Labor Market Heterogeneity and the Lucas Critique

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Motivation

- Representative Agent DSGE Models are commonly used to analyze the effects of monetary and fiscal policies.
- A key assumption in policy experiments is that taste and technology parameters are policy-invariant.

Motivation

- Representative Agent DSGE Models are commonly used to analyze the effects of monetary and fiscal policies.
- A key assumption in policy experiments is that taste and technology parameters are policy-invariant.
- Geweke (1985): *Whenever econometric policy evaluation is undertaken using models estimated with aggregated data, it is implicitly presumed that the aggregator function is structural with respect to the policy intervention.*

What We Do

- Use Heterogeneous agent model economy as data generating process:
- Estimate a Representative Agent Model
- Aggregation error is captured by preference shocks in Rep Agent Model
  - Labor market "wedge" (Hall (1997), Chari, Kehoe, McGrattan (2005))
  - Often interpreted as market failure or inefficiency
- To what extent we can predict the effect of tax changes with the Rep Agent Model, assuming invariance of parameters and shocks?

Related Work

Heterogenous Agent Model and Aggregation

- Heterogeneous Agent Economy (e.g, Chang and Kim, 2006, 2007) features:
    - Individuals face stochastic idiosyncratic productivity
    - Incomplete capital markets
    - Face borrowing constraint
    - Supplies either zero or one unit of labor

- Aggregate labor supply curve depends on cross-sectional reservation wage distribution rather than individuals' willingness to substitute leisure over time.

- Aggregation is not perfect due to:
    - Incomplete capital markets
    - Indivisible nature of labor supply

Heterogeneous Agent Economy: Individual Worker's Problem

$$\max_{\{c_t,h_t\}_{t=0}^{\infty}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t - B \frac{h_t^{1+1/\gamma}}{1+1/\gamma} \right\} \right]$$

$$\text{s.t. } c_t + a_{t+1} = a_t + (1-\tau_H) W_t x_t h_t + (1-\tau_K) R_t a_t + \bar{T}$$

$$a_{t+1} \geq \underline{a}$$

- x_t: stochastic idiosyncratic productivity
- h_t: hours worked, either 0 or $\bar{h}$
- a_t: asset holdings
- τ_H, τ_K: tax rate
- $\bar{T}$: lump-sum transfers.

▸ Remarks ▸ Recursive Representation

Het Agent Economy: Firm

- Each period t, The representative firm maximizes profits:

$$\max_{L_t, K_t} \lambda_t L_t^{\alpha} K_t^{1-\alpha} - W_t L_t - (R_t + \delta) K_t$$

- First-order conditions:

$$W_t = \alpha Y_t / L_t, \quad \text{and} \quad (R_t + \delta) = (1-\alpha) Y_t / K_t$$

- Capital accumulation: $K_{t+1} = (1-\delta) K_t + I_t$
- Exogenous technology: $\ln(\lambda_t / \bar{\lambda}) = \rho_\lambda \ln(\lambda_{t-1}/\bar{\lambda}) + \sigma_\lambda \epsilon_{\lambda,t}$

Het Agent Economy: Government

- Each period t, government spends tax revenues on lump-sum transfers and its own consumption:

$$\bar{T} + G_t = \tau_H W_t \int x_t h_t d\mu_t + \tau_K R_t \int a_t d\mu_t$$

- G is neutral to households' decisions
- Transfers are a fixed fraction of steady state tax revenues

$$\bar{T} = \chi \left(\tau_H \bar{W} \int (xh) d\mu + \tau_K \bar{R} \int a d\mu \right)$$

