Lecture 3. Neoclassical macro models of inequality. Part 2

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The question

1. Is household income and wealth inequality quantitatively important for aggregate consumption, investment and output response to an exogenous Great Recession shock?
2. How do social insurance policies impact these aggregates?
3. How are consumption, welfare losses of aggregate shock distributed across population? How does social insurance affect that distribution?

The Basic Argument: Why May Inequality Matter for Dynamics of Recession?

- Earnings fall in recessions (unemployment rises, real wages fall)
- If low wealth households have higher MPC out of current earnings changes....
- ...then the degree of wealth inequality impacts aggregate C dynamics over the cycle.
- If, in addition, aggregate C matters for output (if Y is partially demand-determined b/c of endogenous TFP, nominal rigidities), then wealth distribution influences aggregate Y dynamics...
- ...and social insurance policies are potentially output-stabilizing.

Data meets Quantitative Theory

- *Empirical* analysis using US household (PSID) y, c, a data:
  - How did y, c, a distribution look prior to Great Recession?
  - How did y, c, a change for individual households in the Great Recession?

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- *Quantitative* analysis using versions of heterogeneous household business cycle (Krusell & Smith 1998) model:
  - Does the model match the inequality facts?
  - Does wealth distribution matter (quantitatively) for response of C, I to Great Recession shock?
  - What about Y response if Y is partially (aggregate consumption C) demand-determined?

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  - What about Y response if Y is partially (aggregate consumption C) demand-determined?
- *Policy* analysis using stylized unemployment insurance (UI) system:
  - How does UI impact $\Delta C, \Delta Y$ for given wealth distribution?
  - How does size of UI impact the wealth distribution itself?
  - How is distribution of welfare losses from Great Recession shaped by UI?

The data

- PSID waves of 2004-2006-2008-2010. Detailed US household-level information about y, c, a.
  - Panel dimension: can assess how individual households changed actions (c expenditures) during the Great Recession
  - Coarse time series dimension (biannual surveys for data between 2004 and 2010)

The data

- Variables of Interest
  - Net Worth = a = Value of all assets (including real estate) minus liabilities
  - Disposable Income = y = Total money income net of taxes (computed using TAXSIM)
  - Consumption Expenditures = c = Expenditures on durables, nondurables and services (excluding health)
- Sample
  - All households in PSID waves 2004-2006-2008-2010, with at least one member of age 22-60

Data: Marginal Distributions

	y	c	a	SCF 07 a
Mean (2006$)	62,549	43,980	291,616	497,747
$\%Share: Q1$	4.5	5.6	-0.9	-0.2
$Q2$	9.9	10.7	0.8	1.2
$Q3$	15.3	15.6	4.4	4.6
$Q4$	22.8	22.4	13.0	11.9
$Q5$	47.5	45.6	82.7	82.5
$90-95$	10.8	10.3	13.7	11.1
$95-99$	12.8	11.3	22.8	25.3
Top 1%	8.0	8.2	30.9	33.5
Sample Size		6442		2910

- a: Bottom 40% holds basically no wealth
- y, c: less concentrated
- a distribution in PSID $\simeq$ SCF except at very top

Heterogeneity (Inequality) in 2006: Joint Distributions

	% Share of:		Exp.Rate
Q.a	y	c	c/y (%)
$Q1$	8.6	11.3	92.2
$Q2$	10.7	12.4	81.3
$Q3$	16.6	16.8	70.9
$Q4$	22.6	22.4	69.6
$Q5$	41.4	37.2	63.1

- a correlated with y and saving
- Wealth-rich earn more and save at a higher rate
- Bottom 40% hold no wealth, still account for almost 25% of spending

Moving to the theory

- Empirical evidence shows:
  - Bottom 40% have no wealth...
  - ...but account for almost 25% of consumption

Moving to the theory

- Empirical evidence shows:
  - Bottom 40% have no wealth...
  - ...but account for almost 25% of consumption
- Is a standard macro model with heterogeneous agents a la Krusell & Smith (1998) consistent with these facts?
- We then use the model as a laboratory for *quantifying*:
  - how wealth distribution affects C, I, Y responses to Great Recession shock
  - how this impact is shaped by social insurance policies
  - how welfare losses from Great Recession are distributed across wealth distribution

Model: Summary of Key Elements

- Augmented Krusell and Smith (1998) model, similar to Carroll, Slacalek, Tokuoka & White (2015)
- Exogenous aggregate shock Z moves aggregate wages w and unemployment rate $\Pi_Z(u)$. Rare but severe (Y drops $\approx 7\%$ below trend) and persistent (22 quarters) recessions.

$$\begin{aligned} Y &= Z^* K^\alpha N(Z)^{1-\alpha} \\ Z^* &= Z C^\omega \end{aligned}$$

- Aggregate consumption C demand externality $\omega \geq 0$.
- Exogenous individual income risk
  - Unemployment risk $s \in \{u, e\}$. Increases in recessions (8.4% vs. 5.3%).
  - Income risk y, conditional on being employed. Sum of iid and persistent ($\phi = 0.97$) component.
- Individual preference heterogeneity $\beta \sim U[0.9265, 0.9672]$.
- Constant retirement and survival risk. Basic life cycle elements and thus age heterogeneity.
- Unemployment insurance system with size $\rho = 50\%$.

