Macroeconomics and Heterogeneity, including Inequality

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The question

- Broad: How important is micro heterogeneity for macro outcomes?
- Narrow: (addressed here):
  - How much Household, income and wealth heterogeneity matters for *aggregate expenditures, investment and output* response to a large macro shock (*Great Recession*)?
  - How do social insurance policies impact *aggregate outcomes*?
  - And how are consumption and welfare losses *distributed* across the population?

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- In preparation for forthcoming Handbook of Macroeconomics: comments very welcome!

Wealth heterogeneity and macro outcomes

- Earnings fall in recessions (employment/wages fall)
- If wealth matters for household expenditure responses (precautionary motives, hands to mouth behavior)..
- ..then wealth distribution matters for aggregate C responses in recessions
- If, in addition, aggregate C matters for Y (Endogenous TFP, Nominal Rigidities), then wealth distribution matters for aggregate Y dynamics

Plan: Data meets Theory

- *Empirical* analysis using PSID y, c, a data:
  - How did wealth inequality look prior to Great Recession?
  - How did the Great Recession hit different segments of the distribution ?
  - How did these segments responded?

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  - Can the model match the cross-sectional facts?
  - How much does distribution matter for response of C, I, Y to Great Recession shock?
  - What are the aggregate consequences of falling expenditures when TFP is endogenous?

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  - How much does distribution matter for response of C, I, Y to Great Recession shock?
  - What are the aggregate consequences of falling expenditures when TFP is endogenous?
- *Policy* analysis: stylized unemployment insurance system:
  - How does it impact the wealth distribution?
  - How does it impact C for a *given* wealth distribution?
  - How is the distribution of welfare losses from a Great Recession shaped by policy?

Empirical Analysis

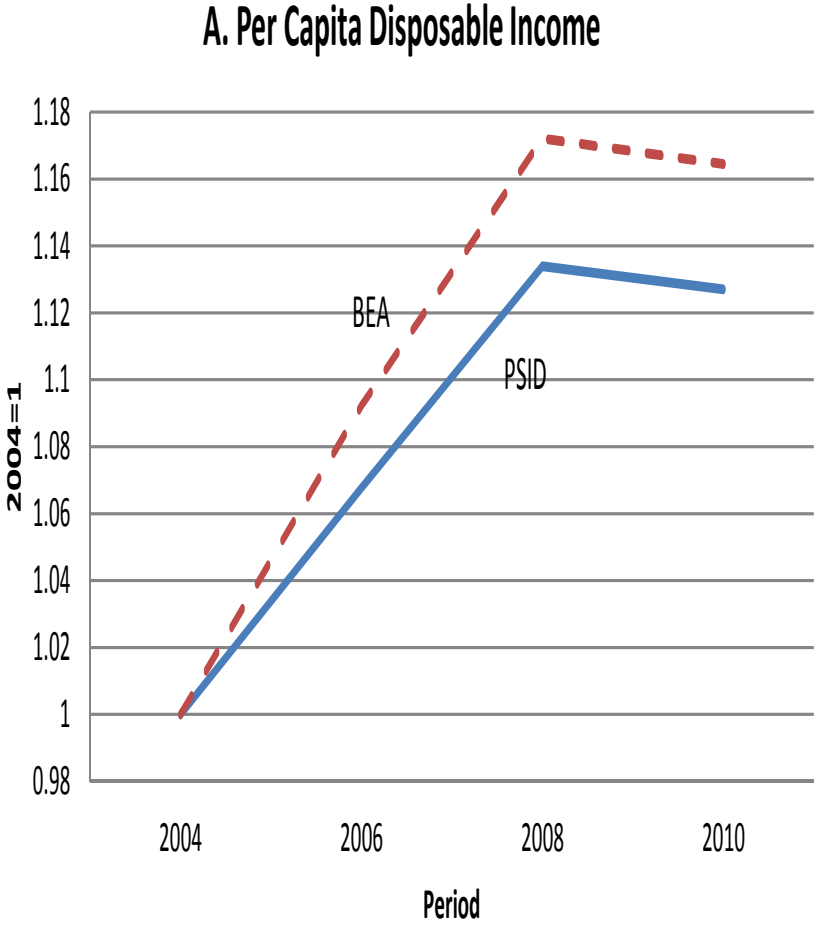
The data

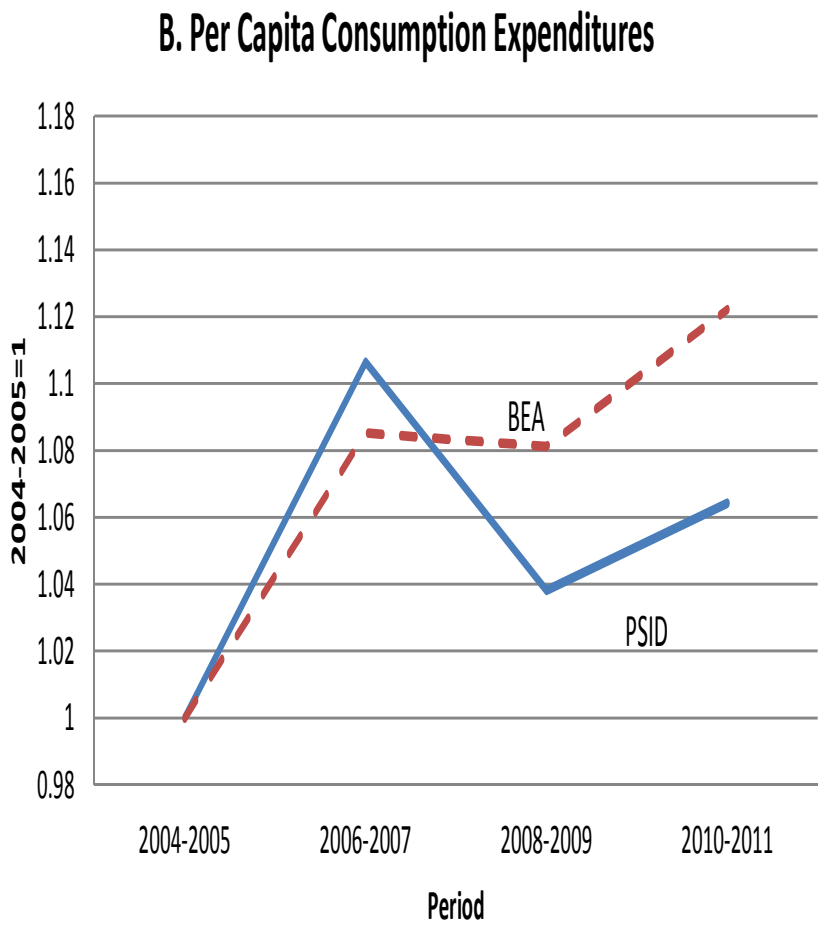
- PSID waves of 2004-2006-2008-2010
- Pluses
  - Panel dimension: can assess how a different households changed actions (expenditures) during the Great Recession
  - Detailed information on earnings, income, wealth and consumption
  - Although sample not large ($\simeq 8000$), PSID yields similar results as other surveys (CPS, SCF) along comparable dimensions
- Minuses
  - Coarse time series dimension (biannual surveys between 2004 and 2010)
  - Misses the super wealthy

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, non durables and services (excluding health)
- Sample
  - All households in PSID waves 2004-2006-2008-2010, with at least one member age 22-60

Aggregates in PSID (Full sample)