Het Agent Economy: Equilibrium Conditions

- Capital Market Clearing:

$$K_t = \int a_t d\mu_t$$

- Labor Market Clearing:

$$L_t = \int x_t h_t d\mu_t.$$

- Goods Market Clearing:

$$Y_t = \lambda_t L_t^{\alpha} K_t^{1-\alpha} = \int c_t d\mu_t + I_t + G_t.$$

▸ Equilibrium

Rep Agent Model: Household

- The representative household solves the following problem

$$
\begin{aligned}
\max \quad & \mathbb{E}_t \left[\sum_{s=0}^{\infty} \beta^{t+s} Z_{t+s} \left(\ln C_{t+s} - \frac{(H_{t+s}/B_{t+s})^{1+1/\nu}}{1+1/\nu} \right) \right] \\
\text{s.t.} \quad & C_t + K_{t+1} \\
& = K_t + (1-\tau_H) W_t H_t + (1-\tau_K) R_t K_t + \bar{T}
\end{aligned}
$$

- We introduce two preference “shocks”:

$$
\begin{aligned}
\ln(B_t/\bar{B}) &= \rho_B \ln(B_{t-1}/\bar{B}) + \sigma_B \epsilon_{B,t} \\
\ln Z_t &= \rho_Z \ln Z_{t-1} + \sigma_Z \epsilon_{Z,t}
\end{aligned}
$$

Rep Agent Model: Firms

- Each period t, The representative firm solves the following static profit maximization problem:

$$\max_{L_t, K_t} A_t H_t^{\alpha} K_t^{1-\alpha} - W_t H_t - (R_t + \delta) K_t$$

- Exogenous technology: $\ln(A_t/\bar{A}) = \rho_A \ln(A_{t-1}/\bar{A}) + \sigma_A \epsilon_{A,t}$

Rep Agent Model: Government

- Each period t, government spends tax revenues on lump-sum transfers and its own consumption:

$$\bar{T} + G_t = \tau_H W_t H_t + \tau_K R_t K_t$$

- Transfers are a fixed fraction of tax revenues

$$\bar{T} = \chi \left(\tau_H \bar{W} \bar{H} + \tau_K \bar{R} \bar{K} \right)$$

Het Agent Economy: Calibrate to Generate Data

- Labor share: $\alpha = 0.64$.
- Depreciation Rate: $\delta = 0.025$
- Aggregate productivity: $\ln \lambda_t = 0.95 \ln \lambda_{t-1} + 0.007\epsilon_{\lambda,t}$.
- Substitution elasticity: $\gamma = 0.4$, consistent with micro estimates.
- Work hour: $\bar{h} = 1/3$, from the Michigan Time-Use Survey.
- Borrowing constraint: $\underline{a} = -2$, two quarters of earnings.
- Disutility of working, B, and discount factor, β: target employment rate of 60% and quarterly interest rate 1% in steady state.
- Idiosyncratic Productivity: $\ln x_t = 0.94 \ln x_{t-1} + 0.287\epsilon_{x,t}$, based on PSID data.
- Match wealth and earnings distribution.

Summary

Characteristics of Wealth Distribution

	Quintile of Wealth Distribution					
	1st	2nd	3rd	4th	5th	Total
PSID						
Share of wealth	-.52	.50	5.06	18.74	76.22	100
Group avg. / Pop avg.	-.02	.03	.25	.93	3.81	1
Share of earnings	7.51	11.31	18.72	24.21	38.23	100
Benchmark Model						
Share of wealth	-1.71	2.96	10.88	24.80	63.06	100
Group avg. / pop avg.	-.10	.15	.55	1.23	3.18	1
Share of earnings	9.60	15.60	19.61	23.91	31.27	100

Lorenz Curves

Business Cycle Statistics

	Model 3000 obs.	U.S. Data 1964-2006
$\sigma(\ln Y)$	.033	.041
$\sigma(\ln C)$	.020	.021
$\sigma(\ln H)$	.013	.042
$\sigma((\ln H)_{HP})$	.007	.018
$\text{corr}(\ln Y, \ln C)$	0.84	0.83
$\text{corr}(\ln Y, \ln H)$	0.80	0.56
$\text{corr}(\ln C, \ln H)$	0.37	0.51

Quantitative Analysis

- Benchmark fiscal policy: $\tau_H = 0.29$, $\tau_K = 0.35$; $\chi = 0.36$. Remarks
  - Generate data from Het Agent Economy
  - Estimate Rep Agent model based on Het Agent Economy data
  - Estimate Rep Agent model based on U.S. data
  - *Question 1*: Does aggregation lead to sizeable preference shocks?

