Course in Heterogeneity: Econ 081

III: OLG Models with an Application to Inter-generational Redistribution in the Great Recession

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Based on joint work with Andrew Glover, Jonanthan Heathcote and Dirk Krueger

1 Introduction

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$$Y = z \; K^{\theta} \; L^{1-\theta}$$

- Aggregate Labor: $L = \sum_i \; \epsilon \; (1 - \ell_i)$
- Aggregate Capital: $K = \sum_i \; a_i$

Recursive Problem of the Household

- State space (i, a, A), where a is individual wealth held by the household.

$$
\begin{aligned}
v_i(a, A) &= \max_{c \geq 0, y, \lambda, a'} \{u(c) + \beta_{i+1} \; v_{i+1}(a\prime, A')\} \\
c + a' &= (1 - \ell_i) \; \varepsilon_i(A) + a \; R(A) \\
A' &= G(A) \\
a_1 &= 0.
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- Policy functions $c_i(a, A), a'_i(a, A), \ell_i(a, A)$

Equilibrium: Markets, Prices and Aggregation

- Factor markets

$$\begin{aligned} w(A) &= (1-\theta)z\ K(A)^{\theta}\ L(A)^{-\theta} \\ R(A) &= \theta z\ K(A)^{\theta-1}\ L(A)^{1--\theta} \end{aligned}$$

- Aggregation

$$\begin{aligned} K(A) &= \sum_{i=1}^{I} A_i, \\ L(A) &= \sum_{i=1}^{I} \epsilon_i\ [1-\ell_i(A_i, A)]. \end{aligned}$$

- Law of Motion: $A_1' = 0$ and

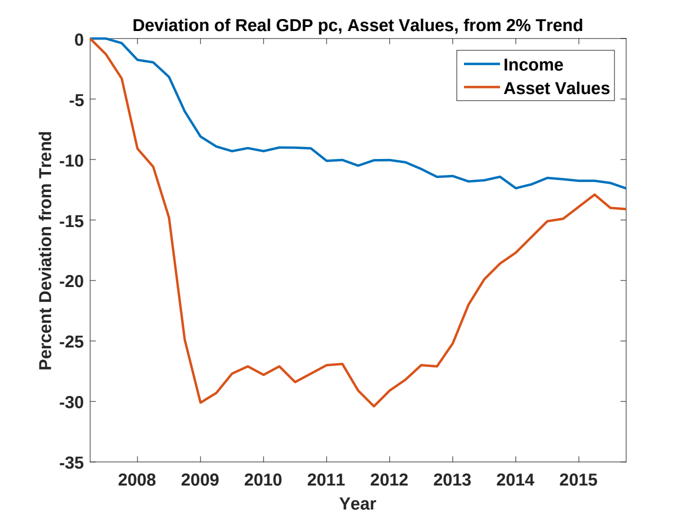
$$A_{i+1}\prime = G_{i+1}(A,) = a_i'(A_i, A).$$

2 Great Recession and Assets Redistribution

Now the Great Recession Issue

- Salient features of the great recession:
    - Large fall in output and labor incomes.
    - Larger fall in asset prices (stocks, houses).
- Research Question: What are the distributional consequences for households at different stages of the life cycle?

Motivating Facts: Aggregate Data



Motivating Facts

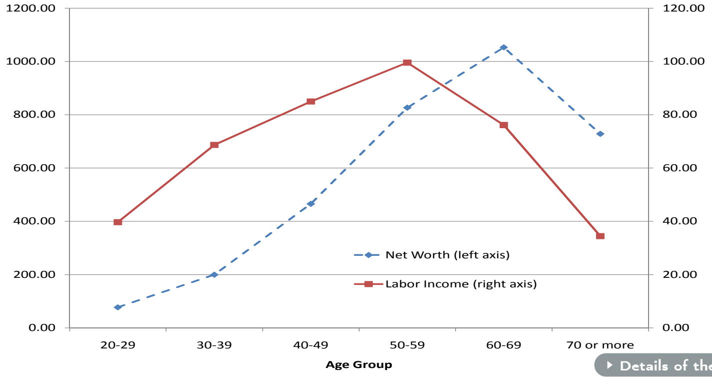
- Why focus on age dimension?

    - Labor income and wealth vary substantially by age.
    - Portfolio composition (risky versus riskless assets) varies substantially by age.
    - Labor income losses in great recession vary substantially by age.

- (1) - (3) $\Longrightarrow$ Wealth and welfare losses vary substantially by age.