2004: PSID \$21634, BEA \$24120

2004/2005: PSID \$15084, BEA \$18705

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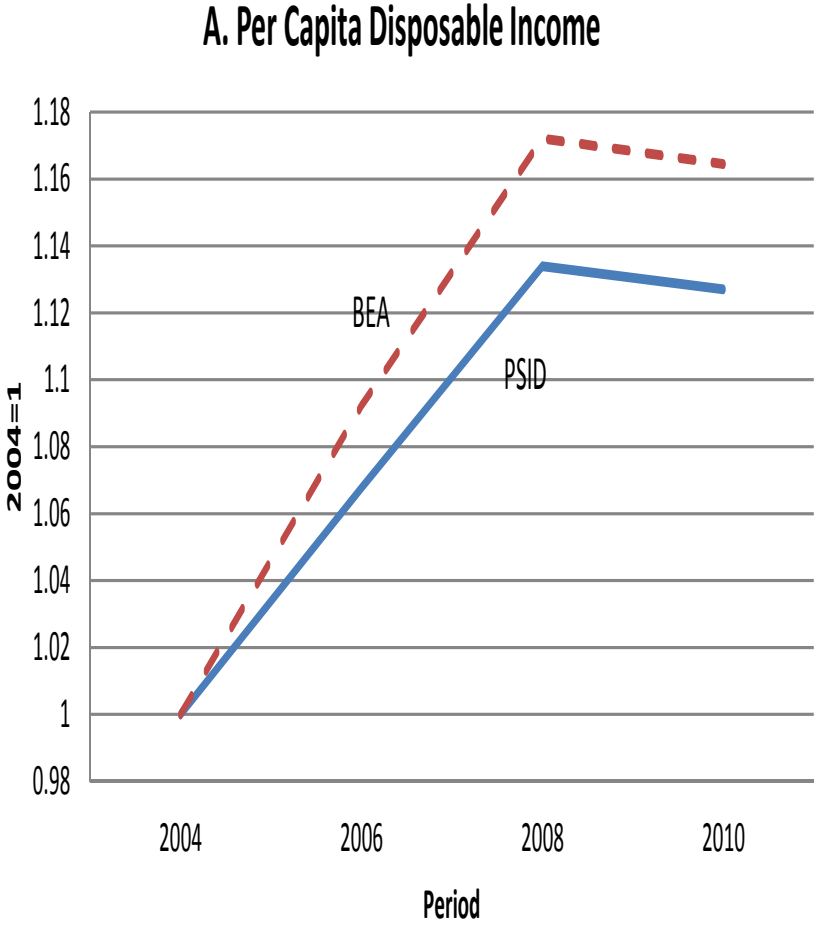

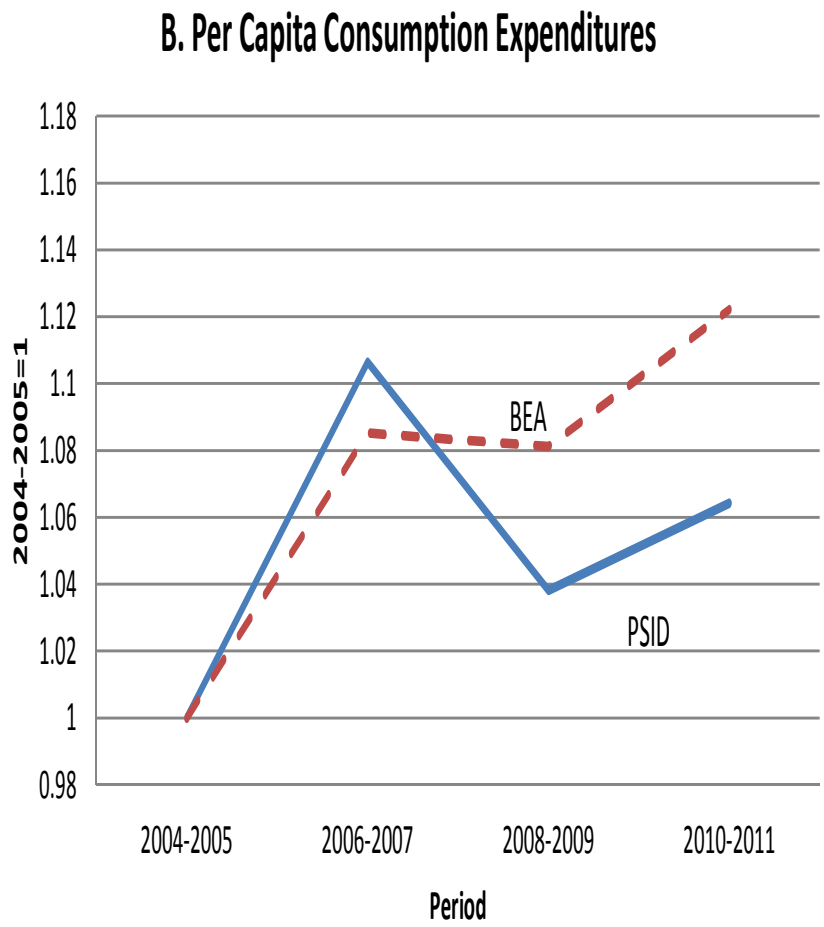

2004: PSID \$21634, BEA \$24120 2004/2005: PSID \$15084, BEA \$18705

- Great Recession evident in PSID
- Expenditures fall more, recover less in PSID than in BEA

Heterogeneity (Inequality) in 2006: Marginal Distributions

	y	c	a	a (SCF 07)
Mean (2006$)	62,549	43,980	291,616	497,747
$\%Share: Q1$	4.3	5.7	-1.2	-0.3
$Q2$	9.7	10.7	0.7	0.9
$Q3$	15.1	15.6	4.1	4.2
$Q4$	22.9	22.5	13.3	11.8
$Q5$	48.0	45.5	83.1	83.4
$90-95$	10.8	10.4	14.0	11.1
$95-99$	13.1	11.4	23.2	25.6
Top 1%	7.8	8.0	30.2	34.1
Sample Size	6442			14725

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

Heterogeneity (Inequality) in 2006: Joint Distributions

a Quint.	% Share of: y	% Share of: c	Expend. Rate (%)	Age	Edu
$Q1$	8.6	11.3	92.2	37.1	12.2
$Q2$	10.7	12.4	81.3	38.6	12.0
$Q3$	16.6	16.8	70.9	41	12.3
$Q4$	22.6	22.4	69.6	45.4	12.7
$Q5$	41.4	37.2	63.1	47.9	13.9

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

Pre v/s Post Recession dynamics in a,y,c/y across a

	Δ a		Δ y (%)		Δ c/y (pp)	
	04-06	06-10	04-06	06-10	04-06	06-10
$Q1$	27k($+\infty$)	12k($+\infty$)	14.3	12.3	-1.4	-8.8
$Q2$	40k(140%)	7k(35%)	13.8	9.1	-1.5	-4.2
$Q3$	40k(50%)	7k(9%)	9.4	3.9	6.3	-1.5
$Q4$	60k(28%)	8k(4%)	10.8	3.3	-1.3	-4.1
$Q5$	266k(21%)	-119k(-11%)	3.4	-2.3	1.4	-3.2

- Pre-Recession (04-06): uniform a,y growth, faster at the bottom (mean reversion)
- Post Recession (06-10):
  - Uniform slowdown in a,y growth, more marked at the top
  - Uniform fall in expend. rates, more marked at the bottom

Decomposing the fall in expenditures

$$
\begin{aligned}
C_i &= Y_i \rho_i \\
\frac{\Delta C_i}{C_i} &= \underbrace{\rho_i \frac{\Delta Y_i}{C_i}}_{\text{HTM}} + \underbrace{Y_i \frac{\Delta \rho_i}{C_i}}_{\text{CER}}
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	2004-2006			2006-2010		
	$\frac{\Delta C_i}{C_i}$	$\rho_i \frac{\Delta Y_i}{C_i}$	$Y_i \frac{\Delta \rho_i}{C_i}$	$\frac{\Delta C_i}{C_i}$	$\rho_i \frac{\Delta Y_i}{C_i}$	$Y_i \frac{\Delta \rho_i}{C_i}$
Q1 (bottom)	6.8	7.7	-1.0	1.0	7.4	-6.4
Q5 (top)	3.1	1.7	1.3	-3.7	-1.1	-2.6

- Slowdown in expenditures similar ($\simeq 6\%$) for Q5 and Q1
-
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- Slowdown in expenditures similar ($\simeq 6\%$) for Q5 and Q1
- For Q5 both HTM and CER terms important
- For Q1 almost all driven by CER. Points to precautionary reasons as important to explain GR expenditure drops (not a simple HtM story)

Moving to the theory

- Is a standard macro model with heterogeneous agents a la Krusell and Smith (1998) consistent with these facts?
- Use model as laboratory for *quantifying*:
  - How does the wealth distribution affect C, I, Y responses to Great Recession, and how this impact is shaped by social insurance policies
  - Welfare losses of aggregate and idiosyncratic shocks across the wealth distribution

The Model and Calibration

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

- Measure 1 of households
- Period utility function $u(c) = \log(c)$
- Follow Carroll et al. (2014):
  - Households draw discount factor β at birth from $U[\bar{\beta} - \epsilon, \bar{\beta} + \epsilon]$
  - Choose $\bar{\beta}, \epsilon$ to match $K/Y = 10.26$, Wealth Gini=0.82
  - $(\bar{\beta} = 0.9835, \epsilon = 0.0104)$
- Working life is 40 years, constant quarterly death probability $\theta = 1 - 1/160$