- Alternative fiscal policy:
  - Generate data from Het Agent Economy under alternative policy
  - *Question 2:* By how much do estimates of Rep Agent Model parameters/shocks change?
  - *Question 3:* How accurate are predictions based on the estimated benchmark Rep Agent Model?

Quantitative Analysis

- Benchmark: $\tau_H = 0.29$, $\tau_K = 0.35$; $\chi = 0.36$.
- Policy Changes we considered: Remarks

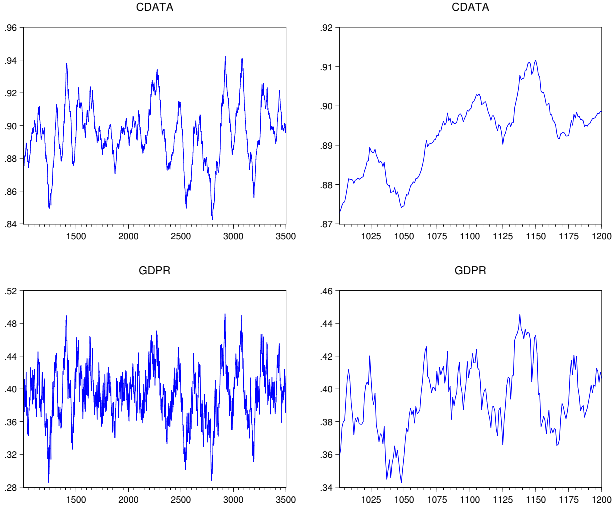
	τ_H	τ_K	χ
Labor Tax Cut	0.22		
Capital Tax Raise		0.47	
More Transfers			0.50
1960 Policy	0.23	0.44	0.22
2004 Policy	0.27	0.33	0.42

Benchmark Estimation – Setup & Priors

- Bayesian estimation of Rep Agent Model based on: *output*, *consumption*, *employment data*.
- Fix $\alpha = 0.64$, $\delta = 0.025$, τ_H, τ_K, and χ
- Priors:

Name	Domain	Density	Mean	Std Dev
R	$\mathbb{R}^+$	Gamma	1.00	0.50
ν	$\mathbb{R}^+$	Gamma	1.00	0.50
$\ln \bar{A}$	$\mathbb{R}$	Normal	0.00	10.0
$\ln \bar{B}$	$\mathbb{R}$	Normal	0.00	10.0
ρ_A	$[0, 1)$	Beta	0.50	0.25
ρ_B	$[0, 1)$	Beta	0.50	0.25
σ_A	$\mathbb{R}^+$	Inv. Gamma	.012	.007
σ_B	$\mathbb{R}^+$	Inv. Gamma	.012	.007
σ_Z	$\mathbb{R}^+$	Inv. Gamma	.012	.007

Consumption and Output Data



Benchmark Specification

1: Estimated steady states match

	"True"	$T = 200$		$T = 2,500$	
		Mean	90% Intv.	Mean	90% Intv.
K	15.2	14.7	[14.2, 15.1]	14.9	[14.7, 15.1]
$H = E/3$	0.20	.200	[.199, .201]	.200	[.200, .200]
C	0.89	0.89	[0.88, 0.90]	0.89	[0.89, 0.90]
Y	1.48	1.46	[1.44, 1.48]	1.47	[1.47, 1.48]
G	0.21	0.21	[.207, .211]	.211	[.210, .211]

