Household Heterogeneity in Macroeconomics

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Reference

- Krueger, Dirk, Kurt Mitman, and Fabrizio Perri. "Macroeconomics and Household Heterogeneity." In Handbook of Macroeconomics, vol. 2, pp. 843-921. Elsevier, 2016.
- Kaplan, Greg, and Giovanni L. Violante. "Microeconomic Heterogeneity and Macroeconomic Shocks." Journal of Economic Perspectives. 2018.
- Krusell, Per, and Anthony A. Smith, Jr. "Income and wealth heterogeneity in the macroeconomy." Journal of political Economy 106, no. 5 (1998): 867-896.

* *In this workshop we restrict our attention to household heterogeneity. Though we abstract from firm heterogeneity, methodological norms and challenges in computing these models are similar.*

Outline

- Household Heterogeneity in Microeconometrics and Macroeconomics
- Stylized Facts about Household Heterogeneity in the U.S
- Benchmark Model
- Calibration
- Evaluating Benchmark Model 1: Matching Moments
- Evaluating Benchmark Model 2: Impulse Response Functions
- Conclusion

Introduction: Household Heterogeneity

- From Macro to Micro:
  The distributional consequence of macroeconomic shocks.
- From Micro to Macro:
  The importance of micro heterogeneity for macroeconomic questions, such as the impact of an aggregate shock.
- Dimensions of Heterogeneity:
  income or wealth; credit constraint; patience and beliefs etc.

Introduction: Household Heterogeneity

- The path-breaking work was done by James Heckman and Daniel McFadden for a rich treatment of cross-sectional heterogeneity in microeconometrics.
  (1) Program Evaluation: Water Filter in Ghana.
- Macroeconomic Examples:
  (2) Evidence: Consumer behaviour in business cycle.
  (3) Policy:'Hand-to-Mouth' consumers and monetary stimulus.
- A next (and prevailing) generation of literature on household heterogeneity in Microeconometrics is essential heterogeneity pioneered by Heckman and Vytlacil.
  (4) Program Evaluation: Treatment effect of college education.

Stylized Facts: Household Heterogeneity before the Great Recession

Table 1: Means and Marginal Distributions in 2006

	Variable						
	Earn.	Disp Y		Cons. Exp		Net Worth	
Source	PSID	PSID	CPS	PSID	CE	PSID	SCF(2007)
Mean (2006$)	54,349	64,834	60,032	42,787	47,563	324,951	538,265
% Share by:							
$Q1$	3.6	4.5	4.4	5.6	6.5	-0.9	-0.2
$Q2$	9.9	9.9	10.5	10.7	11.4	0.8	1.2
$Q3$	15.3	15.3	15.9	15.6	16.4	4.4	4.6
$Q4$	22.7	22.8	23.1	22.4	23.3	13.0	11.9
$Q5$	48.5	47.5	46.0	45.6	42.4	82.7	82.5
$90-95$	10.9	10.8	10.1	10.3	10.2	13.7	11.1
$95-99$	13.1	12.8	12.8	11.3	11.1	22.8	25.3
Top 1%	8.0	8.0	7.2	8.2	5.1	30.9	33.5
Gini	0.43	0.42	0.40	0.40	0.36	0.77	0.78
Sample Size	6,232	6,232	54,518	6,232	4,908	6,232	2,910

Stylized Facts: Household Heterogeneity before the Great Recession

- Earnings and disposable income are quite concentrated (bottom quintile less than 5%; top quintile around 50%)
- Consumption is less unequally distributed.
- Net worth (wealth) is the most concentrated variable. (bottom two quintiles hold almost nothing; top quintile holds more than 80 % ; top 10% holds more than 70%).

Stylized Facts: Household Heterogeneity before the Great Recession (Joint Distribution)

Table 2: PSID Households across the net worth distribution: 2006

	% Share of:			% Expend. Rate		Head's	
NW Q	Earn.	Disp Y	Expend.	Earn.	Disp Y	Age	Edu (yrs)
Q1	9.8	8.7	11.3	95.1	90.0	39.2	12
Q2	12.9	11.2	12.4	79.3	76.4	40.3	12
Q3	18.0	16.7	16.8	77.5	69.8	42.3	12.4
Q4	22.3	22.1	22.4	82.3	69.6	46.2	12.7
Q5	37.0	41.2	37.2	83.0	62.5	48.8	13.9
	Correlation with net worth						
	0.26	0.42	0.20				

Stylized Facts: Household Heterogeneity before the Great Recession (Joint Distribution)

- Households with higher net worth tend to have higher earnings and higher disposable incomes.
- Households at bottom two quintiles, though basically hold no wealth, contribute to 23.7% to aggregate consumption expenditure.
- The lower the net worth, the higher the consumption rate. [1]

[1] consumption rate is measured by fraction of consumption expenditure in income.