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 AR(1) from annual PSID data (1967-1996) only not-unemployed households: quarterly process with $(\hat{\phi}, \hat{\sigma}_y^2) = (0.95, 0.04)$. (Discretized via Rouwenhorst method)
- $a \in A$ asset holdings
- No borrowing, perfect annuity markets
- Households born with 0 assets, and $y = \min Y$

Cross-sectional distribution: $\Phi(y, s, a, \beta)$

Aggregate state of economy summarized by: (Z, Φ)

Government Policy

- Balanced budget unemployment insurance system
  - Replacement rate $\rho = \frac{b(y,Z,\Phi)}{w(Z,\Phi)y}$ if $s = u$
  - Proportional labor income tax $\tau(Z, \Phi)$
  - Baseline $\rho = 0.5$ Substantial Replacement

Fraction unemployed, $\Pi_Z(u)$, and thus tax rate τ only depends on the current aggregate state Z and replacement rate ρ:

$$\tau(Z, \Phi; \rho) = \left(\frac{\Pi_Z(u)\rho}{1 - \Pi_Z(u) + \Pi_Z(u)\rho} \right) = \left(\frac{1}{1 + \frac{1-\Pi_Z(u)}{\Pi_Z(u)\rho}} \right) = \tau(Z; \rho)$$

Recursive Formulation of HH Problem

$$
\begin{aligned}
v(x; Z, \Phi) &= \max_{c, a' \geq 0} u(c) + \theta\beta \mathbb{E}_{s', y', Z' | y, Z}[v(x'; Z', \Phi')] \\
&\quad \text{subj. to} \\
c + a' &= (1 - \tau(Z; \rho)) w(Z, \Phi) y \left[1 - (1 - \rho) 1_{s=u}\right] + \frac{(1 + r(Z, \Phi) - \delta) a}{\theta} \\
\Phi' &= H(Z, \Phi', Z') \\
x &= (y, s, a, \beta)
\end{aligned}
$$

Equilibrium concept: ▸ Recursive Competitive Equilibrium

Calibration of Aggregate Productivity Risk

The expected duration of a recession is:

$$EL_l = 1 \times 1 - \rho_l + 2 \times \rho_l (1 - \rho_l) + ... = \frac{1}{1 - \rho_l}$$

This suggests the following calibration strategy:

1. Choose ρ_l to match the average length of a severe recession EL_l. This is a measure of the persistence of recessions.

2. Given ρ_l choose ρ_h to match the fraction of time the economy is in a severe recession, Π_l.

3. Choose $\frac{Z_l}{Z_h}$ to match the decline in GDP per capita in *severe* recessions relative to normal times

What is a Severe Recession?

- We define a severe recession to start when $u \geq 9\%$ and to last 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:

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

- We target average output drop in severe recessions: $\frac{Y_l}{Y_h} = 0.9298$. This requires setting $\frac{Z_l}{Z_h} = 0.9614$.

Idiosyncratic Employment status Transitions

Transition matrices $\pi(s'|s, Z', Z)$ for employment status $s \in \{u, e\}$, are uniquely pinned down by the quarterly job finding rates (computed from CPS)

- 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: $Z = Z_h . Z' = Z_h$

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

- Economy slips into recession: $Z = Z_h . Z' = Z_l$

$$\begin{pmatrix} 0.34 & 0.66 \\ 0.07 & 0.93 \end{pmatrix}$$

- Economy emerges from recession: $Z = Z_l . Z' = Z_h$

$$\begin{pmatrix} 0.22 & 0.78 \\ 0.04 & 0.96 \end{pmatrix}$$

Results

Versions of the model

- For today we focus on:
  1. Standard Krusell and Smith economy (single discount factor + income risk + low ρ)
  2. 1. + Heterogenous β's + high ρ + $\theta > 0$ [Benchmark]
  3. 2. + Demand externality
- Endogenous labor suppy (and/or demand) is next avenue to explore

Wealth Inequality: data v/s model

New Worth	Data		Models	
% Share held by:	PSID, 06	SCF, 07	Bench	KS
$Q1$	-1.2	-0.3	0.3	7.2
$Q2$	0.7	0.9	0.5	12.0
$Q3$	4.1	4.2	3.0	16.8
$Q4$	13.3	11.8	11.6	23,6
$Q5$	83.1	83.4	84.9	40.3
$90-95$	14	11.1	15.9	10.1
$95-99$	23.2	25.6	28.9	10.4
$T1\%$	30.2	34.1	24.5	3.7

- Benchmark economy does a good job matching bottom and top of wealth distribution, misses very top
- Original KS economy misses inequality at top and bottom

Joint Distributions (2006): data v/s model

	% Share of:					
	y		c		% c/y	
a Quintile	Data	Model	Data	Model	Data	Model
$Q1$	8.6	7.5	11.3	7.5	92.2	100.1
$Q2$	10.7	13.6	12.4	13.5	81.3	98.9
$Q3$	16.6	19.1	16.8	18.6	70.9	97.1
$Q4$	22.6	24.6	22.4	23.8	69.6	96.4
$Q5$	41.4	35.2	37.2	36.7	63.1	104.3

- Model captures that bottom 40% has almost no wealth but significant consumption share
- But understates income and overstates consumption rates of the rich

Pre v/s Post Recession dynamics in $a, y, c/y$ across a: Data v/s Model

	Δa(%)		Δy(%)		Δc/y(pp)	
	2004-06	2006-10	2004-06	2006-10	2004-06	2006-10
			DATA			
$Q1$	$+\infty$	$+\infty$	14	12	-1.4	-8.8
$Q3$	50	9	9	4	6.3	-1.5
$Q5$	21	-11	3	-2	1.4	-3.2
			MODEL			
$Q1$	471	309	43	30	-5.7	-6.1
$Q3$	22	10	3	-5	-2.5	0.5
$Q5$	3	1	-5	-15	4.8	14.3

- Too small changes in a at the top (no price movements)
- Overall increase in c/y (as opposed to decline in the data), but captures differential change in c/y across a distrib.
- Too much y growth for poor and too little for rich (too much mean reversion)

Model Overall assessment

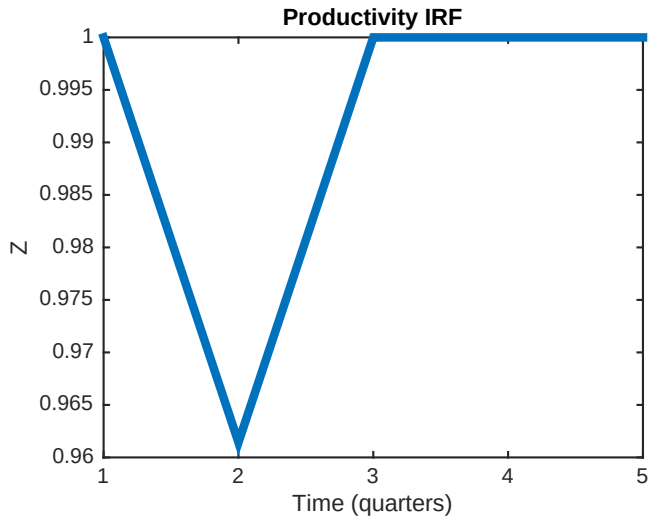
- Successes
  - Captures salient features of cross-sectional wealth distribution and the joint distribution of wealth, income and expenditures.
  - Captures that low-wealth households cut their expenditure to a larger degree during a recession.
- Problems
  - In the model the only difference between wealthy and poor is luck. The data suggest additional differences. Wealthy have lower expenditure rates, have higher income level and growth.
  - No movement in wealth due to prices

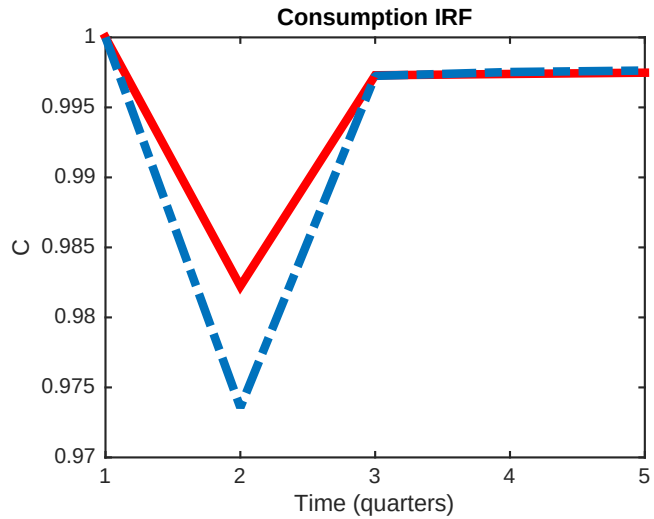
Inequality and the Aggregate Dynamics of a Severe Crisis