- K is high in Heterogenous agent model due precautionary savings

Benchmark Specification

2: Estimates based on simulated versus actual data

	$T = 200$		$T = 2,500$		U.S. Data	
	Mean	90% Intv.	Mean	90% Intv	Mean	90% Intv
ν	1.72	[1.57, 1.86]	2.14	[2.01, 2.26]	0.34	[0.10, 0.60]
$\ln \bar{A}$	-0.26	[-0.26, -0.26]	-0.26	[-0.26, -0.26]	-0.25	[-0.27, -0.22]
$\ln \bar{B}$	-0.33	[-0.34, -0.32]	-0.32	[-0.32, -0.31]	-0.44	[-0.52, -0.37]
ρ_A	0.90	[0.89, 0.91]	0.91	[0.91, 0.92]	0.97	[0.96, 0.99]
ρ_B	0.76	[0.60, 0.92]	0.92	[0.92, 0.93]	0.98	[0.97, 1.00]
R	2.83	[2.68, 2.98]	2.77	[2.71, 2.83]	3.70	[3.25, 4.22]

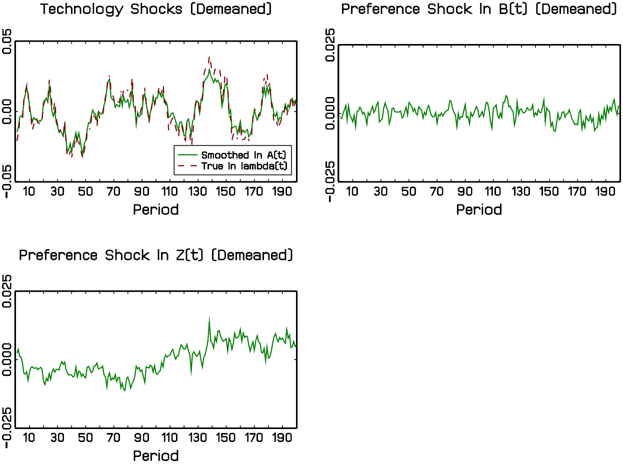
- Aggregate elasticity ν is different from micro elasticity $\gamma = 0.4$.
  - Depends on the reservation wage dist
- Detects preference shocks.

Benchmark Specification

Does aggregation lead to sizeable preference shocks?

	B		Z	
	Mean	90% Intv.	Mean	90% Intv.
Benchmark Economy, $T = 200$				
Output	5	[2, 8]	5	[4, 6]
Consumption	3	[0, 7]	6	[4, 7]
Hours	33	[18, 45]	5	[3, 7]
Benchmark Economy, $T = 2,500$				
Output	9	[8, 10]	5	[4, 5]
Consumption	9	[8, 10]	4	[4, 5]
Hours	43	[41, 46]	4	[4, 4]
U.S. Data				
Output	45	[21, 68]	5	[2, 9]
Consumption	47	[21, 75]	6	[1, 10]
Hours	98	[97, 99]	1	[0, 1]

Benchmark Estimation – Smoothed Shock Processes



▸ Remarks

Increase Transfers from $\chi = 0.36$ to 0.50

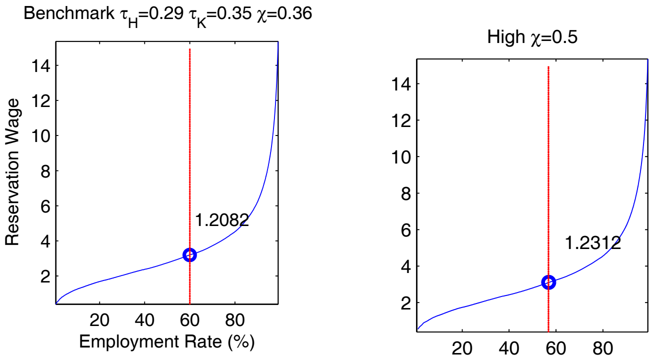
- Increased transfers generates positive income effect.
- Employment rate decreases from 60% to 57%.
- Less need for precautionary savings: K decreases.
- Output decreases.
- Average labor productivity increases (composition effect).
- Experiment:
  - Re-estimate Rep Agent Model
  - By how much do estimates of the Rep Agent Model parameters/shocks change?