Motivating Facts: Income and Wealth Over Life Cycle

Figure: Labor Income and Net Worth by Age, SCF 2007 ($1,000)



Details of the Data

Motivating Facts: Portfolio Shares by Age from 2007 SCF (in %)

Age Head	(1) Stk	(2) Res. RE	(3) Non bus.	(4) Non RE	(5) Risky NW	(6) Bond +CD	(7) Car	(8) Oth.	(9) Debt	(10) Safe NW
All	30.3	47.0	12.9	3.8	94.0	17.0	3.5	4.2	-18.6	6.0
20-29	13.2	77.7	43.3	1.3	135.5	13.7	15.3	4.5	-68.9	-35.5
30-39	26.3	96.5	12.7	5.0	140.4	13.8	9.7	4.2	-68.2	-40.4
40-49	30.4	57.6	12.6	3.8	104.4	15.2	4.4	4.5	-28.5	-4.4
50-59	32.7	42.4	13.5	3.7	92.4	17.0	2.8	4.0	-16.1	7.7
60-69	32.2	35.6	13.4	4.1	85.3	17.5	2.4	4.7	-9.9	14.7
70+	27.1	39.8	9.0	3.3	79.2	19.3	1.8	3.7	-3.9	20.8

Risky Net Worth (5) is equal to sum of columns (1)+(2)+(3)+(4). Safe Net Worth (10) is sum of columns (6)+(7)+(8)+(9). Total Net Worth is sum of (5)+(10)

Motivating Facts: Capital Losses by Age Group

Infl. adj. capital losses from 2007:2 to 2009:1-2013:4 ($1,000, 2007)								
Age of Head	Stocks	Res. RA	Nonc. bus.	Nonres. prop.	Total	(%)net worth	(%) inc.	Total/ 2009Q1
All	30.6	64.4	15.1	6.5	116.5	21.0	139.6	154.5
20-29	1.9	14.8	7.1	0.3	24.0	31.1	61.9	24.5
30-39	9.5	47.5	5.4	3.0	65.4	32.8	93.7	73.0
40-49	25.7	66.1	12.3	5.4	109.6	23.5	117.3	139.8
50-59	49.1	86.4	23.6	9.4	168.5	20.4	142.8	232.3
60-69	61.5	92.4	29.8	13.3	197.0	18.7	180.6	278.9
70+	35.9	71.4	13.8	7.4	128.5	17.6	223.2	173.9

- Capital losses concentrated among older households

Change in Labor Income 2007-10, Relative to Trend, CPS

	(%)
pc earnings	-9.8
20-29	-14.3
30-39	-12.6
40-49	-10.3
50-59	-11.1
60-69	-6.0
70+	-1.4

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  - Can the model generate realistic age profile of asset portfolios?
  - How are wealth and welfare losses from great recession distributed across different age cohorts?

3 Model

An OLG Model with Aggregate Risk

- Labor income and asset prices driven by aggregate shock $z \in Z = \{z_n, z_r, z_d\}$.

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- Households live for I periods. Supply one unit of time, relative labor efficiency (income) $\{\varepsilon_i(z)\}_{i=1}^{I}$. Normalize $\sum_i \varepsilon_i(z) = L = 1$.

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- Time discount factors $\{\beta_i\}_{i=1}^{I}$ vary with age. Utility function $u(c) = \frac{c^{1-\sigma}-1}{1-\sigma}$. Wealth distribution $A = \{A_i\}_{i=1}^{I}$. No bequests.

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- Market Structure: Ownership shares of K traded at price $p(z, A)$. Exogenous net supply B of corporate bonds, price $q(z, A)$.

Discussion of the Assumptions I: Housing

- Can re-interpret the model as explicit model of housing. Assume:
  - Fixed supply 1 of perfectly divisible houses. Competitive rental markets.
  - Cobb Douglas utility over non-durables, housing services $\frac{\left(c^{\nu} s^{1-\nu}\right)^{1-\sigma}}{1-\sigma}$
  - Households can freely invest in three assets: bonds, stocks, houses.
- Results: rents are proportional to dividends, housing prices proportional to stock prices.
- Thus model with housing has exactly the same asset pricing and welfare implications as our model without explicit housing.

Discussion of the Assumptions II: Unemployment

- In recession labor incomes fall because real wages $w(z) = (1-\theta)z$ fall, whereas hours worked $L = 1$ remain constant.

- Could equivalently assume that labor income in recession falls due to reduction in hours worked $L(z)$:

$$Y(z) = L(z)^{1-\theta}$$

- As long as $L(z_r)/L(z_n) = (z_r/z_n)^{\frac{1}{1-\theta}}$ model with TFP shocks z and model with aggregate shocks to hours worked $L(z)$ (or aggregate shocks to unemployment) are isomorphic.