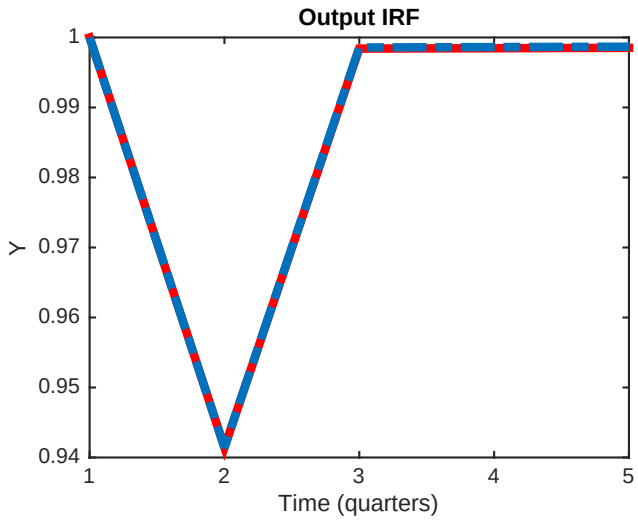
In order to understand how wealth inequality matters for C, I, Y dynamics, we compare:

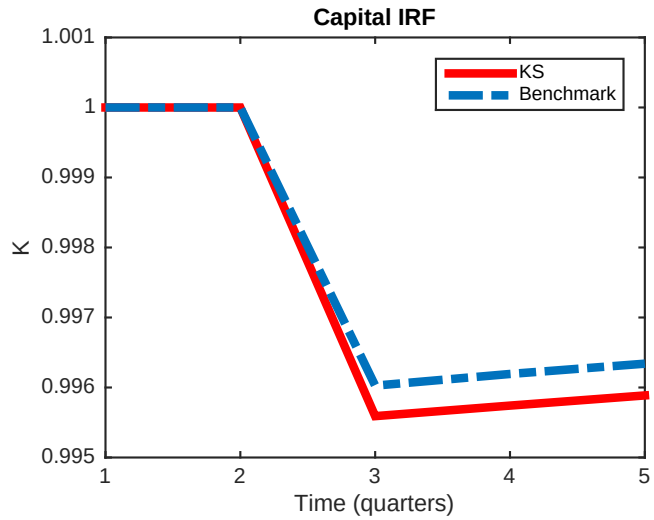
- KS economy, with low wealth inequality (behaves $\approx$ as RA economy)
- The calibrated heterogenous β (baseline) economy
- Note: calibration insures both economies have same wealth (capital) to output ratio

IRF, 2 Economies: One period shock





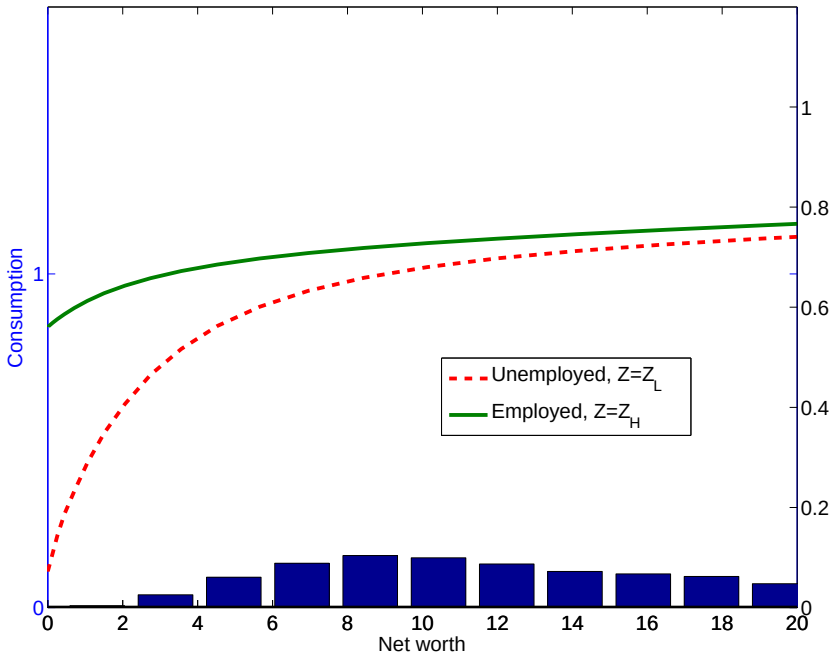




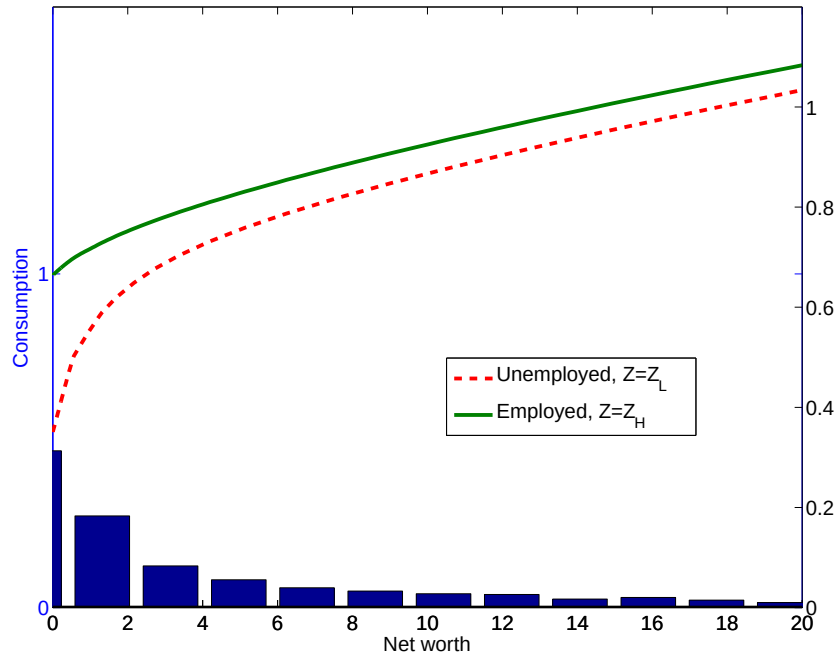
Consumption drop: KS -1.78% vs Baseline -2.64%

Consumption Functions & Wealth Distribution

KS



Het β



- KS $\simeq$ RA ($\rho = 0.1$) has more concave consumption function, but little mass close to zero (no impatient hholds)
- Benchmark ($\rho = 0.5$) less concave but mass of low β hholds end up with zero wealth

Summary

- On impact, realistic heterogeneity in wealth generates an additional aggregate consumption drop of 0.86pp (2.64% vs 1.78%)
- Sharper reduction in aggregate consumption leads to a faster recovery (because of investment)
- But: effect on GDP is small (I is small part of K and Z, L exogenous)

The Impact of Social Insurance Policies

- How does presence of unemployment insurance (UI) affect the response of economy to aggregate shock?
- Two experiments:
  - Benchmark economy: $\rho = 0.5$ v/s $\rho = 0.1$ (different wealth distribution)
  - Run Benchmark economy: $\rho = 0.5$, hit the economy with recession and $\rho = 0.1$ (fixed wealth distribution)