More Transfers: Parameter Estimates $T = 200$

	Benchmark		More Transfers	
	Mean	90% Intv.	Mean	90% Intv
R_A	2.83	[2.68, 2.98]	2.96	[2.81, 3.12]
ν	1.72	[1.57, 1.86]	2.68	[2.13, 3.34]
$\ln \bar{A}$	-0.26	[-0.26, -0.26]	-0.24	[-0.24, -0.23]
$\ln \bar{B}$	-0.33	[-0.34, -0.32]	-0.32	[-0.34, -0.31]
ρ_A	0.90	[0.89, 0.91]	0.92	[0.91, 0.92]
ρ_B	0.76	[0.60, 0.92]	0.90	[0.88, 0.92]

Smoothed Shocks

More Transfers: Why does $\hat{\nu}$ increase?



More Transfers: Why does $\bar{A}$ rise?

- Lower level of employment
- $\longrightarrow$ Fewer low productivity workers are hired
- $\longrightarrow$ Aggregate productivity $\bar{A}$ in rep. agent model needs to rise.

More Transfers: Steady State Predictions [% Changes]

How accurate are predictions based on the estimated benchmark Rep Agent Model?

	"True"	Predicted $T = 200$		Predicted $T = 2,500$	
		Mean	90% Intv.	Mean	90% Intv.
Hours	-5.25	-3.14	[-3.22, -3.04]	-3.38	[-3.43, -3.31]
Consumption	3.09	1.87	[1.79, 1.98]	1.62	[1.56, 1.68]
Output	-2.17	-3.14	[-3.22, -3.04]	-3.38	[-3.43, -3.31]

Message: Lack of invariance of the aggregator function is sufficiently strong to render predictions from representative agent model inaccurate (outside 90% prediction interval).

More Transfers: Explanation of Prediction Errors

- Policy predictions are based on
  - a $\hat{\nu}$ that is too low $\longrightarrow$ under-predict the hours decline;
  - a composition effect $\longrightarrow$ overpredict the output decline.

- Income effect is bigger in heterogeneous agent economy; transfers relax borrowing constraint for low wealth households; large effect on consumption and labor supply.

Labor Tax Cut

- low labor income tax encourages labor supply
- lowers the tax revenue, lump-sum transfer decreases by 18%,
- income effect on labor supply
- more need for precautionary savings
- $\ln \bar{A}$ falls to capture composition effect

- Key parameter estimates:

	R	ν	$\ln \bar{A}$
Benchmark	2.83	1.72	-0.26
Labor Tax Cut	2.64	1.12	-0.29

- Policy predictions:

	Hours	Consumption	Output
"True"	6.30	7.61	3.50
90 % Intv.	[2.96, 3.15]	[7.84, 8.03]	[2.96, 3.15]

Summary of other Policy Changes

- High capital tax has most impact on K, but has little effect on parameter estimates of DSGE model (due to choice of observables).
- "1960 Fiscal Policy" and "2004 Fiscal Policy" generates a combination of effects.
- Neither preference processes nor taste/technology parameters are invariant.
- "True" policy effects lie outside of predictive intervals generated from estimated Rep Agent Model.
- We chose a sample size of $T = 200$, because we wanted to compare the magnitude of aggregation biases to the posterior uncertainty based on a *realistic* sample size.

▸ More Estimates ▸ More Predictions ▸ More Figures ▸ Estimates based on Efficiency Hours

Welfare Gain from Policy

Policy	"True"	Mean	90 % Interval
Labor Income Tax Cut:			
$\tau_H = 0.22$	0.0451	0.0664	[0.0660, 0.0668]
High Capital Tax:			
$\tau_k = 0.47$	-0.0261	-0.0339	[-0.0352, -0.0325]
Higher Transfer:			
$\chi = 0.5$	0.0580	0.0313	[0.0310, 0.0318]
1960 Policy:			
$\tau_H = 0.229$, $\tau_k = 0.443$, $\chi = 0.224$	-0.0309	0.0030	[0.0016, 0.0044]
2004 Policy:			
$\tau_H = 0.27$, $\tau_k = 0.33$, $\chi = 0.42$	0.0407	0.0377	[0.0375, 0.0379]

Conclusion

- Incomplete markets and idiosyncratic productivity shocks can lead to time-varying parameters (preference shocks) in aggregate model.
- Neither labor supply elasticity nor preference shock process in the aggregate model are policy invariant.
- Prediction for policy effects obtained from Rep Agent Model are often inaccurate.