- Exogenous net supply B of corporate bonds. Unit supply of shares.
- Aggregate state of the economy (z, A), where $A = (A_1, \ldots, A_I)$ denotes the beginning of period wealth distribution across age cohorts.
- Stock price $p(z, A)$, bond price $q(z, A)$.
- Stocks pay dividends $d(z, A) = \theta z - [1 - q(z, A)] B$
- Aggregate (start of period) wealth: $W(z, A) = p(z, A) + d(z, A) + B$

Recursive Problem of the Household

- State space (i, a, z, A), where a is the individual share of total wealth $W(z, A)$ held by the household.

$$
\begin{aligned}
v_i(a, z, A) &= \max_{c \geq 0, y, \lambda, a'} \left\{ u(c) + \beta_{i+1} \sum_{z' \in Z} \Gamma_{z,z'} v_{i+1}(a', z', A') \right\} \\
c + y &= \varepsilon_i(z) w(z) + W(z, A) a \\
a' W(z', A') &= \left(\lambda \frac{p(z', A') + d(z', A')}{p(z, A)} + (1 - \lambda) \frac{1}{q(z, A)} \right) y \\
A' &= G(z, A, z')
\end{aligned}
$$

- Policy functions $c_i(a, z, A), y_i(a, z, A), \lambda_i(a, z, A)$ and $a_i'(a, z, A, z')$.

Equilibrium: Markets, Prices and Aggregation

- Labor market: wages $w(z) = (1-\theta)z$ and $\sum_{i=1}^{I} \varepsilon_i(z) = L = 1$.
- Financial Markets: Share prices $p(z, S)$ and bond prices $q(z, A)$

$$\begin{aligned} \sum_{i=1}^{I} y_i(A_i, z, A)\lambda_i(A_i, z, A) &= p(z, A) \\ \sum_{i=1}^{I} y_i(A_i, z, A)\left[1 - \lambda_i(A_i, z, A)\right] &= q(z, A)B \end{aligned}$$

- Law of Motion: $A_1' = 0$ and $A_{i+1}' = G_{i+1}(z, A, z') = a_i'(A_i, z, A, z')$.

Back to Model

Calibration: Productivity Process

- States $z \in Z = \{z_n, z_r, z_d\}$. Normal times $z_n = 1$, Great Recession $z_r < 1$, Great Depression $z_d < z_r$.
  - Set z_r s.t. transition from z_n to z_r involves output decline of 9.84% (average 2009-2013 deviation from 2% growth trend).
  - Set z_d s. t. output in z_d is 28.9% below z_n, (average 1932-1936 deviation from trend).
- Transition matrix Γ
  - Impose (perhaps arbitrary) restrictions $\Gamma_{n,d} = \Gamma_{r,r} = \Gamma_{d,r} = 0$. Note: makes markets sequentially complete with two assets.
  - Choose $\Gamma_{n,r}, \Gamma_{r,d}$ such that unconditional probability of Great Recession is 13.7% and Great Depression is 2.84% (as estimated from Maddison data, 1800-2010.)

$$z = \begin{pmatrix} 1.0000 \\ 0.9016 \\ 0.7109 \end{pmatrix}, \quad \Gamma_{z,z'} = \begin{pmatrix} & 0.835 & 0.165 & 0.000 \\ z & 0.793 & 0.000 & 0.207 \\ & 1.000 & 0.000 & 0.000 \\ & & z' & \end{pmatrix}$$

4 Example

Developing Intuition: A Three Period Model

- Key assumptions:
  - Households only productive when young: $\varepsilon_1 = 1, \varepsilon_2 = \varepsilon_3 = 0$.
  - Households derive no utility from consumption when young. By construction young save everything.
  - Only stocks are traded: $B = 0$.
  - Aggregate shock can only take two values: $Z = \{z_r, z_n\}$.
- State (z, A) where $A = A_3$ is share of assets held by old. Share of wealth held by middle-aged is $1 - A$.
- Only middle-aged make meaningful decision: how many of their shares to sell.
- Note: wealth distribution irrelevant in Rep. Agent model or 2 period OLG model.

- Measure of asset price collapse:

$$\xi(A) = \frac{\log(p(z_r, A)/p(z_n, A))}{\log(z_r/z_n)}$$

Note: in RA economy with $CRRA = \sigma$, iid z shocks: $\xi^{RA} = \sigma$.

- Choice of middle-aged: purchase shares $A' = G(z, A)$, at $p(z, A)$
- Consumption when middle aged and old:

$$\begin{aligned} c_m(z, A) &= (1 - A)\left(p(z, A) + \theta z\right) - G(z, A)p(z, A) \\ c_o(z, A; z', A') &= G(z, A)p(z', A') \end{aligned}$$

- Euler equation

$$u'\left[(1 - A)\left(p(z, A) + \theta z\right) - G(z, A)p(z, A)\right] = \beta \sum_{z'} \Gamma_{z,z'} \frac{[p(z', A') + \theta z']}{p(z, A)} u'\left[G(z, A)p(z', A')\right]$$