Stylized Facts: Household Heterogeneity in the Great Recession

Table 3: Annualized Changes in Selected Variables across PSID Net Worth

	Net Worth*				Disp Y (%)		Cons. Exp.(%)		Exp. Rate (pp)	
	(1)		(2)		(3)	(4)	(5)	(6)	(7)	(8)
	04-06		06-10		04-06	06-10	04-06	06-10	04-06	06-10
All	15.7	44.6	-3.0	-10	4.1	1.2	5.6	-1.3	0.9	-1.6
NW Q										
Q1	NA	12.9	NA	6.6	7.4	6.7	7.1	0.6	-0.2	-4.2
Q2	121.9	19.5	24.4	3.7	6.7	4.1	7.2	2	0.3	-1.3
Q3	32.9	23.6	4.3	3.3	5.1	1.8	9	0	2.3	-1.1
Q4	17.0	34.7	1.7	3.8	5.0	1.7	5.9	-1.5	0.5	-2
Q5	11.6	132.2	-4.9	-68.4	1.8	-1.2	2.7	-3.5	0.5	-1.4

*The first figure is the percentage change (growth rate), the second is the change in 000's of dollars

Stylized Facts: Household Heterogeneity in the Great Recession

- The growth rate of wealth drops in all groups, most significantly in top quintiles (negative).
- Income declines in the recession hit the top wealth quintiles more than the bottom quintiles.
- Consumption drops in all groups. decomposition.
- Households at the bottom quintiles cut expenditure rates more than households in the top quintiles.
- = Saving rate increases in all groups, most significantly at the bottom.

Models: Benchmark Economy

- Aggregate productivity shock. technology
- Explicit life structure. life
- Heterogeneous discount factor. preference
- Idiosyncratic earning risks:
  (1) state-dependent unemployment risk; unemployment
  (2) idiosyncratic labor productivity shocks. productivity
- Government Policies:
  (1) Unemployment insurance; insurance
  (2) Social security program.

Models: Krusell-Smith Economy

- Aggregate productivity shock.
- No life structure.
- No preference heterogeneity.
- Idiosyncratic earning risks:
  (1) state-dependent unemployment risk;
  (2) idiosyncratic labor productivity shocks.
- Government Policies:
  (1) Less generous unemployment insurance; ($\rho = 1\%$.)
  (2) Social security program.

Calibration of the Benchmark Model

- First-Order Markov Chain:
  (1) Aggregate Productivity. aggregate
  (2) Unemployment Risk. employment
  (3) Labor Productivity Risk.
- Preference beta
- Life Cycle

Evaluating Benchmark Model: Wealth Inequality

- Facts: Empirically observed concentration with a share of wealth of the bottom 40% of close to zero.
- Results: table6
  (1) The benchmark model with het. β displays a wealth Gini coefficient in line with the micro data, especially at the bottom distribution.
  (2) Reproduce the well-known KS results that unemployment risk and incomplete market alone are incapable of generating sufficient wealth distribution: people at the top are not wealthy enough and people at the bottom are not poor enough.
- What accounts for the wealth inequality in the benchmark model?

Evaluating Benchmark Model: Wealth Inequality

Mechanism:

- highly persistent earning risk and unemployment risk: increase wealth dispersion very significantly:
  (1) A share of households with permanently low earnings $\Rightarrow$ A share of wealth close to zero.
  (2) A share of households with high earnings outcomes $\Rightarrow$ Accumulate wealth to avoid shocks in earnings.
- More explicit life-cycle structure:
  Reduce wealth concentration at the top; but important for joint wealth-consumption distribution.

Evaluating Benchmark Model: Wealth Inequality

Mechanism:

- Discount factor heterogeneity:
  Create a class of households that are patient $\Rightarrow$ High propensity to save (for two motivations: precautionary saving and for retirement) $\Rightarrow$ Guarantee wealth concentration at the top quintile
- Unemployment insurance system:
  Further reduce wealth hold by bottom households.

Evaluating Benchmark Model: Joint Distribution

Facts:

- Households with higher wealth tend to have higher earnings and higher disposable incomes. (Fact 1)
- Households at bottom two quintiles, though basically hold no wealth, contribute to 23.7% to aggregate consumption expenditure.(Fact 2)
- Lower the net worth, Higher the consumption rate. (Fact 3)

Results: table8

- Fact 1 holds. And wealth has higher correlation with disposable income than with labor earnings.
- Fact 2 holds.
- Fact 3 partially holds. Expend. rates at the top are too high.
- Wealth-poor are too consumption-poor; Wealth-rich are too consumption rich.

Evaluating Benchmark Model: Dynamics

Facts:

- The growth rate of wealth drops in all groups, most significantly in top quintiles (negative). (Fact 1)
- Income declines in the recession hit the top wealth quintiles more than the bottom quintiles. (Fact 2)
- Households at the bottom quintiles reduce expenditure rates more than households in the top quintiles.(Fact 3)

Results: table11

- Fact 1 holds.
- Fact 2 holds.
- Fact 3 doesn't hold.

Evaluating Benchmark Model: Dynamics

Mechanism: When recession hits and income declines, there are two (competing) effects:

- Households have strong incentives to use their wealth to smooth consumption, especially for the unemployed.
- Households have strong incentives to engage in precautionary savings against future unemployment spells increases.

And these two effects are heterogeneous across households

- Households with high wealth: First motive dominates $\Rightarrow$ Consumption rates increases.
- Households with low wealth: Two motives cancelled out $\Rightarrow$ Consumption rates unchanged.
- with a less generous insurance scheme, Households with low wealth: Second motive dominates $\Rightarrow$ Consumption rates drops.