Aggregate Technology

- Standard production function

$$Y = Z^* K^{\alpha} N^{1-\alpha}$$

- Total factor productivity Z^* in turn is given by

$$Z^* = ZC^{\omega}$$

  - C is aggregate consumption
  - $\omega \geq 0$: aggregate demand externality
  - Benchmark model $\omega = 0$

- Focus on $Z \in \{Z_l, Z_h\}$: recession and expansion.

$$\pi(Z'|Z) = \begin{pmatrix} \rho_l & 1-\rho_l \\ 1-\rho_h & \rho_h \end{pmatrix}.$$

- Capital depreciates at a constant rate $\delta = 0.025$ quarterly.
- Capital share: $\alpha = 36\%$

Household Preferences

- Continuum of households with idiosyncratic y risk
- Period utility function $u(c) = \log(c)$
- To generate sufficient wealth dispersion follow Carroll, Slacalek & Tokuoka (2015):
  - Households draw discount factor β at birth from $U[\bar{\beta} - \epsilon, \bar{\beta} + \epsilon]$
  - Choose $\bar{\beta}, \epsilon$ to match quarterly $K/Y = 10.26$, Wealth Gini of working pop.=0.77. Yields annual $\beta \in [0.9265, 0.9672]$
- In working life, constant retirement prob. $1 - \theta = 1/160$.
- In retirement constant death probability $1 - \nu = 1/60$.

Household Preferences

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- In working life, constant retirement prob. $1 - \theta = 1/160$.
- In retirement constant death probability $1 - \nu = 1/60$.
- Other mechanisms to generate large wealth dispersion
  - Entrepreneurs [Quadrini 1997]
  - Bequest motives [De Nardi 2004]
  - Health expenditure shocks in old age [De Nardi, French, Jones 2010, Ameriks, Briggs, Caplin, Shapiro, Tonetti 2015]
  - Extreme income realizations [Castaneda, Diaz-Gimenez, Rios-Rull 2003]
  - Heterogeneous investm. returns [Benhabib, Bisin, Zhu 2011]

Household Endowments

- Time endowment normalized to 1
- Idiosyncratic unemployment risk, $s \in S = \{u, e\}$
  - $\pi(s'|s, Z', Z)$
- Idiosyncratic labor productivity risk, $y \in Y$
  - Estimate stochastic process from annual PSID (1967-1996) data (only employed households):

$$\begin{aligned} \log(y') &= p + \epsilon \\ p' &= \phi p + \eta \end{aligned}$$

    with persistence ϕ, innovations (η, ϵ). Find estimates of $(\hat{\phi}, \hat{\sigma}_\eta^2, \hat{\sigma}_\epsilon^2) = (0.9695, 0.0384, 0.0522)$
  - Turn into quarterly process, discretize into Markov chain

Government Policy

- Balanced budget unemployment insurance system
  - Replacement rate $\rho = \frac{b(y,Z,\Phi)}{w(Z,\Phi)y}$ if $s = u$
  - Thus benefits given by $b(y, Z, \Phi) = \rho w(Z, \Phi)y$
  - Baseline $\rho = 0.5$. Compare to $\rho = 0.1$.
  - Proportional labor income tax $\tau(Z; \rho)$ to balance budget:
- Balanced PAYGO social security system
  - Payroll tax rate $\tau_{SS} = 15.3\%$
  - Lump-sum benefits that balance the budget

Recursive Formulation of HH Problem

- Individual state variables $x = (y, s, a, \beta)$
- Aggregate state variables (Z, Φ)
- Aggregate law of motion $\Phi' = H(Z, \Phi', Z')$
- Household dynamic program problem of worker reads as

$$
\begin{aligned}
v_W(s, y, a, \beta; Z, \Phi) = & \\
& \{ \max_{c, a' \geq 0} u(c) \quad + \quad \beta \sum_{(Z', s', y') \in (Z, S, Y)} \pi(Z'|Z)\pi(s'|s, Z', Z)\pi(y'|y) \\
& \qquad * \quad [\theta v_W(s', y', a', \beta; Z', \Phi') + (1 - \theta) v_R(a', \beta; Z', \Phi')] \}
\end{aligned}
$$

subject to

$$
\begin{aligned}
c + a' &= (1 - \tau(Z; \rho) - \tau_{SS}) w(Z, \Phi) y \left[1 - (1 - \rho) 1_u\right] + (1 + r(Z, \Phi) - \delta) a \\
\Phi' &= H(Z, \Phi', Z')
\end{aligned}
$$

Calibration of Aggregate Productivity Risk

- Recall that $Z \in \{Z_l, Z_h\}$ and

$$\pi(Z'|Z) = \begin{pmatrix} \rho_l & 1-\rho_l \\ 1-\rho_h & \rho_h \end{pmatrix}$$

- Expected *duration* of a recession is $EL_l = \frac{1}{1-\rho_l}$. Fraction of time economy is in recession is $\Pi_l = \frac{1-\rho_h}{2-\rho_l-\rho_h}$

- Choose $\rho_l, \rho_h, \frac{Z_l}{Z_h}$ to match:

  1. the average length of a severe recession EL_l
  2. the fraction of time economy is in severe recession, Π_l.
  3. the decline in GDP per capita in *severe* recessions relative to normal times

What is a Severe Recession?