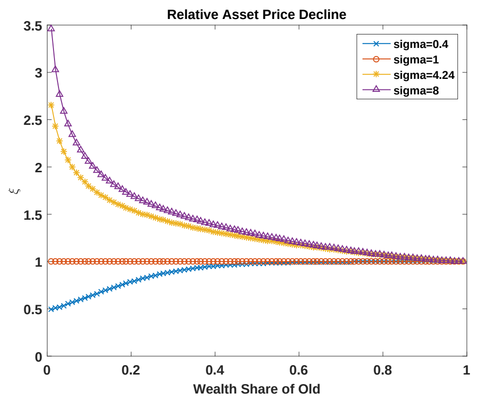
Developing Intuition: A Three Period Model

- Solution is pair of functional equations in the unknown functions $p(z, A), G(z, A)$.
- Consumption, welfare can be calculated from $p(z, A), G(z, A)$.
- Note: for log-utility complete analytical characterization of RCE:
  - Asset prices are proportional to output z, that is $\xi = 1$.
  - Wealth distribution $(1 - A, A)$ does not respond to shock z.
  - Consumption of all generations move one for one with z.
  - If z is iid, then young are exactly indifferent between being born into a Great Recession and being born into normal times.

More on the Log-Case

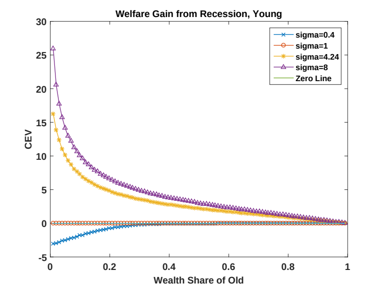
- Now: display (numerical) solution for $\sigma \neq 1$. Other parameters consistent with calibration of full model (e.g. income falls 9.84%)

Asset Price Decline Relative to Output



- The more households dislike consumption fluctuations (the higher σ) the larger is the fall in p relative to z in the recession.
- When $IES = 1/\sigma < 1$ a larger wealth share of the middle-aged (smaller A) translates into greater asset price collapse $\xi(A)$.

Welfare Consequences of Recessions for the Young



- Welfare measured as % consumption equivalent variation (positive numbers indicate welfare gains from recession).
- Welfare consequences mirror the elasticity of asset prices to output. Young can easily win from Great Recession. But in the simple model:
  - Young do not value consumption in Great Recession.
  - Young not disproportionally affected by labor income declines.
  - Middle-aged (and old) only have access to risky assets.

Logarithmic Utility ($\sigma = 1$)

Let $\sigma = 1$ and $\varepsilon_i(z) = \varepsilon_i \ \forall z$. Then there exists a recursive competitive equilibrium such that

- The distribution of wealth $A = \bar{A} = (\bar{A}_1, \ldots, \bar{A}_I)$ is constant over time: $\forall z, z', i = 1, \ldots, I-1$

$$\begin{aligned} G_{i+1}(z, \bar{A}, z') &= a_i'(z, \bar{A}, z', \bar{A}_i) = \bar{A}_{i+1} \\ G_1(z, \bar{A}, z') &= 0 \qquad \forall z, z' \end{aligned}$$

- Aggregate wealth is proportional to the aggregate shock: $\forall z$

$$p(z, \bar{A}) + q(z, \bar{A})B = z\Psi$$

- Asset Portfolios are identical across age groups:

$$\lambda_i(z, \bar{A}, \bar{A}_i) = \lambda(z) = \frac{p(z)}{z\Psi} \qquad \forall z, \ \forall i = 1, \ldots, I-1.$$

- Consumption and savings at each age are given by:

$$\begin{aligned} c_i(z, \bar{A}, \bar{A}_i) &= z\left[(1-\theta)\varepsilon_i + \theta\bar{A}_i + \left(\bar{A}_i - \bar{A}_{i+1}\right)\Psi\right], \\ y_i(z, \bar{A}, \bar{A}_i) &= z\bar{A}_{i+1}\Psi \qquad \forall z, \ \forall i = 1, \ldots, I-1. \end{aligned}$$

back

Logarithmic Utility ($\sigma = 1$)

Let $\sigma = 1$ and $\varepsilon_i(z) = \varepsilon_i \ \forall z$. Then there exists a recursive competitive equilibrium with the following properties:

- **Stock and bond prices are given by**

$$
\begin{aligned}
p(z, \bar{A}) &= p(z) = z\Psi - B\frac{z}{R}\sum_{z' \in Z}\Gamma_{z,z'}\frac{1}{z'} \\
q(z, \bar{A}) &= q(z) = \frac{z}{R}\sum_{z' \in Z}\Gamma_{z,z'}\frac{1}{z'} \qquad \forall z.
\end{aligned}
$$

  where $R = (\Psi + \theta)/\Psi$.