Related Work

- Chang and Kim (IER, 2006): Calibrate heterogeneous agent model; simulate date; estimate aggregate Frisch elasticity (slope of reservation wage distribution), value is about 1.
- Chang and Kim (AER, 2007): Same model economy; calculate "wedge" between marginal rate of substitution and labor productivity; investigate cyclical properties of this "wedge"
- An, Chang, and Kim (AEJ Macro, 2009): Same model economy; focus on GMM based estimates of equilibrium conditions; apparent failure of equilibrium conditions due to aggregation rather than market failure.
- Scheinkman and Weiss (1987), Krüger and Lustig (2007); Liu, Waggoner, and Zha (2008)

▸ Back

Remarks

- There are two assets: (i) claims to physical capital; (ii) IOU's. The returns on the claims to capital are taxed; the returns on the IOU's are not. IOU's are in zero net supply. After tax returns on both assets are identical.
- Lump-sum transfers are independent of asset holdings and productivity. They are constant over time $\longrightarrow$ no additional state variable.

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Recursive Representation of Worker's Problem

- Value of working:

$$V^E(a,x,A,\mu) = \max_{a' \in \mathcal{A}} \left\{ \ln c - B\frac{\bar{h}^{1+1/\nu}}{1+1/\nu} + \beta E\left[V(a',x',A',\mu')\middle| x,A\right] \right\}$$
$$\text{s.t. } c + a' = a + (1-\tau_H)Wx\bar{h} + (1-\tau_K)Ra + \bar{T}$$

- Value of Not-working:

$$V^N(a,x,A,\mu) = \max_{a' \in \mathcal{A}} \left\{ \ln c + \beta E\left[V(a',x',A',\mu')\middle| x,A\right] \right\}$$
$$\text{s.t. } c + a' = a + (1-\tau_K)Ra + \bar{T}$$

- Labor supply decision:

$$V(a,x,A,\mu) = \max \left\{ V^E(a,x,A,\mu), V^N(a,x,A,\mu) \right\}.$$

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Equilibrium

- Value functions: $V^E(a, x, A, \mu)$, $V^N(a, x, A, \mu)$ and $V(a, x, A, \mu)$
- Decision rules: $a'(a, x, A, \mu)$, $c(a, x, A, \mu)$ and $h(a, x, A, \mu)$
- Aggregate factor inputs: $K(A, \mu)$ and $L(A, \mu)$
- Factor prices: $W(A, \mu)$ and $R(A, \mu)$
- Government consumption: $G(A, \mu)$
- Law of motion for distribution: $\mu' = \mathbf{T}(A, \mu)$

such that

- Individual workers optimize.
- The representative maximizes profits.
- Markets clears.
- Government balances budget.
- Individual and aggregate behaviors are consistent.

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Parameters of the Benchmark Economy: Summary

Parameter	Description
$\alpha = 0.64$	Labor share in production function
$\beta = 0.98332$	Discount factor
$\delta = 0.025$	Capital depreciation rate
$\gamma = 0.4$	Individual labor-supply elasticity with divisible labor
$B = 101.0$	Utility parameter
$\bar{h} = 1/3$	Labor supply if working
$\underline{a} = -2.0$	Borrowing constraint
$\rho_x = 0.939$	Persistence of idiosyncratic productivity shock
$\sigma_x = 0.287$	St. dev. of innovation to individual productivity
$\rho_A = 0.95$	Persistence of aggregate productivity shock
$\sigma_A = 0.007$	St. dev. of innovation to aggregate productivity

