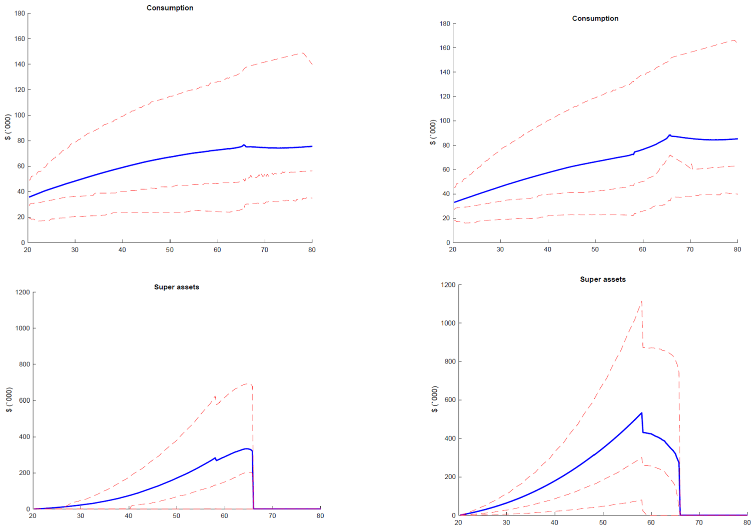
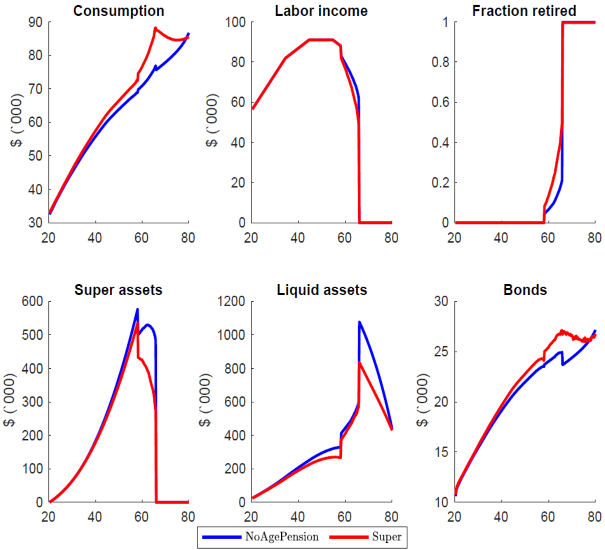


Age-pension

Plots by age (means): No Age-pension and Age-pension



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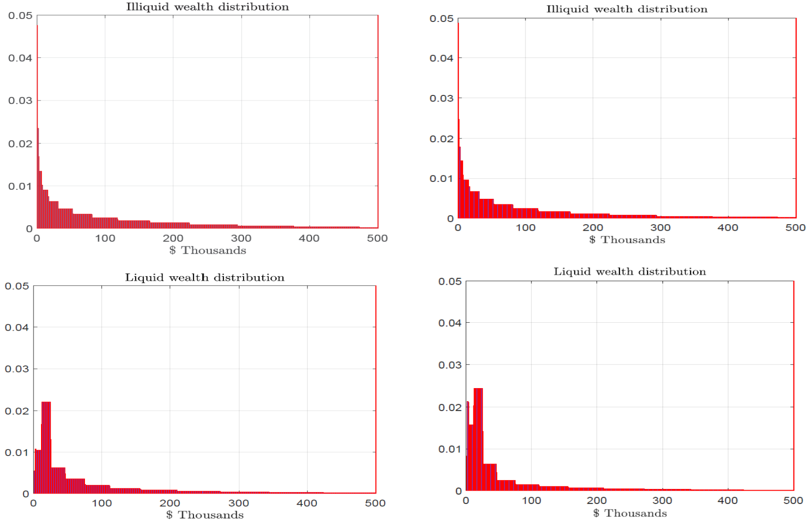
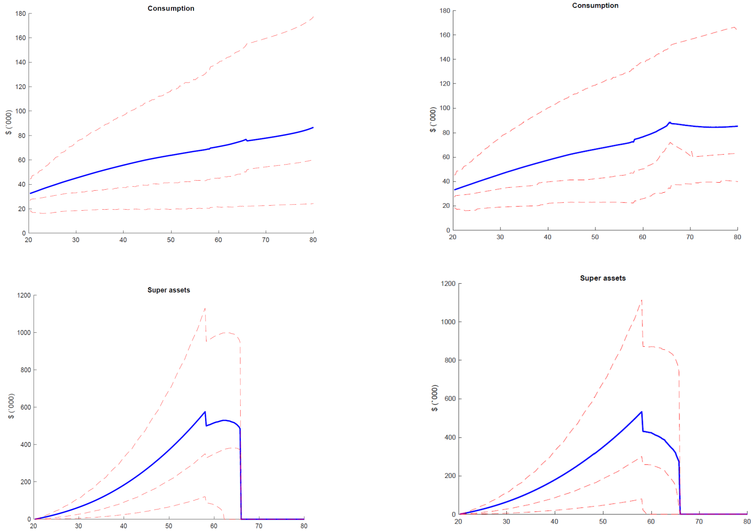


Plots by age

- No Age-pension (left panel) and Age-pension (right panel)



Next steps

- Calibrate the model carefully. Bring the model closer to data
- Extend the current model to a general equilibrium model