- Define start of severe recession when $u \geq 9\%$. Lasts as long as $u \geq 7\%$.
- From 1948 to 2014.III two severe recessions, 1980.II-1986.II and 2009.I-2013.III.
- Frequency of severe recessions: $\Pi_l = 16.48\%$, expected length of 22 quarters.
- Average unemployment rate $u(Z_l) = 8.39\%$, $u(Z_h) = 5.33\%$
- Implied transition matrix:

$$\pi = \begin{pmatrix} 0.9545 & 0.0455 \\ 0.0090 & 0.9910 \end{pmatrix}$$

- Average output drop in severe recessions measured as $\frac{Y_l}{Y_h} = 0.9298$. Matching this in model requires $\frac{Z_l}{Z_h} = 0.9614$.
- Severe recession similar in spirit to rare disasters [Rietz 1988, Barro 2006, Gourio 2015]

Idiosyncratic Employment status Transitions

Transition matrices $\pi(s'|s, Z', Z)$ for $s, s' \in \{u, e\}$ calibrated to quarterly job finding rates (computed from CPS). For example

- Economy is and remains in a recession: $Z = Z_l, Z' = Z_l$

$$\begin{pmatrix} 0.34 & 0.66 \\ 0.06 & 0.94 \end{pmatrix}$$

- Economy is and remains in normal times: $Z = Z_h, Z' = Z_h$

$$\begin{pmatrix} 0.19 & 0.81 \\ 0.05 & 0.95 \end{pmatrix}$$

- In recessions more likely to lose job and less likely to find one.
- Thus as economy falls into recession, UE *risk* up (and more persistent) even for those not yet having lost job. Strong precautionary savings motive for wealth-poor!

Model: Summary of Key Elements

- Exogenous aggregate shock Z moves aggregate wages w and unemployment rate $\Pi_Z(u)$. Rare but severe recessions.
- Potentially: aggregate consumption C demand externality $\omega > 0$.
- Exogenous individual income risk
  - (Un-)employment risk $s \in \{u, e\}$. Increases in recessions
  - Income risk y, conditional on being employed
- Exogenous individual preference heterogeneity $\beta \sim U[\bar{\beta} - \epsilon, \bar{\beta} + \epsilon]$. Constant survival risk θ.
- Basic life cycle elements and thus age heterogeneity
- Unemployment insurance system with size ρ.

Versions of Model

1. Original Krusell & Smith (1998) [KS] economy (single discount factor + income risk + low ρ)

2. Economy 1 + heterogenous β's, survival risk $\theta < 1$ and high $\rho = 50\%$ [Benchmark]

3. Economy 2 + aggregate demand externality $\omega > 0$

Inequality in the Benchmark Economy

New Worth	Data		Models	
% Share held by:	PSID, 06	SCF, 07	Bench	KS
$Q1$	-0.9	-0.2	0.3	6.9
$Q2$	0.8	1.2	1.2	11.7
$Q3$	4.4	4.6	4.7	16.0
$Q4$	13.0	11.9	16.0	22.3
$Q5$	82.7	82.5	77.8	43.0
$90-95$	13.7	11.1	17.9	10.5
$95-99$	22.8	25.3	26.0	11.8
$T1\%$	30.9	33.5	14.2	5.0
Gini	0.77	0.78	0.77	0.35

- Benchmark economy does a good job matching bottom and top of wealth distribution, but still misses very top.
- Original KS economy does not produce enough inequality.

Joint Distributions (2006): data v/s model

	% Share of:					
	y		c		%c/y	
a Quintile	Data	Model	Data	Model	Data	Model
$Q1$	8.6	6.0	11.3	6.6	92.2	90.4
$Q2$	10.7	10.5	12.4	11.3	81.3	86.9
$Q3$	16.6	16.6	16.8	16.6	70.9	81.1
$Q4$	22.6	24.6	22.4	23.6	69.6	78.5
$Q5$	41.4	42.7	37.2	42.0	63.1	79.6

- Model captures well that bottom 40% has almost no wealth but significant consumption share
- But overstates consumption shares and rates of the rich.
- Rudimentary life cycle is crucial for level of consumption rates and their decline with wealth.

Dynamics of $a, y, c/y$ During Recession (2006-2010) across Wealth Quintiles: Data v/s Model

	Δa(%)		Δy(%)		Δc/y(pp)	
a Q.	Data	Model	Data	Model	Data	Model
$Q1$	NA	24	7.4	4.9	-4.4	-0.4
$Q2$	4	15	5.2	0.3	-2.1	0.8
$Q3$	6	8	2.1	-2.4	-0.7	2.2
$Q4$	2	4	1.7	-4.0	-2.1	3.2
$Q5$	-5	-1	-1.1	-6.4	-1.6	4.6