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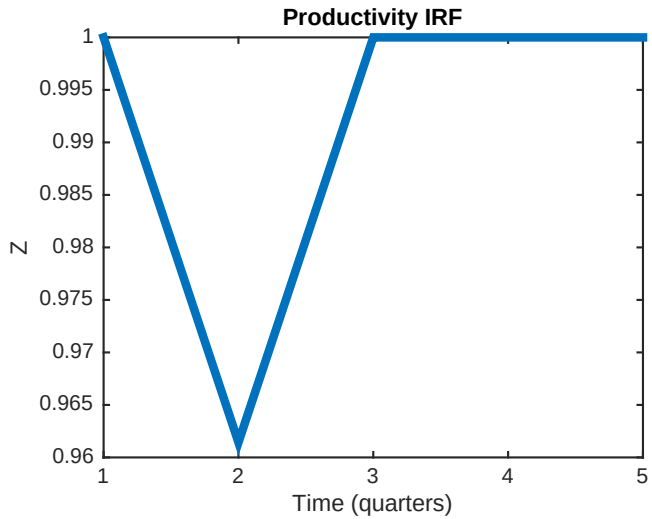
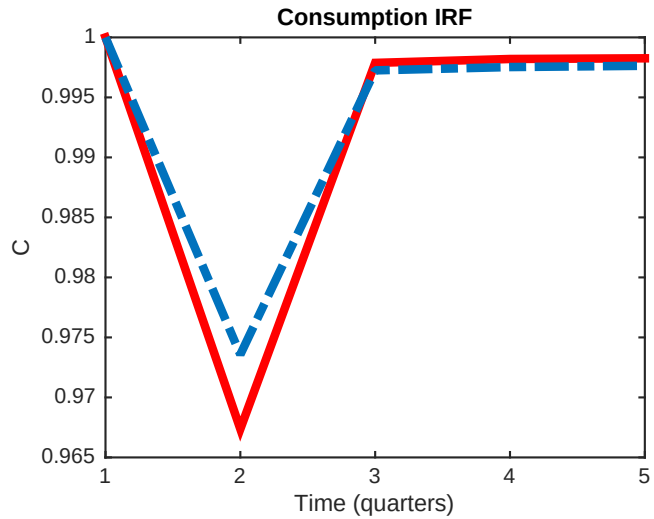
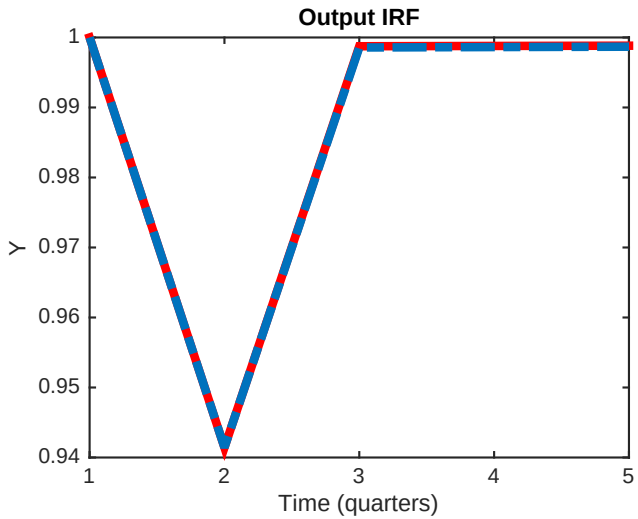
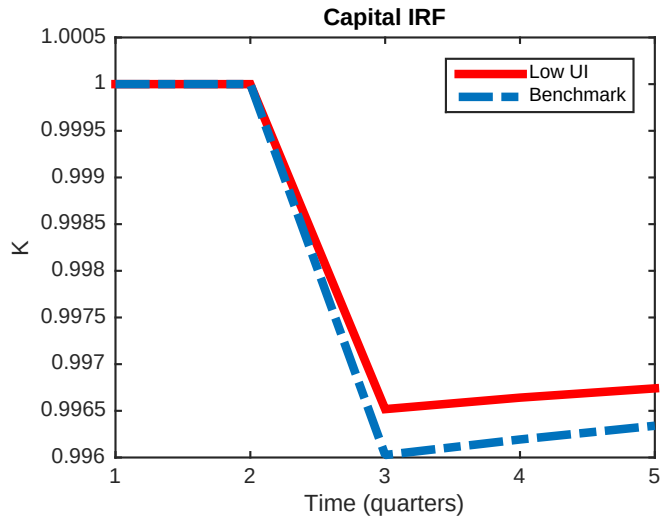
  - Run Benchmark economy: $\rho = 0.5$, hit the economy with recession and $\rho = 0.1$ (fixed wealth distribution)
- Important caveats:
  - UI does not impact individual/firm incentives to seek/create jobs (will address in model with endogenous labor supply)

IRF, 2 UI Economies: One Time Shock





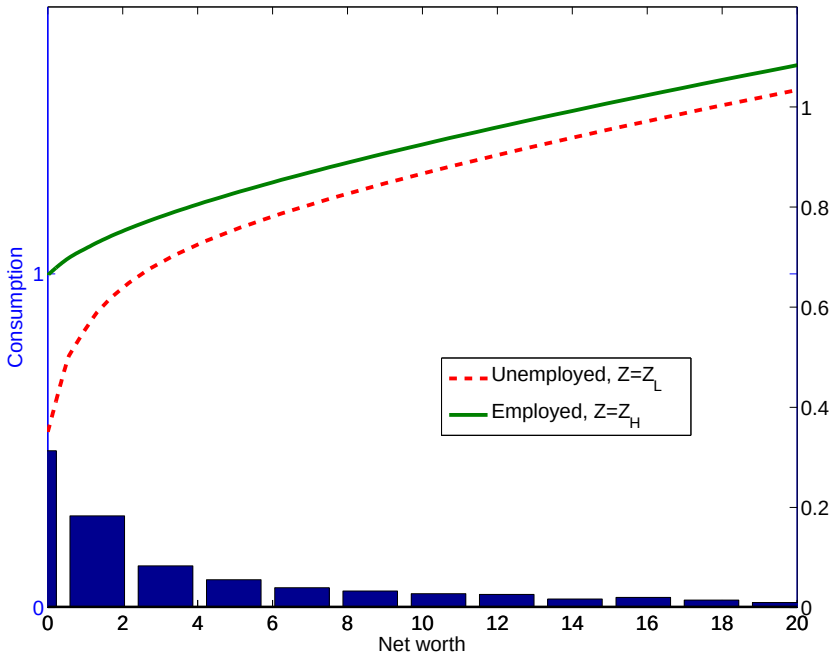




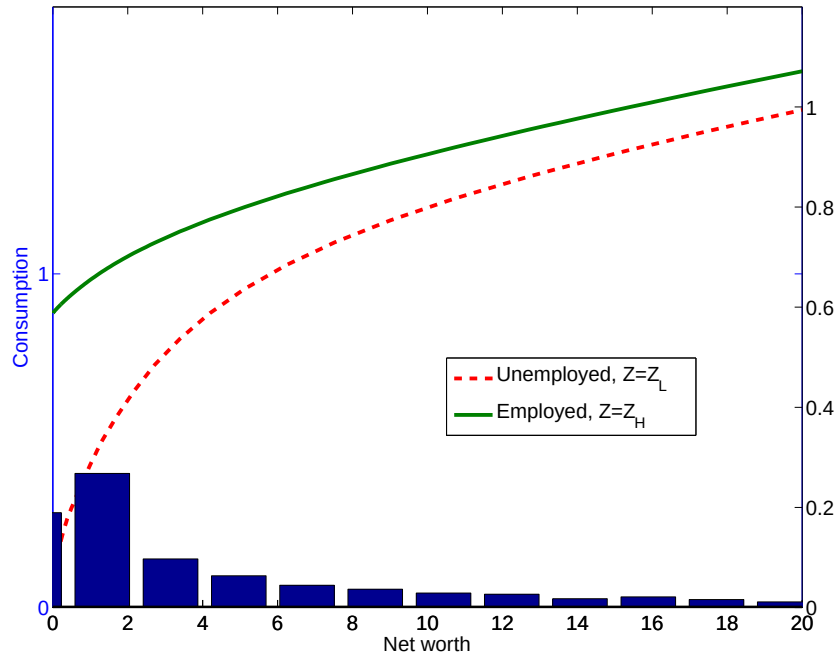
Consumption drop: Low UI -3.26% vs Baseline -2.64%