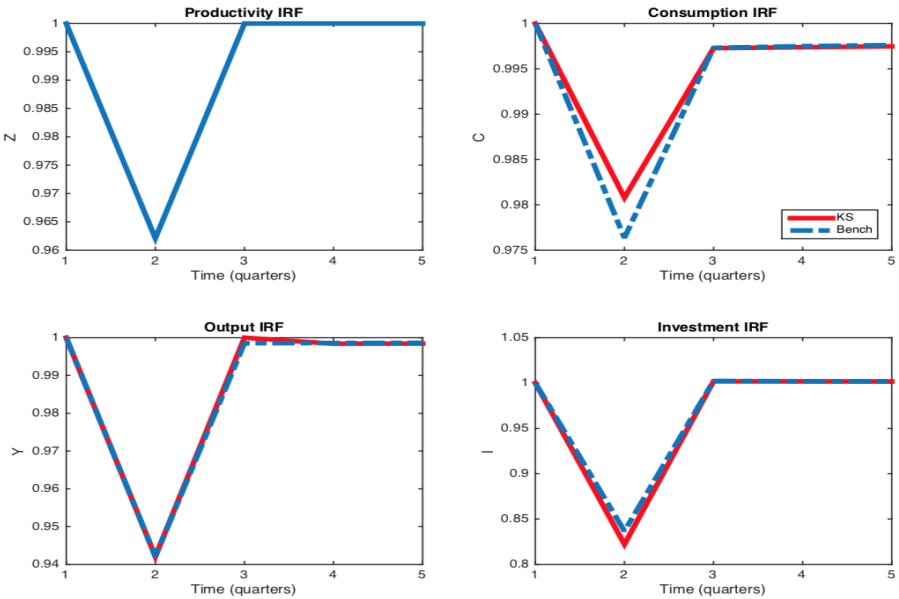
Evaluating Benchmark Model: Impulse Response Functions

In this section, we show that:

- Cross-sectional distribution of households is a crucial determinant of the aggregate consumption/ investment response to a negative business cycle shock.
- With heterogeneous agent the generosity of social insurance policies strongly affects the dynamic of macroeconomic aggregates. (skipped)
- The aggregate consumption and investment behaviour over the business cycle in KS economy approximates an economy of representative agents (RA) very well. figure3

Impulse Response Functions: One-Period Shock

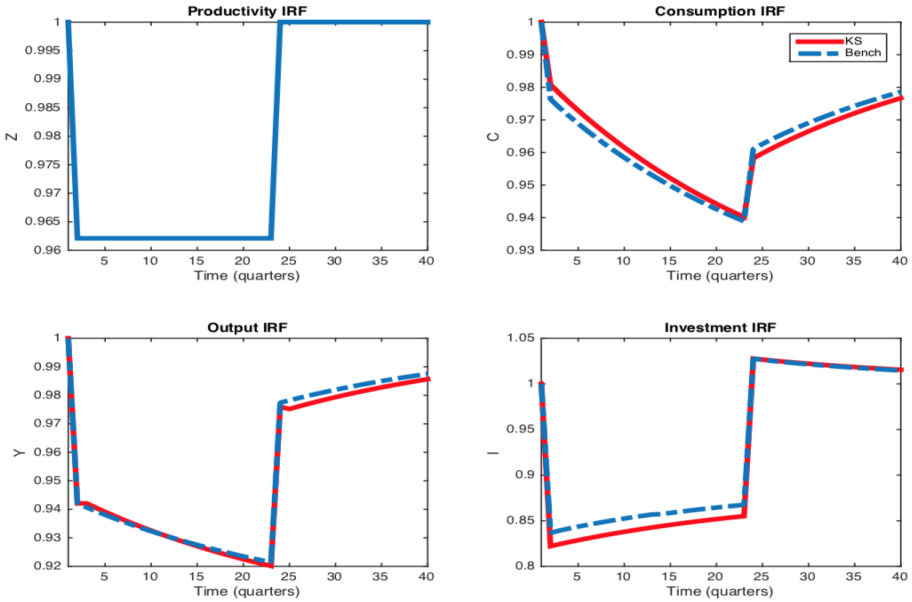
Figure 2: Impulse Response to Aggregate Technology Shock in 2 Economies: One Time Technology Shock



Aggregate consumption (and thus investment) response to the negative productivity shock differs substantially b/w the two economies.

Impulse Response Functions: Prolonged and Severe Shock

Figure 4: Impulse Response to Aggregate Technology Shock in 2 Economies: "Typical" Severe Recession Technology Shock



In prolonged recession, the differences in capital and output dynamics are now more noticeable, especially towards the end of recession.

Question: What's the mechanism for generating the differences?

Impulse Response Functions: Prolonged and Severe Shock

Mechanism:

- An equilibrium wealth distribution that makes the wealth-poor poor enough and have them cut consumption more significantly.
- These wealth-poor households comprise a significant share of aggregate consumption.

Question: What are the factors that generate the mechanism?

Impulse Response Functions: Prolonged and Severe Shock

Factors:

- We need highly persistent income shocks that generates a set of households that are born wealth-poor and never accumulate much wealth; and compounded by the presence of impatient households who do not want to do so.
- Access to the generous unemployment insurance implies less incentive to accumulate wealth for these households.
- Preference Heterogeneity not only produces impatient households with above characteristics, but also a group of patient households who find it optimal to accumulate wealth $\Rightarrow$ wealth inequality.