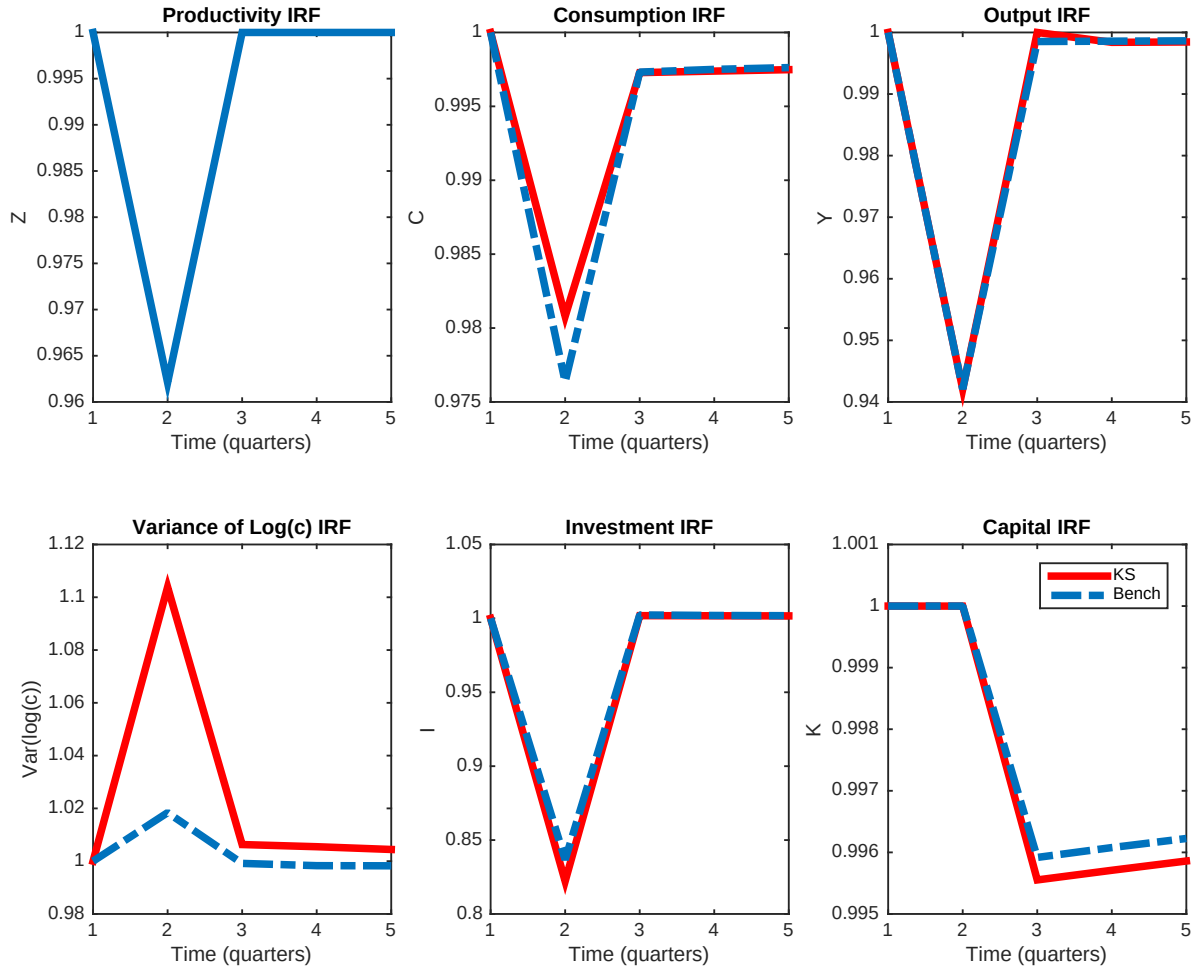
- Model's issues:
  - Model captures well that wealth-poor cut consumption rates the most.
  - Too much y fall for rich (too much mean reversion).
  - Too small decline in a at the top of wealth distribution in model (no price movements).
- Now: use the model to understand how wealth inequality matters for C, I, Y dynamics.

Inequality and the Aggregate Dynamics of a Severe Crisis

In order to understand how wealth inequality matters for C, I, Y dynamics, we compare:

- KS economy, with low wealth inequality (behaves $\approx$ as RA economy)
- The calibrated heterogenous β (baseline) economy
- Note: calibration insures both economies have same average K/Y ratio.
- Focus on household heterogeneity and consumption dynamics in recessions shared with Guerrieri & Lorenzoni (2011), Berger & Vavra (2014), Glover, Heathcote, Krueger & Rios-Rull (2014), Heathcote & Perri (2014)