- **The equity premium is given by**

$$
R\sum_{z}\frac{\Pi_z}{z}\left\{\frac{\sum_{z' \in Z}\Gamma_{z,z'}z' - \left(\sum_{z' \in Z}\Gamma_{z,z'}\frac{1}{z'}\right)^{-1}}{1 - \frac{B}{R\Psi}\sum_{z' \in Z}\Gamma_{z,z'}\frac{1}{z'}}\right\}
$$

back

If z **is** *iid* **then for all** $z \in Z$

$$p(z) = z\left(\Psi - \frac{B}{R}\sum_{z' \in Z} \Pi_{z'} \frac{1}{z'}\right)$$

$$q(z) = z\left(\frac{1}{R}\sum_{z' \in Z} \Pi_{z'} \frac{1}{z'}\right)$$

and the average equity premium is given by

$$R\,\frac{\left(\sum_z \frac{\Pi_z}{z} \sum_z \Pi_z z - 1\right)}{\left(1 - \frac{B}{R\Psi}\sum_z \frac{\Pi_z}{z}\right)}$$

In the limit as $\Gamma_{z,z} \to 1\ \forall z$ **(perfectly persistent shocks)**, $q(z) \to R^{-1}$ **and** $p(z) \to z\Psi - BR^{-1}$.

back

5 Calibration

Calibration Strategy

- Model period 10 years. Agents enter at age 20, live for 6 periods.

Calibration Strategy

- Model period 10 years. Agents enter at age 20, live for 6 periods.
- Aggregate endowment process $z \in Z = \{z_n, z_r, z_d\}$, $\Gamma_{z,z'}$ derived directly from aggregate time series data. In Great Recession (z_r) output falls 9.84%.

Calibration Strategy

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- Choose $\sigma = 4.24$ s.t. model ξ lines up with Great Recession $\xi = \Delta W / \Delta z = 26.8\% / 9.84\% = 2.7$. Why need low IES $1/\sigma$?

Calibration: Productivity Process

- States $z \in Z = \{z_n, z_r, z_d\}$. Normal times $z_n = 1$, Great Recession $z_r < 1$, Great Depression $z_d < z_r$.

$$z = \begin{pmatrix} 1.0000 \\ 0.9016 \\ 0.7109 \end{pmatrix}, \ \Gamma_{z,z'} = \begin{pmatrix} & 0.835 & 0.165 & 0.000 \\ z & 0.793 & 0.000 & 0.207 \\ & 1.000 & 0.000 & 0.000 \\ & & z' & \end{pmatrix}$$

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    - Choose $\Gamma_{n,r}, \Gamma_{r,d}$ such that unconditional probability of Great Recession is 13.7% and Great Depression is 2.84% (as estimated from Maddison data, 1800-2010.)

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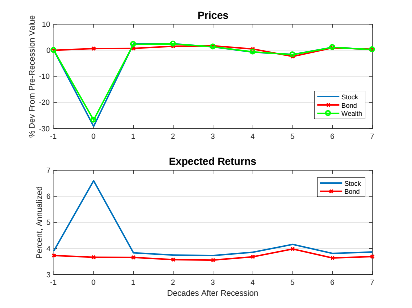
Calibration: Earnings Losses in Great Recession

- Estimate age-specific earnings declines (relative to aggregate trend) from 2007 to 2010 using CPS data to obtain $\{\varepsilon_i(z_r)\}_{i=1}^{I}$.

	(%)
20-29	-14.3
30-39	-12.6
40-49	-10.3
50-59	-11.1
60-69	-6.0
70+	-1.4
Average	-9.8

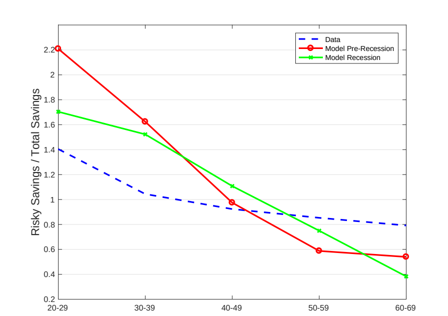
Results: Asset Price Decline



- Thought experiment: Following long period of normal times, Great Recession for 10 years with $\Delta z = 9.8\%$, then recovery.
- p falls by 29.2% ($\sigma > 1$ is key), price of bonds q barely moves.
    - Positive expected consumption growth (q should fall)
    - But: Increase in income *risk* $\Longrightarrow$ precautionary savings up. Keeps q from falling, risk free rate from rising (as in actual Great Recession).

▸ Standard Asset Pricing Statistics

Results: Portfolio Shares: Models and Data



- Share of risky assets in portfolio declines strongly with age. Why?
  - Markets sequentially complete $\Longrightarrow$ All households *born prior to recession* share recession consumption risk perfectly.
  - For same risk exposure, young require more leveraged portfolios.
- Portfolio age profile flattens in model Great Recession: Fear of Great Depression curbs appetite of young for risky assets in Great Recession.
- Endogenous portfolio shares depend too strongly on age. Will consider model with exogenous (factual) portfolios.