Discussion: "Hand-to-Mouth" and Precautionary Saving

- "Hand-to-Mouth" Economy:
  Fixed fraction of households k that always have zero wealth and consume their income in every period.
- Drop of consumption after one-period recession:
  (1) H-T-M Economy: 2%.
  (2) Benchmark Economy: 2.4%
- Implication: Even households at the bottom wealth distribution find it optimal to reduce consumption rate for precautionary reasons, since:
  (1) The recession is expected to be long;
  (2) Unemployment risks.

Discussion: RANK vs. HANK

The similarity (and difference) b/w RANK (Representative Agent New Keynesian) and HANK (Heterogeneous Agent New Keynesian) depends crucially on the shock being analyzed:

- Demand shock (from a change in discount factor):
  Hank and Rank generate similar aggregate dynamics through largely the same mechanism. demand
- Technology shock:
  Similar aggregate dynamics but through different economic mechanisms. tech
- Monetary and Fiscal policy shocks:
  The two models generate different aggregate responses that households are more sensitive to income and less sensitive to interest rates in heterogeneous agent models than in RA models. policy

Discussion: Macro Questions Demanding Heterogeneity

- Micro-foundations of a fall in aggregate demand.
  (1) RANK: Assume a shock to the discount factor;
  (2) HANK: Tight credit limits $\Rightarrow$ reduce borrowing capacity $\Rightarrow$ Constrained agents de-leverage sharply and unconstrained agents increase savings.
  (3) HANK: Precautionary savings for un-insurable labor market risk (unemployment).
- Heterogeneity in transmission mechanism.
  Demand for cross-sectional or panel data in addition to time series data.
- Impact from aggregate shocks on inequality: From 'Macro' to 'Micro'.

Appendix: Decomposition of Expenditure Growth

Table 4: Decomposing changes in expenditures growth

	Change C Growth	Change Y Growth	Change C/Y Growth
	$g_{c,t} - g_{c,t-1}$	$g_{y,t} - g_{y,t-1}$	$\frac{\rho_{it}-\rho_{it-1}}{\rho_{it-1}} - \frac{\rho_{it-1}-\rho_{it-2}}{\rho_{it-2}}$
All	-6.9	-2.9 (42%)	-3.8 (55%)
NW Q			
Q1	-6.5	-0.7 (11%)	-4.5 (69%)
Q2	-5.2	-2.6 (50%)	-2.3 (44%)
Q3	-9.0	-3.3 (37%)	-5.2 (58%)
Q4	-7.4	-3.3 (48%)	-3.8 (55%)
Q5	-6.2	-3.0 (42%)	-3.4 (55%)

recession

Appendix: Aggregate Production Technology

Aggregate production function is given as:

$$Y = ZF(K, N) \tag{1}$$

$Z \in \{Z_l, Z_h\}$: Aggregate productivity shocks.
Z_l: severe recessions;
Z_h: normal periods.

benchmark

Appendix: Explicit Life Structure

Households (j):

- W: Young and working (in the labor force)
  retire with prob. 1-θ
- R: Old and retired (out of labor force)
  die with prob. 1-ν
- D: Dead [2]

Population distribution:

$\pi_W = \frac{1-\theta}{(1-\theta)+(1-\nu)}$

$\pi_R = \frac{1-\nu}{(1-\theta)+(1-\nu)}$

benchmark

[2] This ensures a bounded wealth accumulation.

Appendix: Heterogeneous Discount Factor

1. Only consumption enters period utility function:

$$u = u(c) \tag{2}$$

2. Time discount factor β is heterogeneous across individuals (but fixed over time for the same individual). $\beta \in B$.

benchmark

Appendix: Unemployment Risks

- $s \in S = \{u, e\}$: current status of a household.
  s=u: unemployment;
  s=e: employment.
- Employment follows a first order Markov Chain with transition $\pi(s' \mid s, Z', Z)$:
  it depends on the state of the aggregate business cycle and previous unemployment status.

benchmark

Appendix: Labor Productivity Risks

- $y \in Y$: labor productivity conditional on being employed.
- Labor productivity follows a first order Markov Chain with transition $\pi(y' \mid y)$:
  it is independent of the state of the aggregate business cycle.
- We assume a law of large numbers for idiosyncratic shocks (s,y), so only aggregate risk determines the number of agent in a specific idiosyncratic state (s,y).

benchmark

Appendix: Unemployment Insurance

The government implements a balanced budget unemployment insurance system whose size is parametrized by a replacement rate:
$\rho = \frac{b(y,Z)}{w(y,Z)y}$
where b is the benefit and wy is the potential earning[3].
In our benchmark model, $\rho = 50\%$.

benchmark

[3] Recall that even unemployed households carry with them the idiosyncratic state y even though it does not affect their current labor earnings since they are unemployed.

Appendix: Calibrating First-Order Markov Chain: Technology Parameters

- Technology: $Y = ZK^{\alpha}N^{1-\alpha}$
  $\alpha = 0.36$ matches the capital share.
- Productivity: $Z \in \{Z_l, Z_h\}$.
  Transition follows First-Order Markov Chain with transition matrix $\pi = \begin{bmatrix} \rho_l & 1-\rho_l \\ 1-\rho_h & \rho_h \end{bmatrix}$
  i.e., $\rho_h = \pi(\rho_h \mid \rho_h)$.
  We need to calibrate $\{Z_l, Z_h; \rho_l, \rho_h\}$.