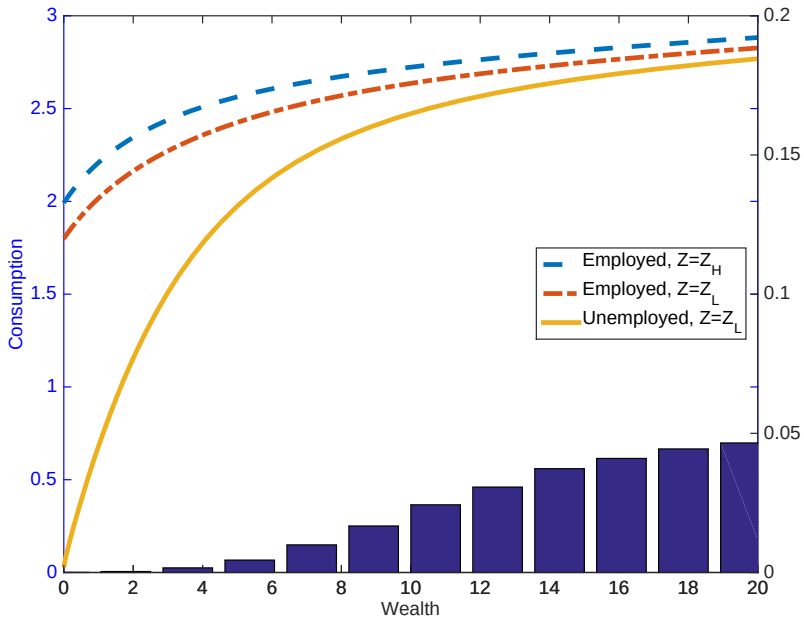
IRF, 2 Economies: One Period Recession



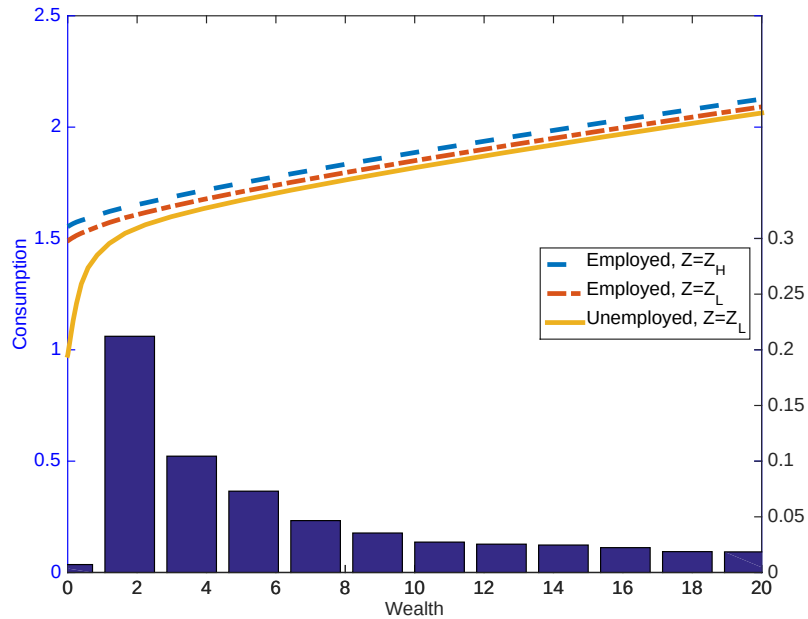
- Consumption drop: KS -1.9% vs Baseline -2.4.%
- More wealth inequality -> to $\approx 26\%$ bigger consumption drop. WHY?

Consumption Functions & Wealth Distribution

KS



Het β



- KS: more concave consumption function (because of $\rho = 0.01$), but little mass close to $a \approx 0$
- Benchmark puts significant mass where consumption falls the most in recessions
- Note: households with $a \approx 0$ do not all act as hand-to-mouth (HtM) consumers. Those without job losses cut c *more* than y.
- Alternatives for generating high MPC households: Wealthy HtM [Kaplan & Violante 2014], Durables [Berger & Vavra 2015]

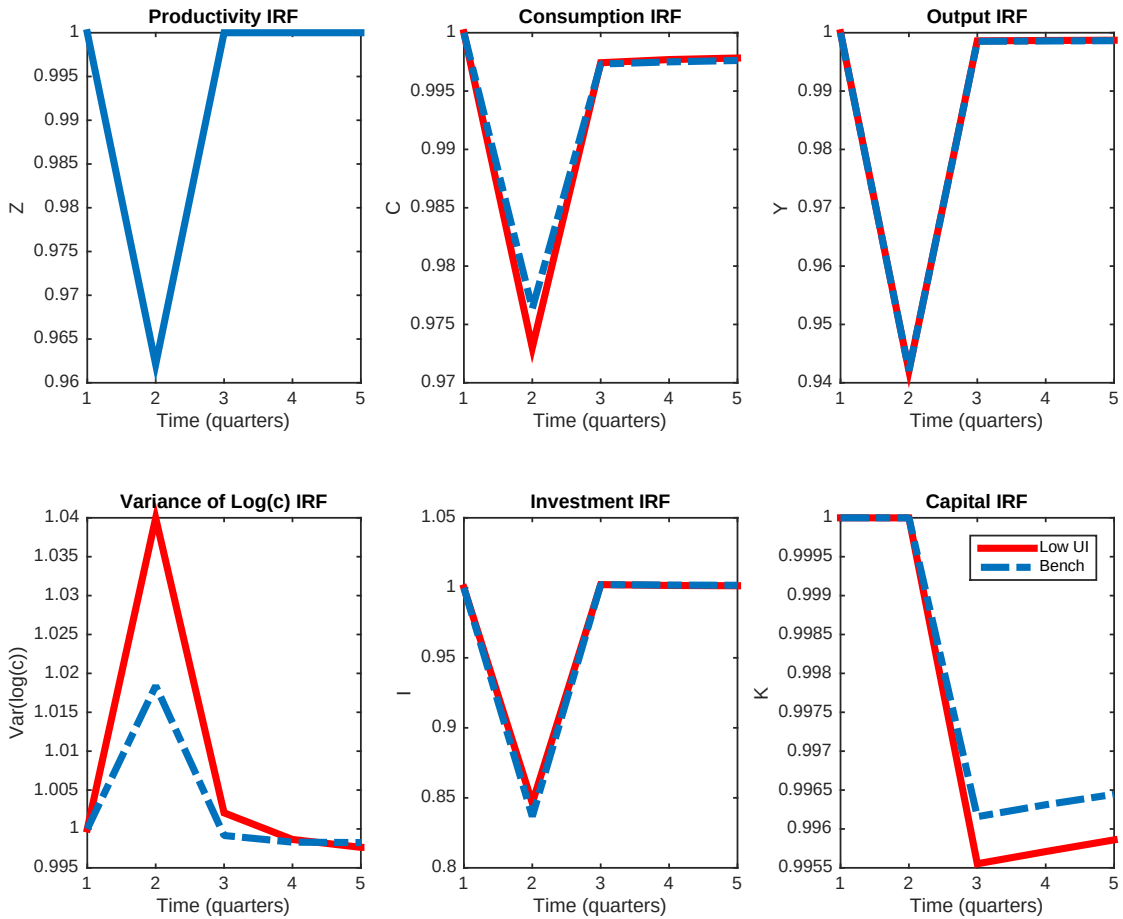
Net Worth Distributions and Consumption Decline: Different Versions of the Model