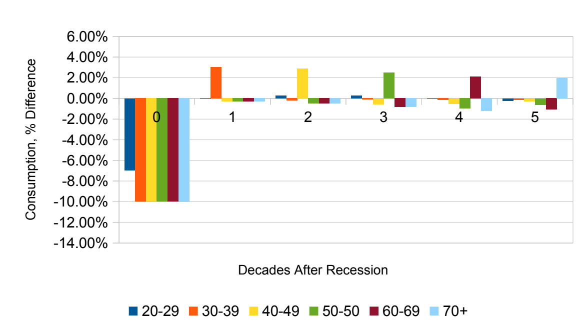
Results: Welfare Losses from the Great Recession

- Welfare measured as percentage change in consumption (in all future dates, states) under no-recession scenario needed to make households indifferent between current state being z_n and z_r.

Age	Δ Welf.
20-29	**-1.07%**
30-39	-4.78%
40-49	-5.69%
50-59	-7.48%
60-69	**-9.61%**
70+	**-10.00%**

▸ Wealth-Based Welfare Measure

Exploring the Welfare Losses: Consumption



- Immediate age-specific consumption response to recession symmetric (-10%) across generations alive prior to recession.
- Newborns see smaller consumption drop (relative to no recession (-7.0%) percent. Permanent consumption advantage in future.

Importance of Asset Pricing Channel?

- Three welfare impacts from Great Recession in baseline model:

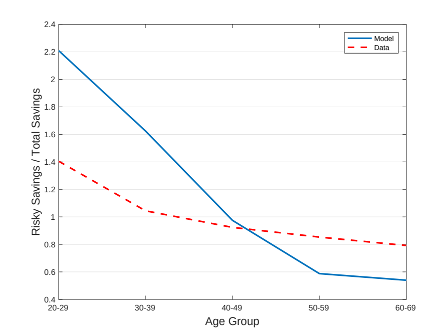
  1. Reduced PDV of future labor earnings
  2. Reduced value of asset portfolio on impact
  3. Gains from future asset price recovery

- Now: Partial equilibrium with *constant* $q's$. Goal: isolate effect 3.

  - Counterfactual A: Hold wealth distribution constant at onset of recession. Only effect 1.
  - Counterfactual B: Reduction in age-specific wealth implied by asset price fall. Effects 1 and 2.

Age	Benchmark	A (Eff 1.)	B (Eff. 1. & 2.)
20-29	-1.07	-6.53	-6.53
30-39	-4.78	-7.19	-14.03
40-49	-5.69	-6.90	-17.40
50-59	-7.48	-6.55	-16.33
60-69	-9.61	-3.38	-11.27
70+	-10.00	-1.88	-10.00

Exogenous Portfolios



- Now households are forced to hold empirical portfolios (from 2007 SCF). Still make consumption-savings decisions.
- Key plus: more realistic capital losses in Great Recession
- Key minus: Asset price movements do not reflect time-varying appetite for taking on aggregate risk.

Exogenous Portfolios

- Elasticity of Asset Prices to Output. Key: bond prices fall a lot too (big increase in risk-free rate in recession).

Asset	Endog.	Exog.
Wealth	2.72	2.02
Stock	2.97	2.08
Bond	-0.07	1.31

- Welfare? More significant welfare losses of very young, very old.

Age	Endog.	Exog.
20-29	-1.07%	-2.39%
30-39	-4.78%	-2.91%
40-49	-5.69%	-2.54%
50-59	-7.48%	-7.30%
60-69	-9.61%	-13.73%
70+	-10.00%	-11.37%

Welfare Losses from Recession by Age: Symmetric Earnings Losses

- Given asset pricing channel, why do the young actually lose?
- Answer: because they are especially hard-hit by the Great Recession in the labor market.

Age	Bench.	Sym. Δ Earn.
20-29	-1.07%	0.32%
30-39	-4.78%	-5.04%
40-49	-5.69%	-5.90%
50-59	-7.48%	-7.64%
60-69	-9.61%	-9.74%
70+	-10.00%	-10.09%

Implications for the Dynamics of the Wealth Distribution: Model vs. Data

	Endog. Portfolios			Exog. Portfolios			Data: NW, SCF		
Age	2007	2010	2013	2007	2010	2010	2007	2010	2013
20-29	0.00	0.00	0.00	0.00	0.00	0.00	2.30	1.27	1.50
30-39	6.29	4.20	7.74	6.25	5.67	5.75	5.95	4.20	6.05
40-49	14.73	11.98	14.61	14.42	14.06	13.35	13.94	13.97	14.25
50-59	25.59	25.20	25.23	25.31	25.28	24.90	24.70	24.52	22.92
60-69	31.76	34.71	31.21	32.03	32.44	31.84	31.45	32.66	30.53
70+	21.62	23.91	21.21	21.99	22.55	24.16	21.67	23.38	24.74

- Wealth share of young cohort (30-39) declines in Great Recession, then rebounds. Both in model and in data.
- Wealth Share of retiring cohort (60-69) increases in Great Recession, then returns to normal. Both in model and in data.