Appendix: Calibrating First-Order Markov Chain: Technology Parameters

- Stationary distribution:

$$\pi_l = \frac{1-\rho_h}{2-\rho_h-\rho_l}; \pi_h = \frac{1-\rho_l}{2-\rho_h-\rho_l} \tag{3}$$

- Normalization:

$$E(Z) = \pi_l Z_l + \pi_h Z_h = 1 \tag{4}$$

- Expected length of recession (conditional on falling into one):

$$EL_l = 1(1-\rho_l) + 2\rho_l(1-\rho_l) + ... = \frac{1}{1-\rho_l} \tag{5}$$

- GDP per capita in severe recessions relative to in normal times

$$\frac{Z_l}{Z_h} \tag{6}$$

Appendix: Calibrating First-Order Markov Chain: Technology Parameters

Calibration Strategy:

- Use Equation (5) to calibrate ρ_l;
- Use Equation (3) and calibrated ρ_l to calibrate ρ_h;
- Use Equation (6) to calibrate $\frac{Z_l}{Z_h}$;
- Use Equation (4) and calibrated ρ_l,ρ_h and $\frac{Z_l}{Z_h}$ to calibrate Z_l and Z_h.

calibration

Appendix: Calibrating First-Order Markov Chain: Unemployment Risks

- Unemployment Status: $s \in S = \{u, e\}$ with transition matrix depending on aggregate business cycle, $\pi(s' \mid s; Z, Z')$.
- We calibrate transition matrix in all four states: $\{Z_l, Z_h\} \times \{Z_l, Z_h\}$.
  For example, we calibrate in the state from $Z = Z_h$ to $Z' = Z_l$, from $Z = Z_h$ to $Z' = Z_h$, from $Z = Z_l$ to $Z' = Z_h$, from $Z = Z_l$ to $Z' = Z_l$ respectively.
- For each of the four states, we calibrate: $\begin{bmatrix} \pi_{e,e} & \pi_{e,u} \\ \pi_{u,e} & \pi_{u,u} \end{bmatrix}$

calibration

Appendix: Calibrating Discount Factor and Life Cycle

- We assume at the beginning households draw their β from a uniform distribution $[\bar{\beta} - \varepsilon, \bar{\beta} + \varepsilon]$.
  In practice the authors assume households draw their β from five values in $[\bar{\beta} - \varepsilon, \bar{\beta} + \varepsilon]$.
  Calibrate $\{\bar{\beta}, \varepsilon\}$ by matching a Gini Coefficient (of 77%) and a quarterly wealth-to-output ratio (of 10.26) in the data.
- Prob. of retirement $(1 - \theta)$: match the expected work life of 40 years.
- Prob. of death $(1 - \nu)$: match the length of retirement phase of 15 years in expectation.

calibration

Appendix: Table 6

Table 6: Net Worth Distributions: Data v/s Models

	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

inequality

Appendix: Table 8

Table 8: Selected Variables by Net Worth: Data v/s Models

	% Share of:						% Expend. Rate			
	Earnings		Disp Y		Expend.		Earnings		Disp Y	
NW Q	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod
Q1	9.8	6.5	8.7	6.0	11.3	6.6	95.1	96.5	90.0	90.4
Q2	12.9	11.8	11.2	10.5	12.4	11.3	79.3	90.3	76.4	86.9
Q3	18.0	18.2	16.7	16.6	16.8	16.6	77.5	86.0	69.8	81.1
Q4	22.3	25.5	22.1	24.3	22.4	23.6	82.3	87.3	69.6	78.5
Q5	37.0	38.0	41.2	42.7	37.2	42.0	83.0	104.5	62.5	79.6
	Correlation with net worth									
	0.26	0.46	0.42	0.67	0.20	0.76				

joint

Appendix: Table 11

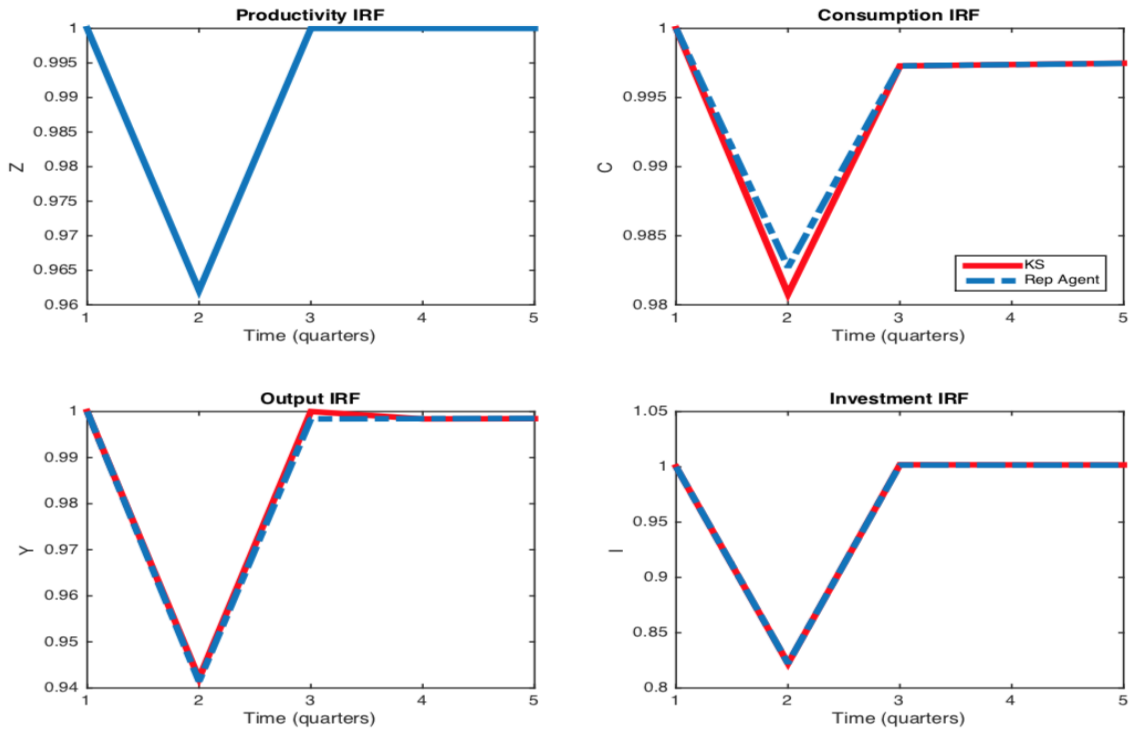
Table 11: Difference in Annualized Growth Rates between Recession Period and Normal Times: Data and Model