Consumption Functions & Wealth Distribution

High UI

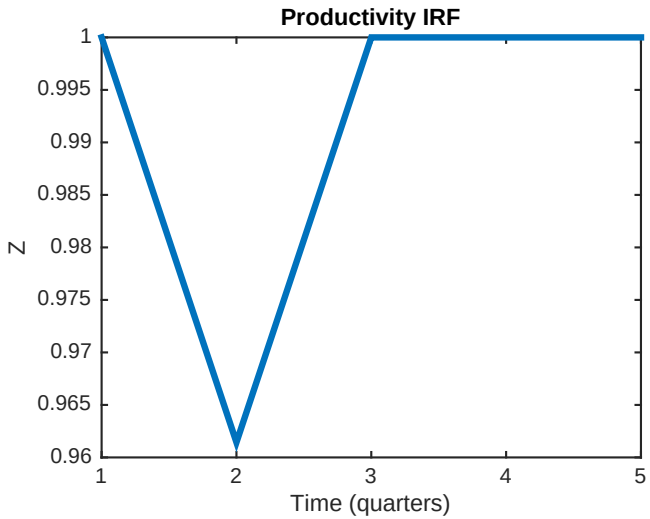


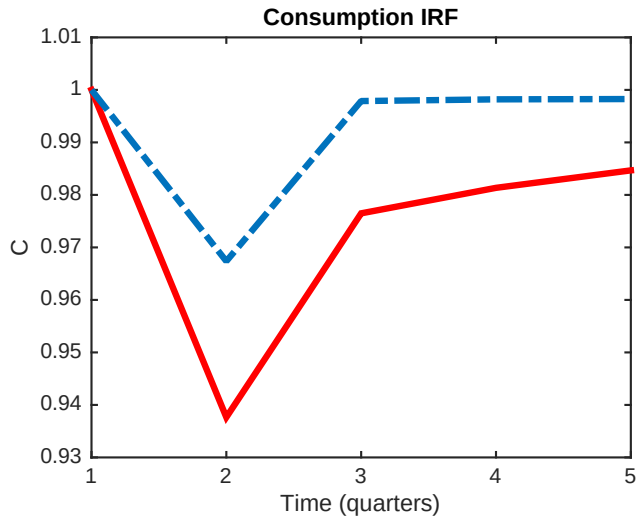
Low UI

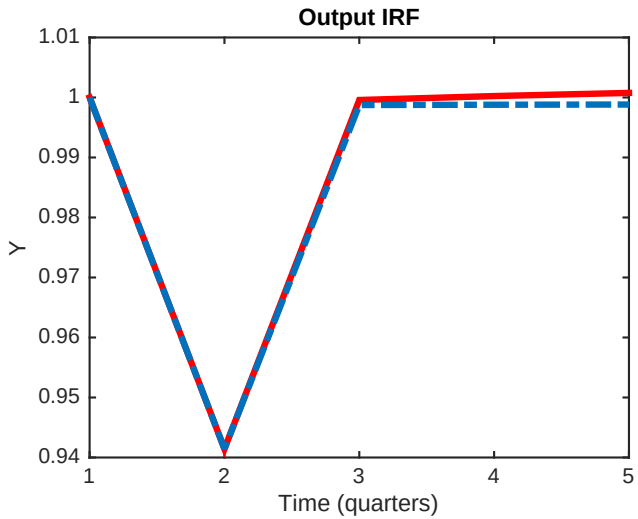


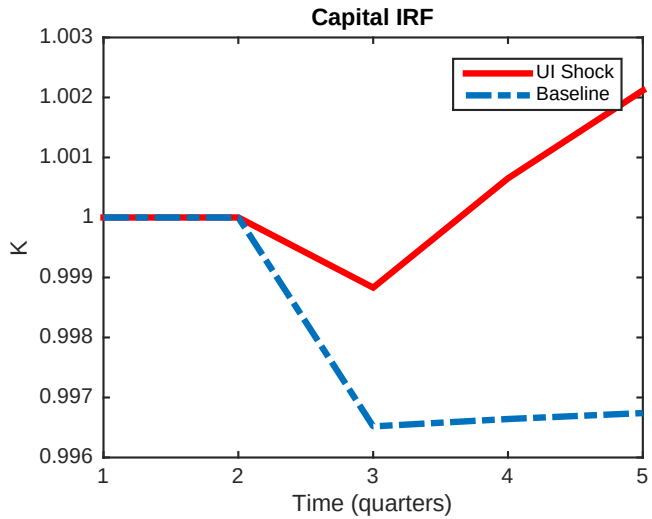
- Benchmark: 8% at zero NW, compared to 1% with low UI
- Impact of UI on aggregate consumption response muted because in its absence the wealth distribution shifts

IRF, Fixed Distribution: One Time Shock









Consumption drop: Low UI -6.24% vs Baseline -2.64%

The importance of the Distribution

- Low UI economy has two offsetting effects:
  - Consumption policy functions get steeper
  - Wealth distribution shifts to right
  - Total effect: extra 0.62pp drop in C
- For a fixed wealth distribution:
  - Unexpected drop in social insurance leads to 3.8pp additional drop in C
  - But, does not affect output in short run and in the medium run leads to an *increase* in Y because of larger K

Inequality and Aggregate Economic Activity

- So far, output has been predetermined in the short-run
- Now: Incorporate supply and demand-side elements
  - The supply side: Endogenous Labor (not today)
  - The demand side: Consumption Externality

A Model with an Aggregate Consumption Externality

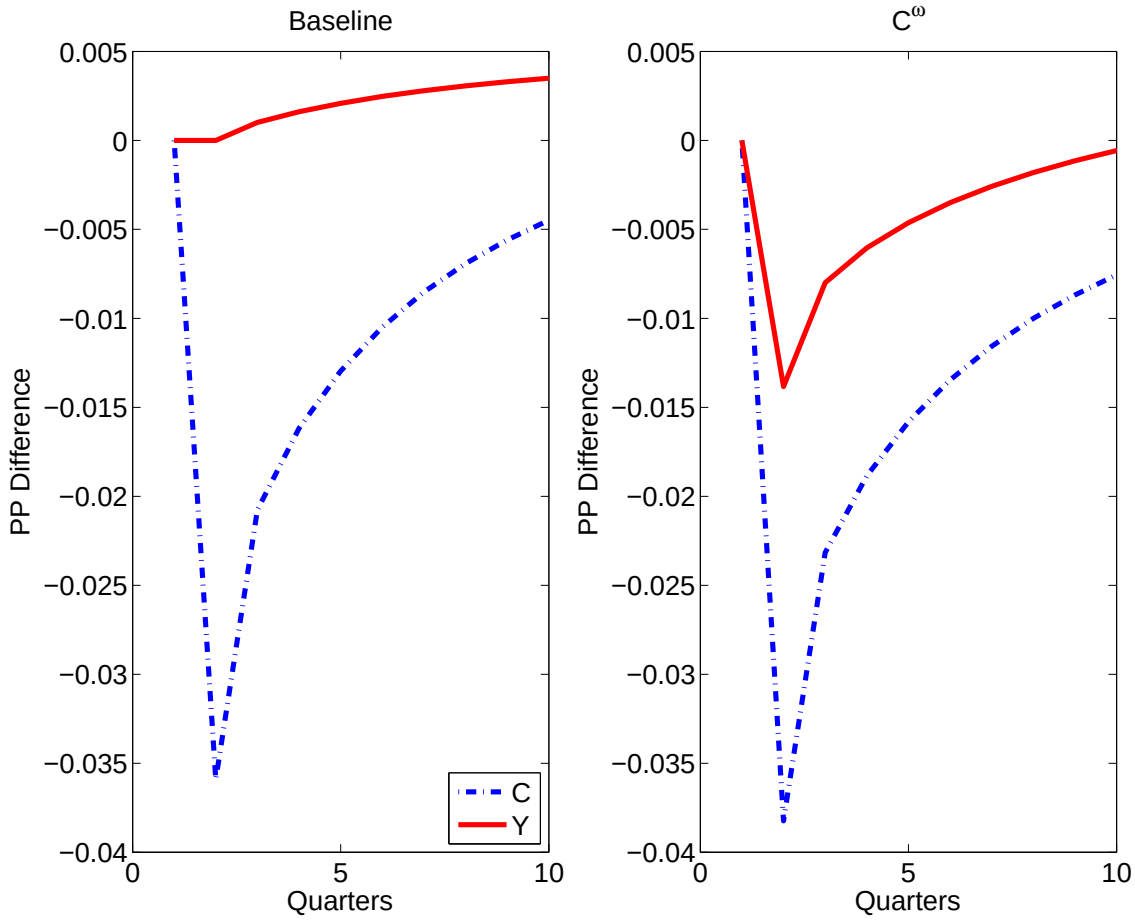
- Recall $Z^* = ZC^{\omega}$, now switch on $\omega > 0$
- Reduction in C feeds back into TFP
- "Demand management" may be called for even in absence of household heterogeneity
- Social insurance may be desirable from individual insurance *and* aggregate point of view
- Ours is a reduced form version of real aggregate demand externalities in spirit of e.g. Bai et al. (2012), Huo and Rios-Rull (2013) and Kaplan and Menzio (2014)
- Alternatively, could have introduced nominal rigidities that make output partially demand determined (see, e.g., Challe et al 2014, Gornemann et al 2013)

Thought Experiments

1. Re-calibrate Z, ω to match output volatility, so model generates reasoble business cycles

2. Repeat the low-UI with fixed distribution thought experiment. Aggregate benefits of demand stabilization through UI?

Fall in C, Y stemming from lower social insurance: Fixed Wealth Distribution



- Persistent negative effect on output of low UI in demand externality economy: social insurance can significantly impact GDP!