Level- or Growth Rate Shocks?

- So far aggregate output z mean reverting, thus in a great recession output and asset prices are expected to recover.
- Robustness to *permanent* shocks to z? See also Khan (2017). We explored this in a 3-generation OLG model calibrated to the same income losses.
- Three basic results
    - For given risk aversion, asset price decline comparable to model with trend-stationary output if (*and only if*) output growth over ten or twenty years is *negatively* correlated, as in U.S. data (corr ≈ -0.55).
    - Absolute welfare losses from the great recession significantly larger in the stochastic growth economy for all (but oldest) generation.
    - *Relative welfare losses* of young vs. middle aged comparable in both economies.

Incorporating (Limited) Intra-Cohort Heterogeneity

- Assume the wealthy are passive investors.
- Calibrate model to bottom 90% earnings, wealth life cycle profile.
- Requires (on average) less patient individuals.
- Overall: asset price mechanism less relevant to bottom 90%.

	Economy	
Age Group	Baseline	Low Wealth
20-29	-1.07%	-5.12%
30-39	-4.78%	-6.76%
40-49	-5.69%	-7.23%
50-59	-7.48%	-8.20%
60-69	-9.61%	-9.57%
70+	-10.00%	-9.88%

6 Conclusion

What Is This Useful For?

- Policy implications?
  - By construction nothing can be done about the recession itself.
  - But: government can of course affect distribution of welfare losses or gains.
  - E.g. by purchasing assets at distressed prices (TARP?) government may have mitigated welfare losses of elderly at expense of welfare gains of young.
  - Same might be true for expansion of outstanding government debt.

Conclusion

- We have explored asset price implications of large recessions. Can rationalize large price drops of (only) risky assets with fear of Great Recession (and IES $1/\sigma < 1$).
- We have explored the portfolio implications of the model. It can account for (too much of the) relatively risky portfolios of young and relatively safe portfolios of the old in the data.
- We have explored the redistributive implications of such recessions. Old lose a lot, young little. Might have gained if it wasn't for the dismal labor market.
- Heterogeneity within young generation?
    - Winners not the ones that don't much participate in financial markets ....

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- We have explored the redistributive implications of such recessions. Old lose a lot, young little. Might have gained if it wasn't for the dismal labor market.
- Heterogeneity within young generation?
    - Winners not the ones that don't much participate in financial markets ....
    - ... bud rather those who plan to have large wealth-to-income ratio in their 50's.

7 appendix

Calibration: Model with Exogenous Portfolios

- Alternative version of the model in which savings is a choice, but in which the portfolio shares are exogenous.
- New parameters: age-varying portfolio shares $\{\lambda_i(z)\}_{i=1}^{I}$.
- Set equal to age-specific shares of risky assets from SCF:

Age	$\lambda_i(\%)$
20-29	135
30-39	140
40-49	104
50-59	92
60-69	85
70+	79
Aggr.	94

8 Baseline Results

Results

- Asset Prices in a Great Recession
- Portfolio Choices
- Welfare Results
- Quantifying the Asset Price Channel
- Exploring the Sensitivity of Results
    - Exogenous (Data Implied) Portfolios
    - The Importance of Asymmetric Earnings Declines
    - Intracohort Heterogeneity

Motivating Facts: Income and Wealth Over the Life Cycle (2007 SCF, $1,000)

Age	Total Income	Labor Income	Asset Income	Assets	Debts	Net Worth
All	83.43	70.07	13.36	659.00	103.34	555.66
20-29	38.83	39.68	-0.85	130.66	53.30	77.36
30-39	69.83	68.68	1.15	335.87	136.12	199.75
40-49	93.40	84.97	8.43	598.21	132.62	465.59
50-59	117.97	99.56	18.41	959.77	133.24	826.53
60-69	109.06	76.15	32.90	1156.96	104.10	1052.86
70+	57.56	34.46	23.11	756.76	28.48	728.28

▸ Back to Plot

Key Channel

- The young have lots of future labor income, few financial assets.
- Hurt by lower current wages, might benefit from lower asset prices.
- Welfare consequences of downturn depend on:
  - Size of labor income asset price decline
  - Its persistence
  - Behavioral response of households (consumption-savings and portfolio allocation choices).
- Thus want labor income, asset prices and household choices be *endogenously* determined in quantitative life cycle model.