	Net Worth (%)		Disp Y (%)		Expend.(%)		Exp. Rate (pp)	
NW Q	Data	Model	Data	Model	Data	Model	Data	Model
Q1	*NaN*	-20	-0.7	-2.3	-6.5	-2.2	-4.0	0.0
Q2	-98	-18	-2.6	-2.8	-5.2	-2.4	-1.6	0.3
Q3	-29	-12	-3.3	-4.0	-9.0	-2.7	-3.4	1.4
Q4	-15	-5	-3.3	-4.5	-7.4	-2.8	-2.5	2.0
Q5	-17	-4	-3.0	-5.4	-6.2	-2.9	-1.9	3.2
All	-19	-4	-2.9	-4.4	-6.9	-2.6	-2.5	1.3

dynamic

Appendix: Figure 3

Figure 3: Impulse Response to Aggregate Technology Shock in Krusell-Smith and RA Economy

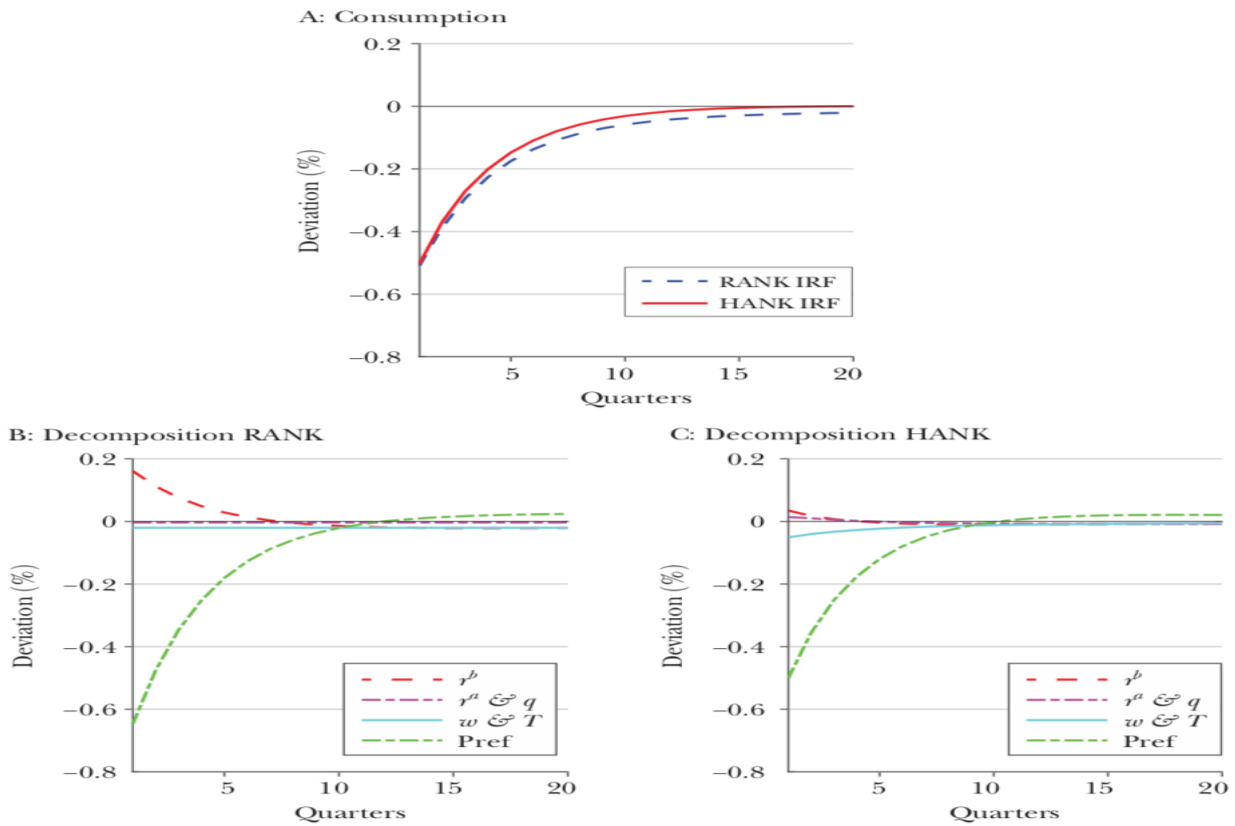


irf

Appendix: Rank vs. Hank in Demand Shock

Figure 1

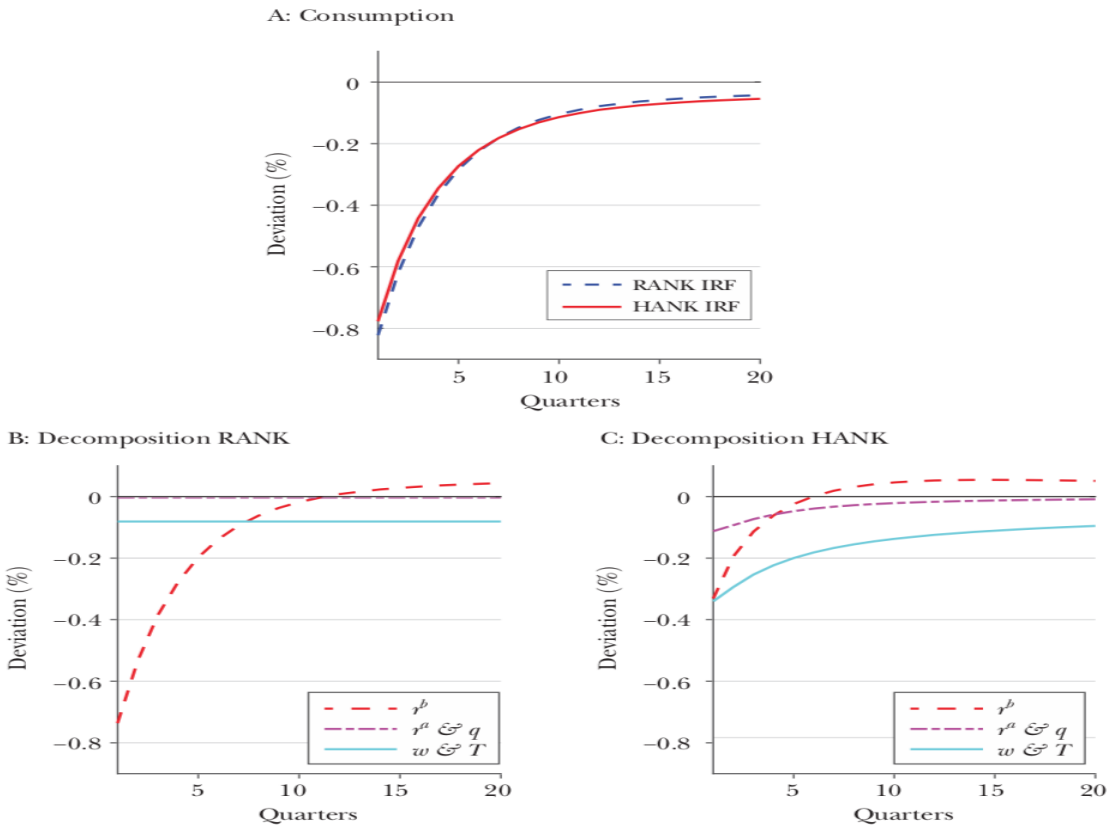
Negative Demand Shock in HANK and RANK: Impulse Response Functions (IRFs) for Consumption and their Decomposition



rank

Appendix: Rank vs. Hank in Technology Shock

Figure 2
Negative Total Factor Productivity (TFP) Shock in HANK and RANK: Impulse Response Functions (IRFs) for Consumption and their Decomposition