	Models*					
% Share:	KS	$+\sigma(y)$	+Ret.	$+\sigma(\beta)$	+UI	KS+Top 1%
$Q1$	6.9	0.7	0.7	0.7	0.3	5.0
$Q2$	11.7	2.2	2.4	2.0	1.2	8.6
$Q3$	16.0	6.1	6.7	5.3	4.7	11.9
$Q4$	22.3	17.8	19.0	15.9	16.0	16.5
$Q5$	43.0	73.3	71.1	76.1	77.8	57.9
$90-95$	10.5	17.5	17.1	17.5	17.9	7.4
$95-99$	11.8	23.7	22.6	25.4	26.0	8.8
$T1\%$	5.0	11.2	10.7	13.9	14.2	30.4
Wealth Gini	0.350	0.699	0.703	0.745	0.767	0.525
ΔC	-1.9%	-2.5%	-2.6%	-2.9%	-2.4%	-2.0%

The Impact of Social Insurance Policies

- How does presence of unemployment insurance (UI) affect the response of macro economy to aggregate shock?
- Two effects:
  - UI moderates individual consumption decline for given wealth
  - UI changes precautionary savings incentives and thus modifies the wealth distribution
- Two experiments:
  - (I) Run $\rho = 0.5$ v/s $\rho = 0.1$ in benchmark economy. Both effects present.
  - (II) Hit both $\rho = 0.5$ v/s $\rho = 0.1$ economies with recession, starting with *same* wealth distribution. Isolates the first effect.

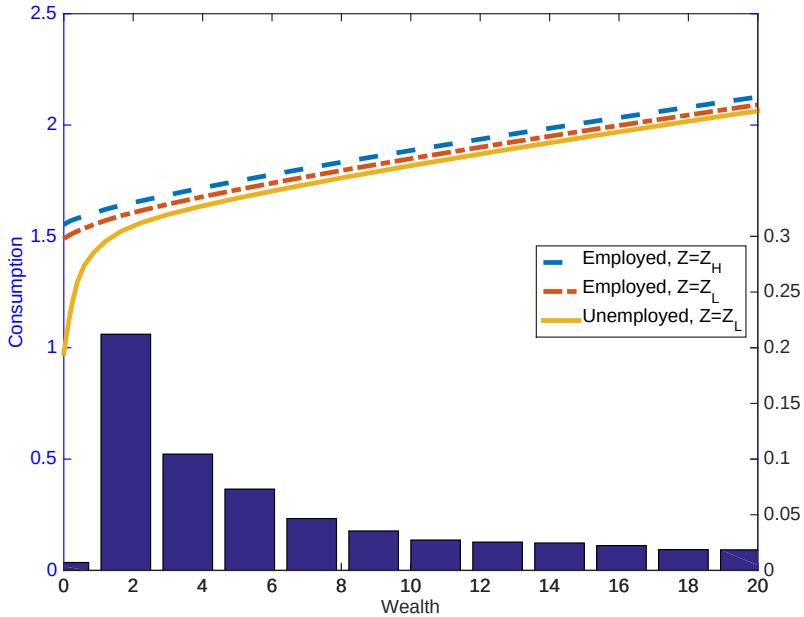
Experiment I: One Time Shock, two Levels of UI



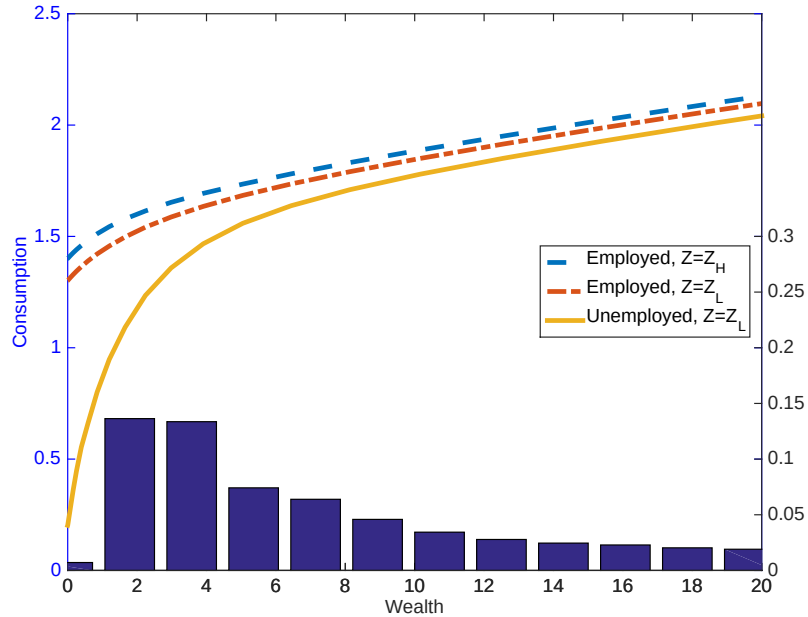
- Consumption drop: Low UI -2.9% vs Baseline -2.4%.
- Difference moderated by adjustment of wealth distribution.