Conclusions: where do we stand?

- In a model that does a decent job in matching cross-sectional distributions, we find wealth inequality has significant effects on aggregate consumption dynamics (1% to 3%)
- With demand externality channel, wealth inequality can affect also GDP
- Social insurance policies can have significant effect on consumption, and on GDP

Conclusions: Moving forward

- Model's issues
  - Rich have larger consumption share than in data. Since wealth-rich households $\simeq$ PI consumers (with low precautionary motive), model likely *understates* aggregate consumption decline.
  - Model misses completely wealth dynamics due to price changes that might also play a role in understanding consumption responses
  - Employment fluctuations are exogenous
- Potential fixes:
  - Higher saving rate for rich: high income state (a la Casteneda, Dias-Gimenez and Rios-Rull (2003), long retirement
  - Financial shocks
  - Endogenous labor supply decision, nominal rigidities

Appendix Slides

Recursive Competitive Equilibrium

Definition

A recursive competitive equilibrium is given by value and policy functions of the household, v, c, k', pricing functions r, w and an aggregate law of motion H such that

1. Given the pricing functions r, w, the tax rate and the aggregate law of motion H, the value function v solves the household Bellman equation above and c, k' are the associated policy functions.
2. Factor prices are given by

$$\begin{aligned} w(Z, \Phi) &= Z F_N(K, N) \\ r(Z, \Phi) &= Z F_K(K, N) \end{aligned}$$

3. Budget balance in the unemployment system
4. Market clearing

Recursive Competitive Equilibrium

5. Law of motion: for each Borel sets $(\mathcal{S}, \mathcal{Y}, \mathcal{A}, \mathcal{B}) \in P(\mathcal{S}) \times P(\mathcal{Y}) \times B(\mathcal{A}) \times P(\mathcal{B})$

$$H(Z, \Phi, Z')(\mathcal{S}, \mathcal{Y}, \mathcal{A}, \mathcal{B}) = \int Q_{(Z,\Phi,Z')}((s, y, a, \beta), (\mathcal{S}, \mathcal{Y}, \mathcal{A}, \mathcal{B}))d\Phi$$

The Markov transition function Q itself is defined as follows. For $0 \notin \mathcal{A}$ and $y_1 \notin \mathcal{Y}$:

$$\begin{aligned} & Q_{(Z,\Phi,Z')}((s, y, a, \beta), (\mathcal{S}, \mathcal{Y}, \mathcal{A}, \mathcal{B})) \\ = & \sum_{s' \in \mathcal{S}} \sum_{y' \in \mathcal{Y}} \sum_{\beta' \in \mathcal{B}} \begin{cases} \theta\pi(s'|s, Z', Z)\pi(y'|y)\pi(\beta'|\beta) : & a'(s, y, a, \beta; Z, \Phi) \in \mathcal{A} \\ 0 & else \end{cases} \end{aligned}$$

and

$$\begin{aligned} & Q_{(Z,\Phi,Z')}((s, y, a, \beta), (\mathcal{S}, \{y_1\}, \{0\}, \mathcal{B})) = (1 - \theta) \sum_{s' \in \mathcal{S}} \Pi_Z(s') \sum_{\beta' \in \mathcal{B}} \Pi(\beta') \\ + & \sum_{s' \in \mathcal{S}} \sum_{\beta' \in \mathcal{B}} \begin{cases} \theta\pi(s'|s, Z', Z)\pi(y_1|y)\pi(\beta'|\beta) : & a'(s, y, a, \beta; Z, \Phi) = 0 \\ 0 & else \end{cases} \end{aligned}$$

◂ Return

Idiosyncratic Employment status Transitions

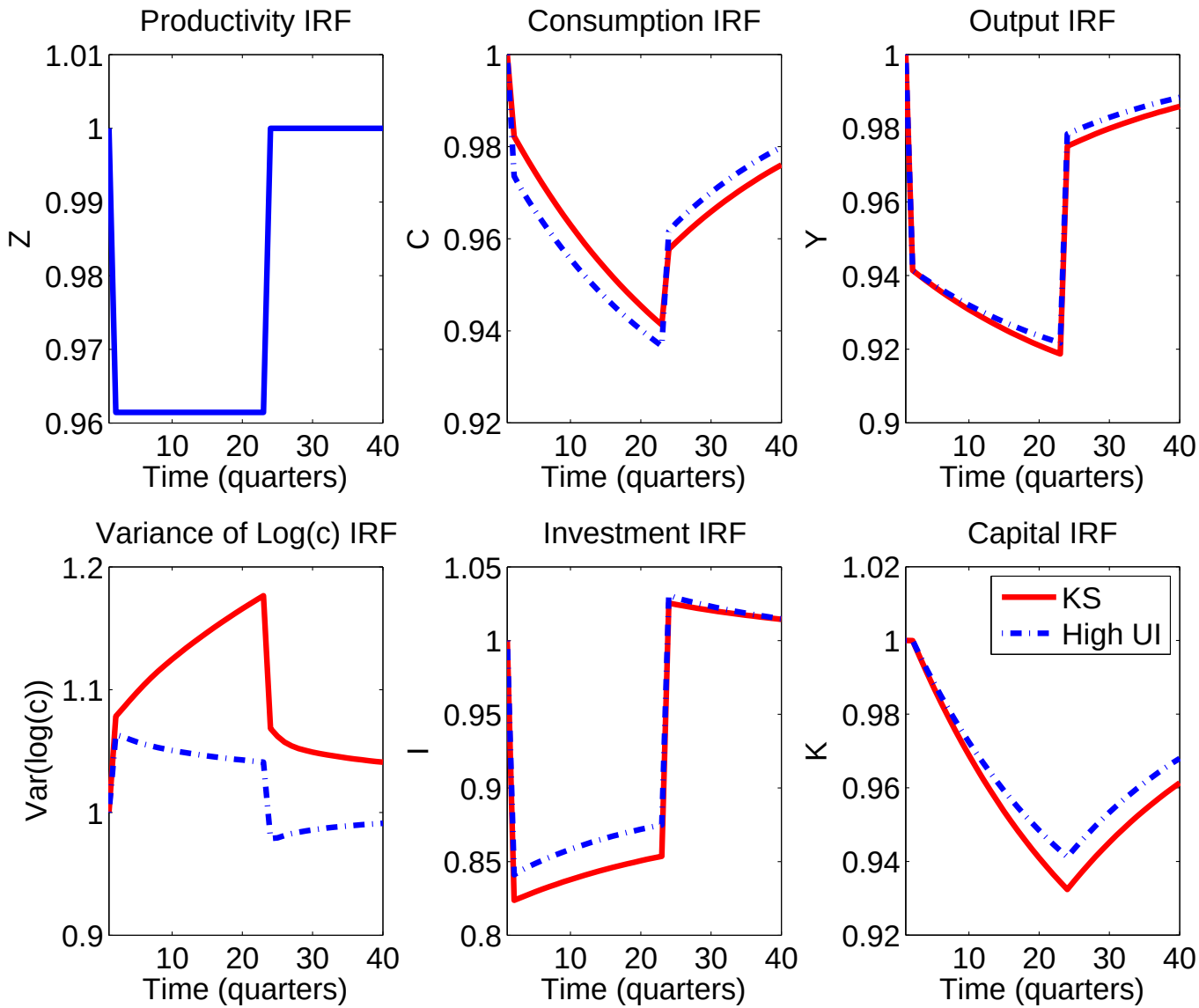
- $\pi(s'|s, Z', Z)$ has the form:

$$\begin{bmatrix} \pi_{u,u}^{Z,Z'} & \pi_{u,e}^{Z,Z'} \\ \pi_{e,u}^{Z,Z'} & \pi_{e,e}^{Z,Z'} \end{bmatrix}$$