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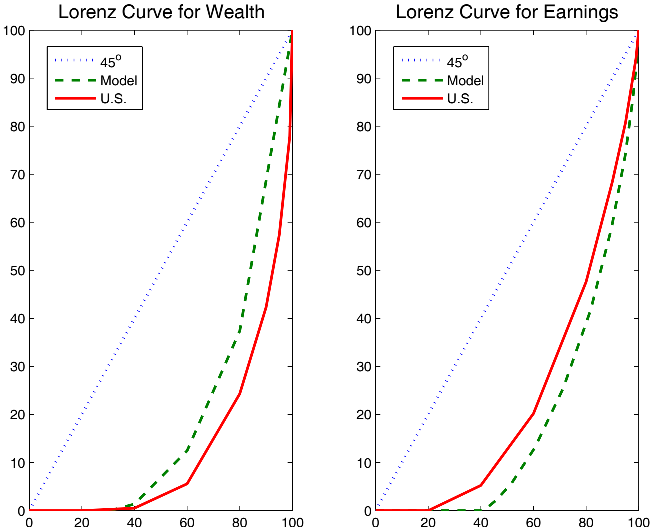
Lorenz Curves of Wealth and Earnings



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Remarks

- Capital and labor tax rates correspond to 1984 values as reported in Chen, Imrohoruglu, and Imrohorogul (2007)
- To choose a value for $\chi = T/(T+G)$ we used data on Government Consumption (G) and Net Government Social Benefits (T):

Year	$T/(T+G)$	G/Y
1960	0.22	0.16
1984	0.36	0.16
2004	0.41	0.15

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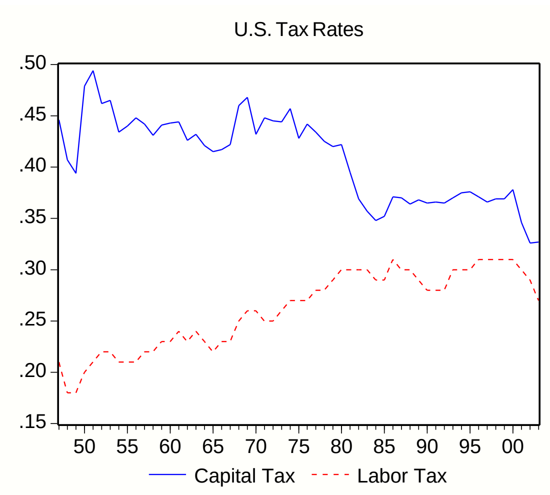
U.S. Tax Rates



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Remarks

- The measured technology shock from the Rep Agent Model is less volatile than the true technology shock.
- In booms, low-efficiency workers enter the labor force, which dampens measured productivity.
- Correlation between technology and intratemporal (intertemporal) preference shock is 0.3 (0.2).

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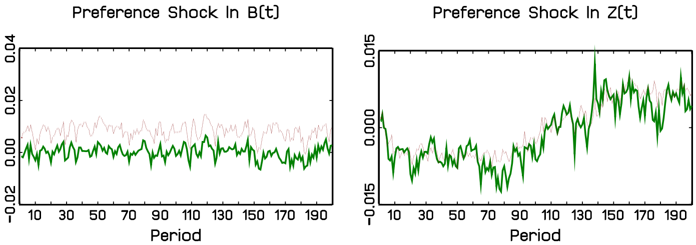
Benchmark versus High Transfers – Smoothed Shock Processes



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Posterior Means Based on Het Agent Economy Data

	Bench-mark	Lab. Tax Cut	Cap. Tax Raise	More Transfers	1960 Policy	2004 Policy
τ_H	0.29	0.22			.229	.269
τ_K	0.35		0.47		.443	.327
χ	0.36			0.50	.224	.417
R	2.83	2.64	2.84	2.96	2.61	2.80
ν	1.72	1.12	1.67	2.68	1.07	1.70
$\ln A_0$	-0.26	-0.29	-0.26	-0.24	-0.30	-0.26
$\ln B_0$	-0.33	-0.33	-0.33	-0.32	-0.32	-0.33
ρ_A	0.90	0.94	0.92	0.92	0.95	0.94
ρ_B	0.76	0.90	0.87	0.90	0.91	0.92
σ_A	.005	.006	.006	.005	.006	.006
σ_B	.003	.003	.003	.003	.003	.003
σ_ζ	.003	.003	.003	.002	.002	.003