Consumption Functions & Wealth Distribution

High UI

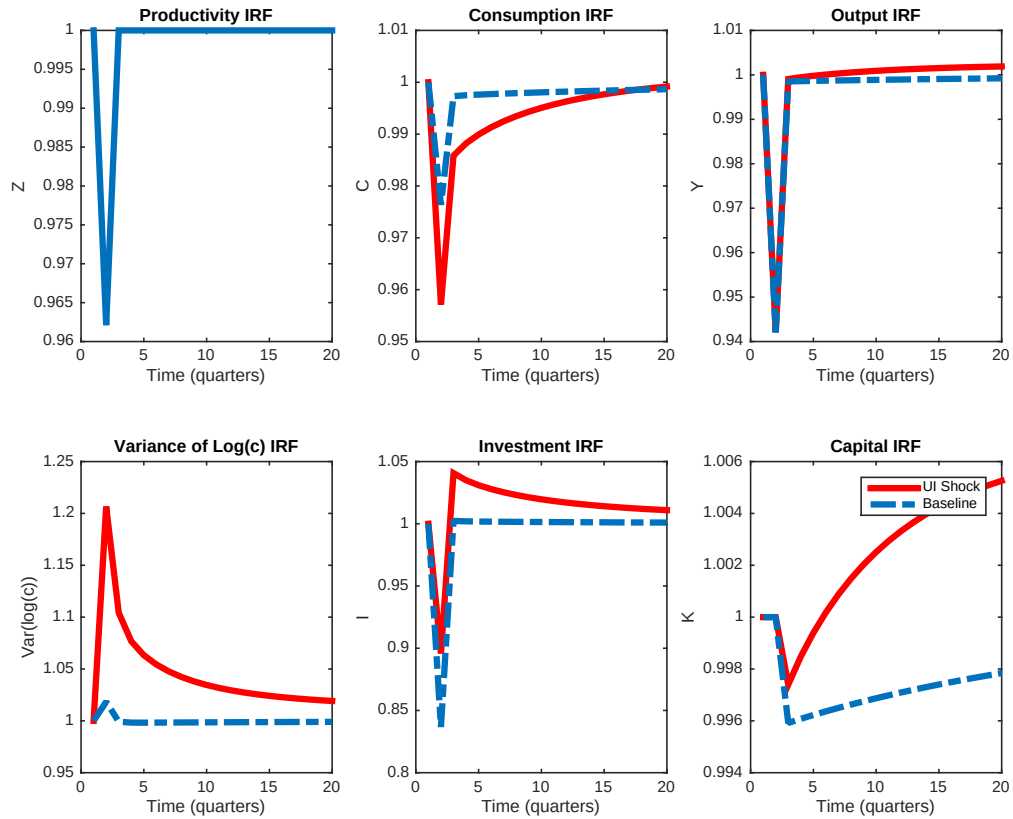


Low UI



- Benchmark: 25% with close to zero NW, compared to 15% with low UI
- Impact of UI on aggregate consumption response is muted because low UI shifts wealth distribution to right.
- How important is this effect? Suppose wealth distribution would *NOT* respond: Consumption disaster!

IRF, Fixed Distribution: One Time Shock



- Consumption drop: Low UI -4.4% vs Baseline -2.4%.
- Note: consumption would drop almost as much as output! But faster recovery.

Inequality and Aggregate Economic Activity

- So far, output Y was predetermined in the short-run
  - Z^* and N fluctuating exogenously.
  - K predetermined in short run

$$Y = Z^* K^{\alpha} N^{1-\alpha}$$

- Focus was on consumption C. Now: model supply and demand-side determinants of Y:
  - The supply side: Endogenizing labor supply N [see Chang & Kim 2007]
  - The demand side: Consumption Externality $Z^* = ZC^{\omega}$. Reduction in C feeds back into TFP
- Key question again: how does wealth distribution affect output dynamics now that Y is meaningfully endogenous.

A Model with an Aggregate Consumption Externality

- Now $Z^* = ZC^{\omega}$ with $\omega > 0$.
- Reduced form version of real aggregate demand externalities [e.g. Bai, Rios-Rull & Storesletten 2012, Huo & Rios-Rull 2013, Kaplan & Menzio 2014]
- Alternatively, could have introduced nominal rigidities making output partially demand determined [Het. HH New Keynesian models: Görnemann, Küster, Nakajima 2014, Challe, Matheron, Ragot, Rubio-Ramirez 2014, Auclert 2015, Kaplan, Moll and Violante, 2018]
- "Demand management" may be called for even in absence of household heterogeneity
- Social insurance policies (such as UI) may be desirable from individual insurance *and* aggregate point of view

Thought Experiments

- Re-calibrate Z, ω to match output volatility
- Simulate Great Recession with externality turned on, off. *Question I*: How much amplification?
- Repeat low-UI thought experiment in $\omega > 0$ economy. *Question II*: How important is aggregate demand stabilization through UI?
- Measure welfare losses of falling into a great recession and losing job. *Question III*: How do losses depend on household characteristics, ω, UI?