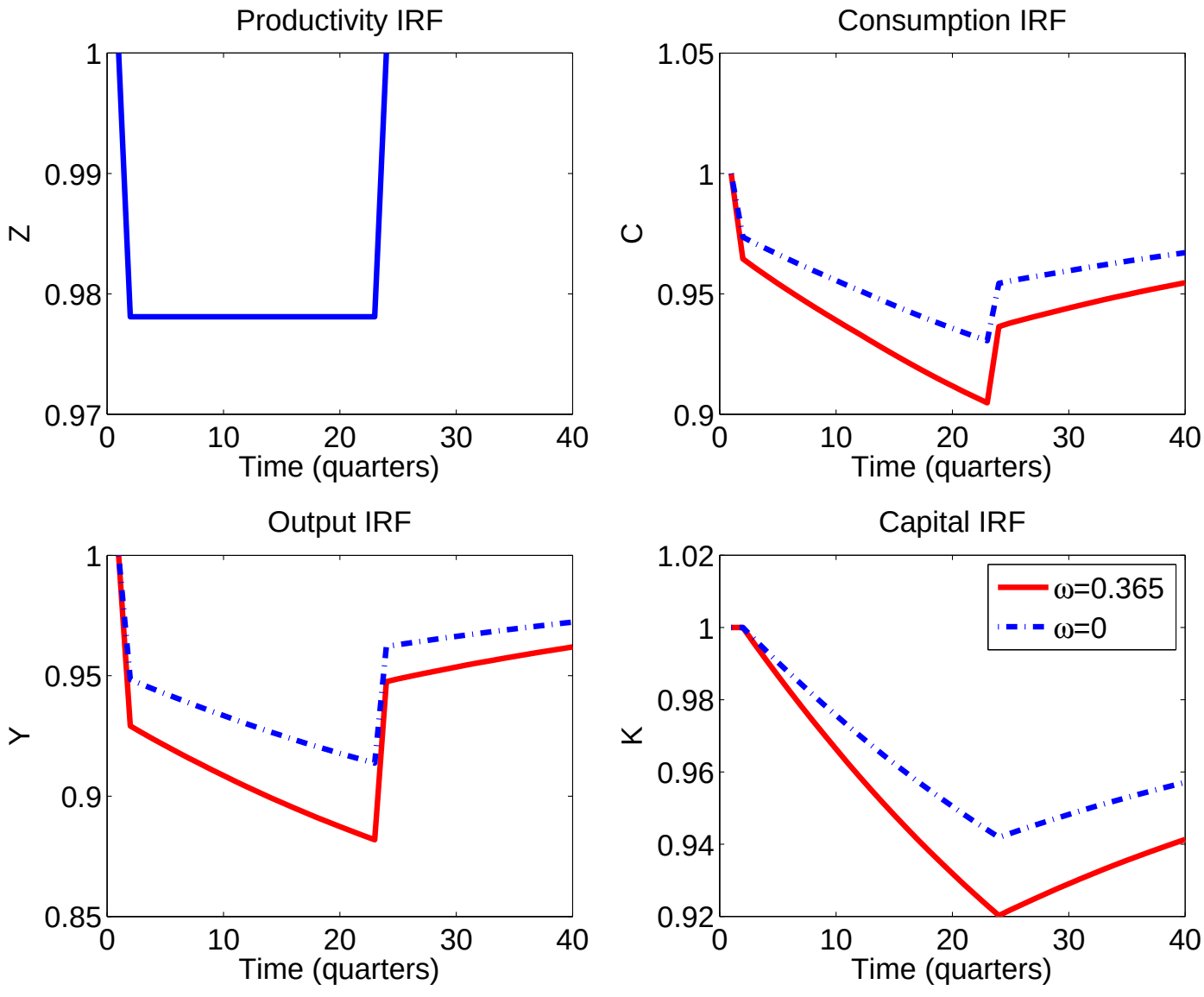
- where, e.g. ,$\pi_{e,u}^{Z,Z'}$ is the probability that unemployed individual finds a job between today and tomorrow, when aggregate productivity transits from Z to Z'.
- Targeted unemployment rates $u(Z_l), u(Z_h)$ impose joint restriction on $(\pi_{u,u}^{Z,Z'}, \pi_{e,u}^{Z,Z'})$, for each (Z, Z') pair.
- Thus transition matrices are uniquely pinned down by the quarterly job finding rates
- Compute job-finding rate (using monthly job-finding and separation rates) and correct for time aggregation

◂ Return

IRF, 2 Economies: "Typical" great recession



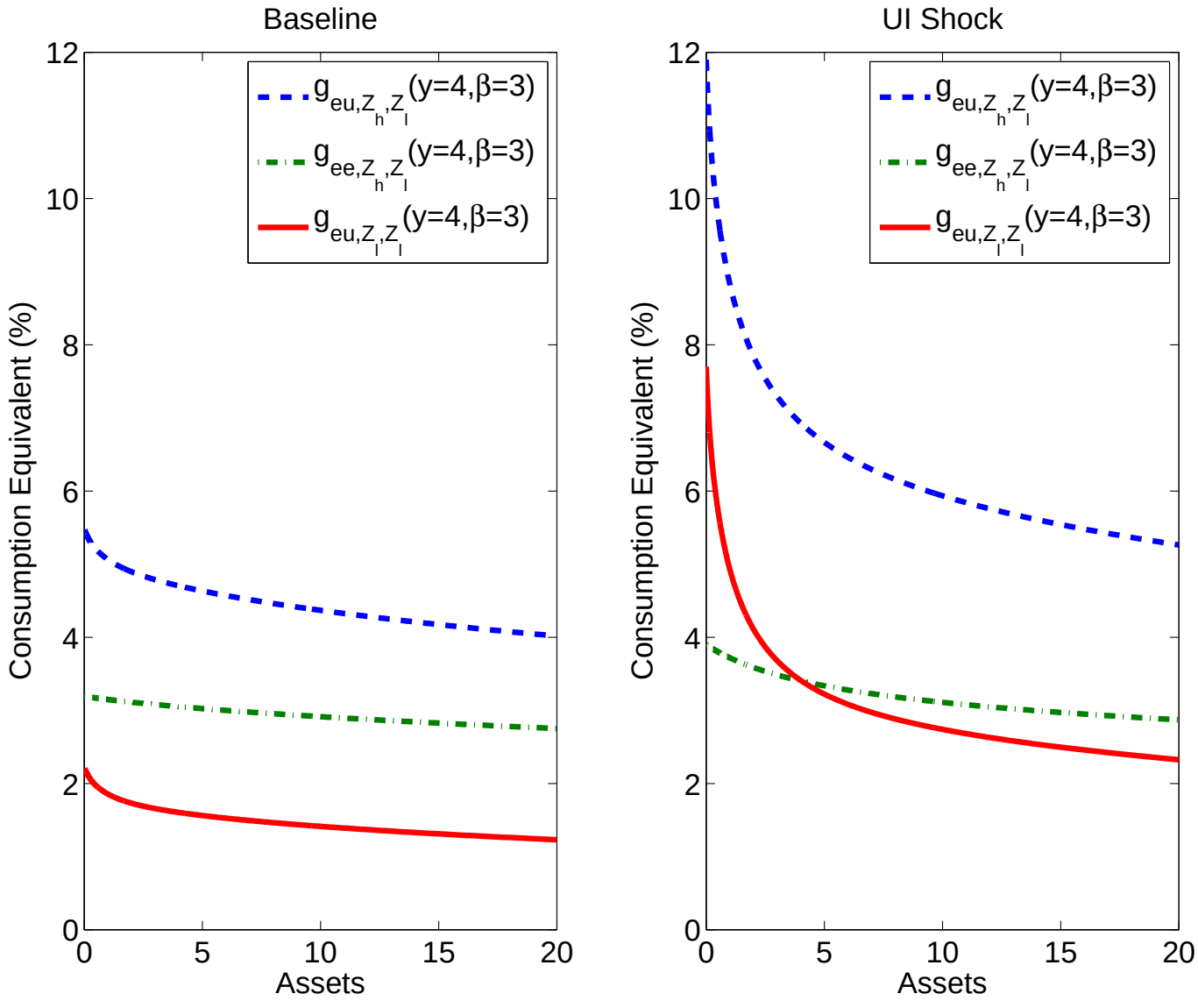
Amplification from Demand Externality



Welfare Losses of Great Recessions

- Question: how painful is it to lose your job in the great recession? And why?
- Welfare losses (% of lifetime consumption):
  - Are large (2.5%-6.5%)
  - Are strongly decreasing in wealth, especially with low UI
  - Have significant aggregate component (captures wage losses + increased future unemployment risk)
  - Get larger with consumption externality and low UI (up to 12.5%)

Welfare Losses with Demand Externality



$$g_{eu,Z_hZ_l}(y,a,\beta) \approx g_{ee,Z_hZ_l}(y,a,\beta) + g_{eu,Z_lZ_l}(y,a,\beta)$$