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Predictions Based on Estimated Benchmark Rep Agent Model

		Hours	Consumption	Output
Lab.Tax Cut	"True"	6.30	7.61	3.50
$\tau_H = 0.22$	90 % Intv.	[2.96, 3.15]	[7.84, 8.03]	[2.96, 3.15]
Cap.Tax Raise	"True"	-0.15	-2.69	-2.85
$\tau_K = 0.47$	90 % Intv.	[-0.31, -0.28]	[-3.63, -3.37]	[-4.07, -3.84]
More Transf.	"True"	-5.25	3.09	-2.17
$\chi = 0.5$	90 % Intv.	[-3.22, -3.04]	[1.79, 1.98]	[-3.22, -3.04]
1960 Policy	"True"	9.95	1.75	2.60
	90 % Intv.	[5.18, 5.51]	[2.25, 2.65]	[2.28, 2.63]
2004 Policy	"True"	-0.15	3.93	0.82
	90 % Intv.	[-0.21, -0.20]	[3.66, 3.71]	[0.36, 0.41]

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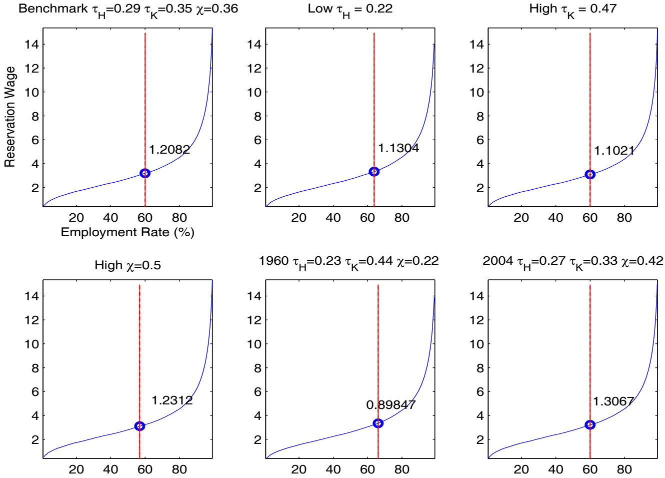
Employment Rate Based on the Reservation Wage Distribution



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Estimates based on Efficiency Unit of Hours

	Bench-mark	Lab. Tax Cut	Cap. Tax Raise	More Transfers	1960 Policy	2004 Policy
τ_H	0.29	0.22			.229	.269
τ_K	0.35		0.47		.443	.327
χ	0.36			0.50	.224	.417
r_A	2.75	2.54	2.71	2.82	2.51	2.73
ν	0.64	0.54	0.67	0.80	0.47	0.64
$\ln \bar{A}$	0.01	0.00	0.01	0.01	0.00	0.01
$\ln \bar{B}$	-0.81	-0.82	-0.81	-0.79	-0.83	-0.81
ρ_A	0.91	0.94	0.93	0.92	0.94	0.92
ρ_B	0.91	0.91	0.93	0.91	0.89	0.90
σ_A	.007	.007	.007	.007	.007	.007
σ_B	.002	.002	.002	.002	.002	.002
σ_ζ	.003	.003	.003	.002	.002	.002

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Auxiliary Model Economies

		Labor Market	
		Divisible	Indivisible
Capital Market	Complete	1	2
	Incomplete	3	4

Comparisons: Chang and Kim (2007)

Incomplete Market (& Divisible Labor) economy:

- Similar to representative agent economy
- Households labor supply respond similarly to aggregate shocks
- Aggregation holds approximately (Krusell & Smith, 1998)

Indivisible Labor (& Complete Markets) economy:

- Aggregation theorem holds
- Aggregate FOC holds in efficiency units
- Aggregate elasticity is not the same as individual elasticity

Labor Market Wedges