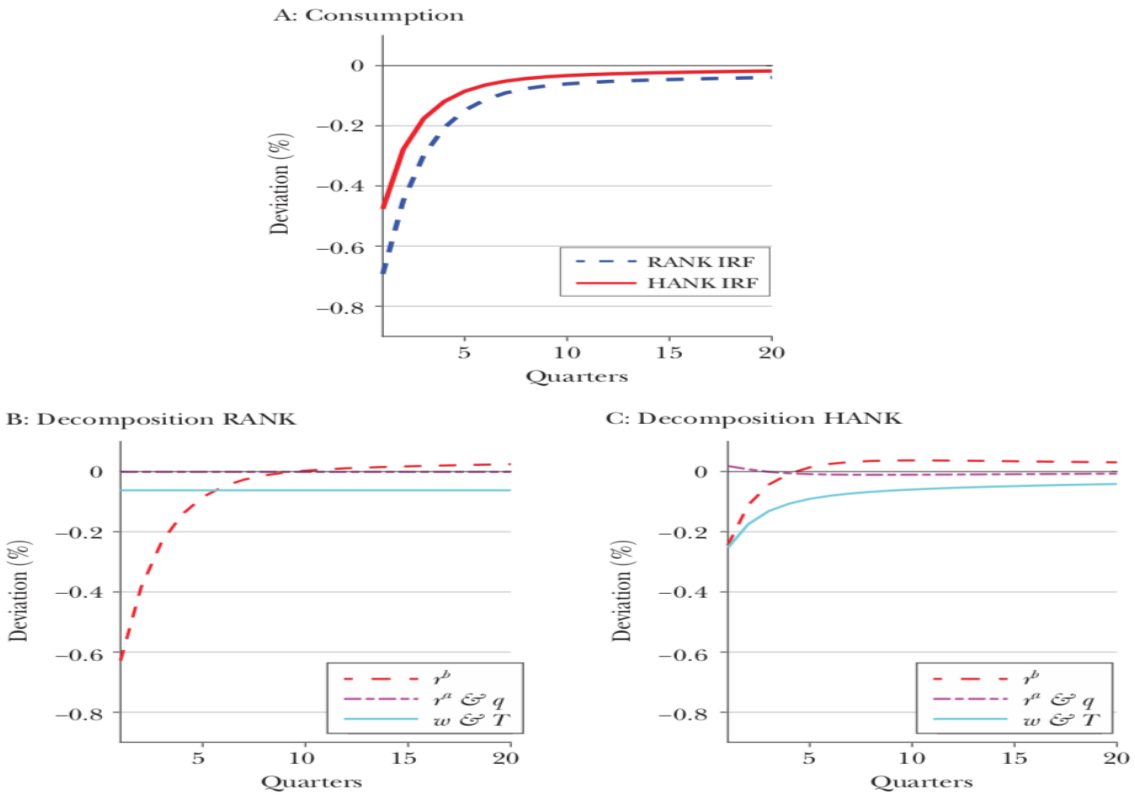


rank

Appendix: Rank vs. Hank in Monetary Shock

Figure 3

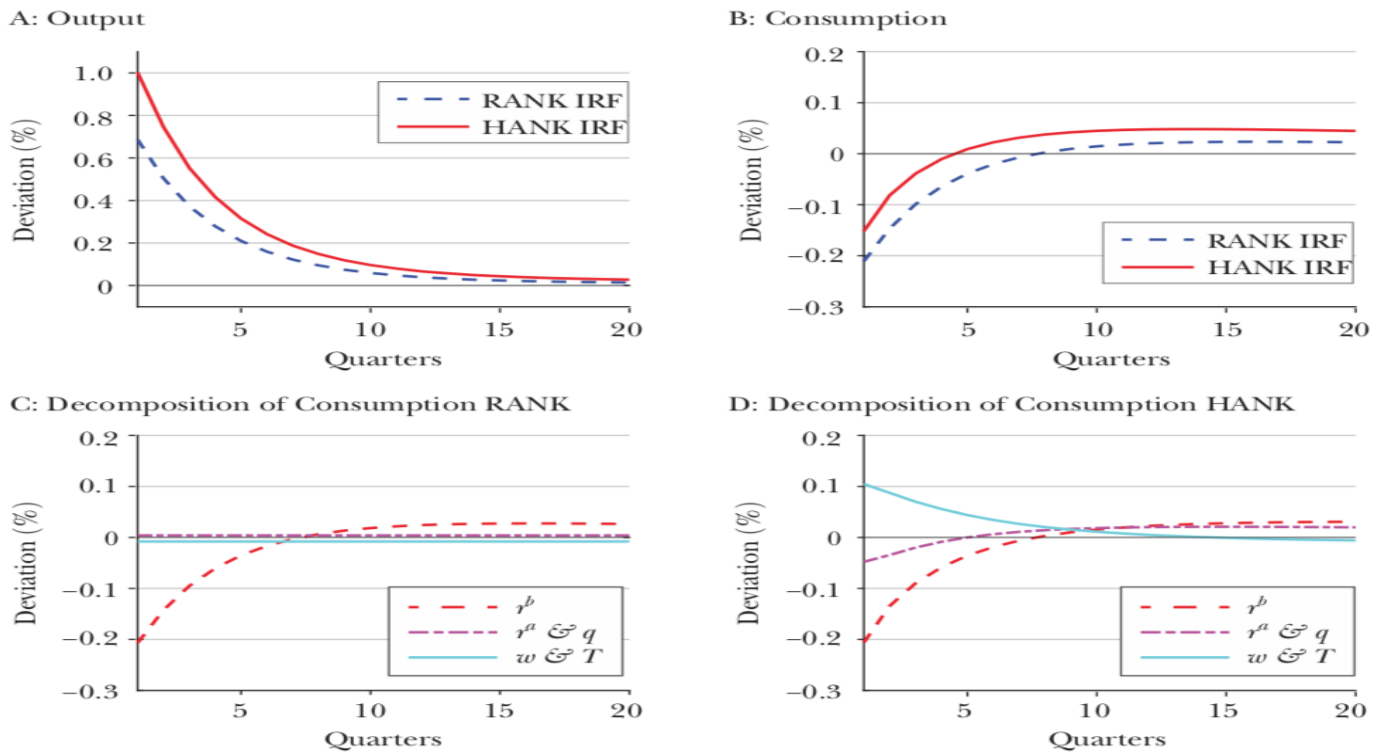
Negative Monetary Shock (Positive Innovation to the Taylor Rule) in HANK and RANK: Impulse Response Functions (IRFs) for Consumption and their Decomposition



Appendix: Rank vs. Hank in Fiscal Stimulus

Figure 4

Fiscal Stimulus (Rise in Government Expenditures) in HANK and RANK: Impulse Response Functions (IRFs) for Output and Consumption and Decompositions for Consumption



rank