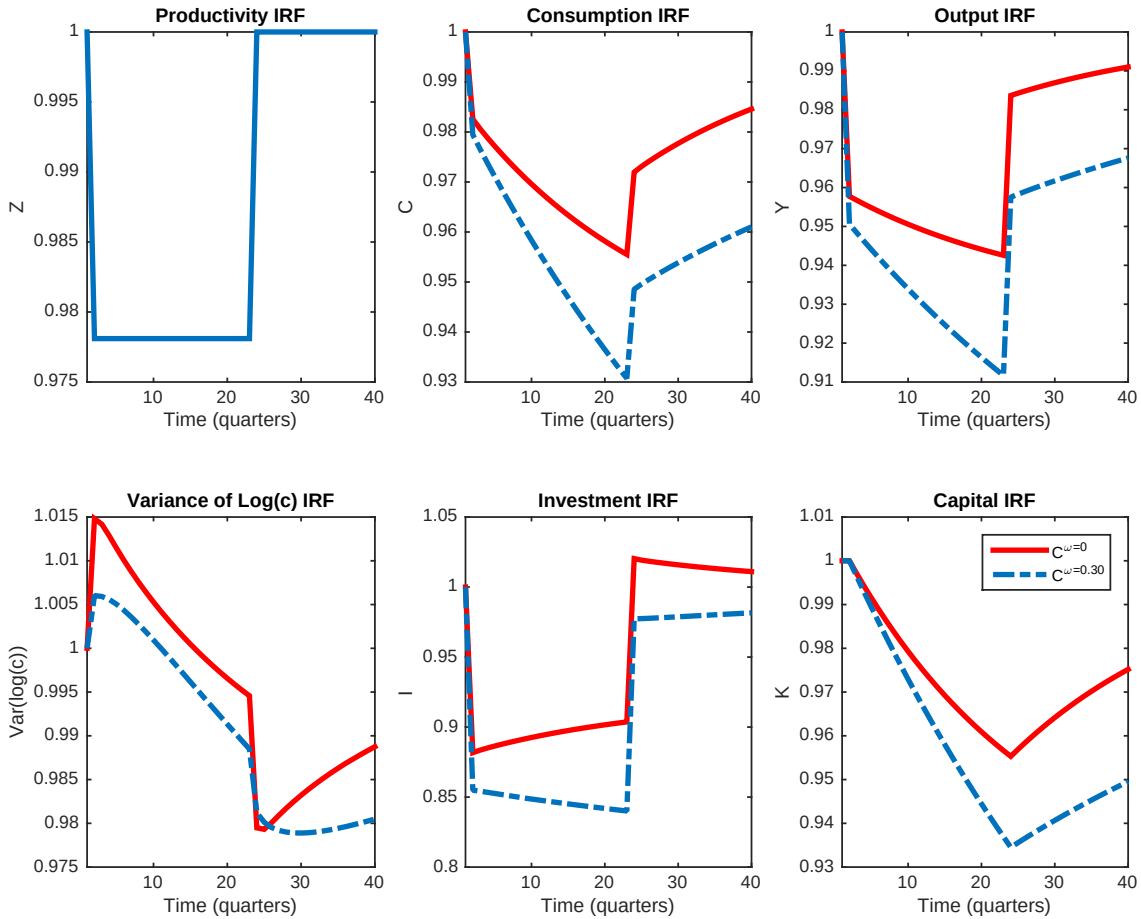
Thought Experiments: Executive Summary of Answers

- Simulate Great Recession with externality turned on, off.
  - *Question I*: How much amplification?
  - *Answer*: Recession 2-3 pp deeper. Gap increasing over time

- Repeat low-UI thought experiment in $\omega > 0$ economy.
  - *Question II*: How important is aggregate demand stabilization through UI?
  - *Answer*: Avoids additional output recession of 1%

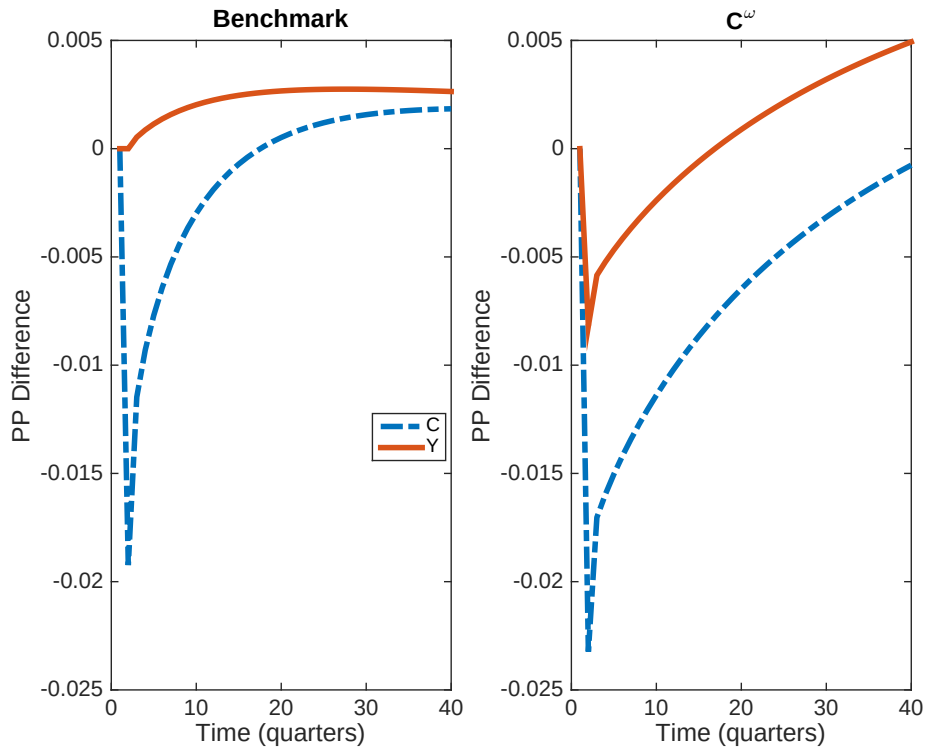
- Measure welfare losses of falling into a great recession and losing job.
  - *Question III*: How do losses depend on household characteristics, ω, UI?
  - *Answer*: Welfare losses very heterogeneous and large (1.5% to 11%). Have significant aggregate component. Much larger for wealth-poor if UI is small. Amplified by $\omega > 0$.

Question I: How much Amplification from $\omega > 0$?



Recession $2-3$ pp deeper with $\omega > 0$. Gap increasing over time.

Question II: Difference in C, Y IRF with High, Low UI ($\omega = 0, \omega > 0$), Fixed Wealth Distribution?



- Baseline (left panel): Low UI makes consumption recession much more severe, but no impact on output dynamics.
- Demand externality economy (right panel): Now low UI also has persistent negative effect on output.