Wealth-Based Welfare Measures

- Wealth-based welfare measure invariant to remaining lifetime horizon.
- How much must *wealth* be reduced in the no-recession state for households to be indifferent between life with or without the recession in the current period?
- Normalize wealth measure by pc consumption in normal times.

▸ back

Age	Bench.	Sym. Δ Earn.	Exog.
20-29	-1.98%	0.60%	-3.90%
30-39	-11.20%	-11.87%	-6.30%
40-49	-15.79%	-16.38%	-6.83%
50-59	-22.83%	-23.31%	-20.39%
60-69	-25.90%	-26.24%	-35.77%
70+	-14.95%	-15.08%	-19.11%

	Return Stats: Benchmark Model		
Asset	Average	Std. Dev.	Corr. w/ Stock
Stock	4.50%	31.2%	1.00
Bond	4.09%	25.3%	0.79
	Return Stats: Model w/o Great Depr.		
Asset	Average	Std. Dev.	Corr. w/ Stock
Stock	4.41%	16.6%	1.00
Bond	3.68%	1.2%	-0.07
	Return Stats: Data		
Asset	Average	Std. Dev.	Corr. w/ Stock
Stock	6.62%	36.4%	1.00
Bond	2.29%	30.4%	0.01

back

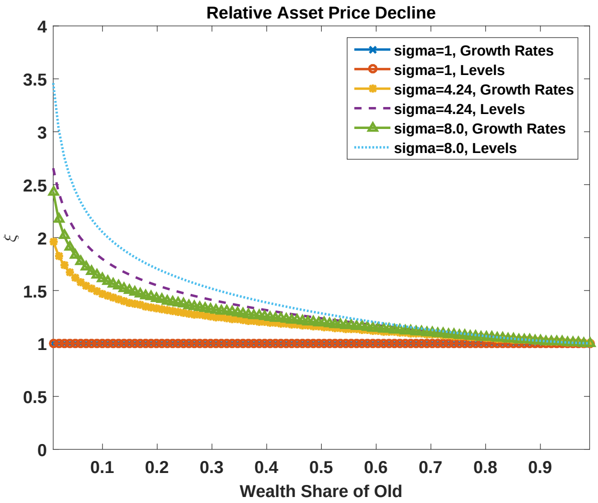
Implications for the Dynamics of the Wealth Distribution: Model vs. Data

	Model End. Portf.			Model Exog. Portf.			Data		
Age	PreR	Rec.	Reco	PreR	Rec.	Reco	2007	2010	2013
20-29	0.0	0.0	0.0	0.0	0.0	0.0	2.3	1.3	1.5
30-39	2.6	-1.4	6.0	4.9	3.9	4.5	6.0	4.2	6.1
40-49	9.9	4.6	12.0	13.6	13.0	12.5	13.9	14.0	14.3
50-59	24.9	24.1	23.4	25.2	25.2	24.8	24.7	24.5	22.9
60-69	36.9	42.6	32.8	33.0	33.7	32.7	31.5	32.7	30.5
70+	25.6	30.1	25.8	23.3	24.2	25.6	21.7	23.4	24.7

Level- or Growth Rate Shocks?

- So far aggregate output z mean reverting, thus in a great recession output and asset prices are expected to recover.
- Robustness to permanent shocks to z? Consider 3-period model but assume that $g' = z'/z$ follows Markov process with $\Gamma_{g,g'}$.
- Calibrate s.t. output falls 9.83% in recession.
- Three basic results
  - For given risk aversion, ξ comparable to model with trend-stationary output if (*and only if*) output. growth over ten or twenty years *negatively* correlated, as in U.S. data (corr ≈ -0.55).
  - Absolute welfare losses from the great recession significantly larger in the stochastic growth economy (for all but oldest generation).
  - *Relative welfare losses* by age are comparable in both economies.

Asset Prices: Two Economies



Relative Welfare Losses by Age: Two Economies

	Economy	
Age Group	Shocks to z	Shocks to z'/z
Old (absolute)	−12.3%	−11.4%
Middle (absolute)	−3.7%	−6.0%
Young (absolute)	2.9%	−5.0%
Middle rel.to Old	8.6%	5.4%
Young rel. to Old	15.2%	6.4%

Incorporating (Limited) Intra-Cohort Heterogeneity

- Are welfare losses of "average household" within an age group representative? Now consider limited intra-cohort heterogeneity.

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- In essence: recalibration of a model with lower income- and wealth households. Key difference: wealth-to-income ratio is lower among asset pricers now.
- Results fairly unchanged relative to baseline model, but asset price channel somewhat less important.

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- Redistributional consequences by age of other aggregate shocks:

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THANK YOU FOR COMING AND LISTENING

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