SOE and Chinese Real Business Cycle

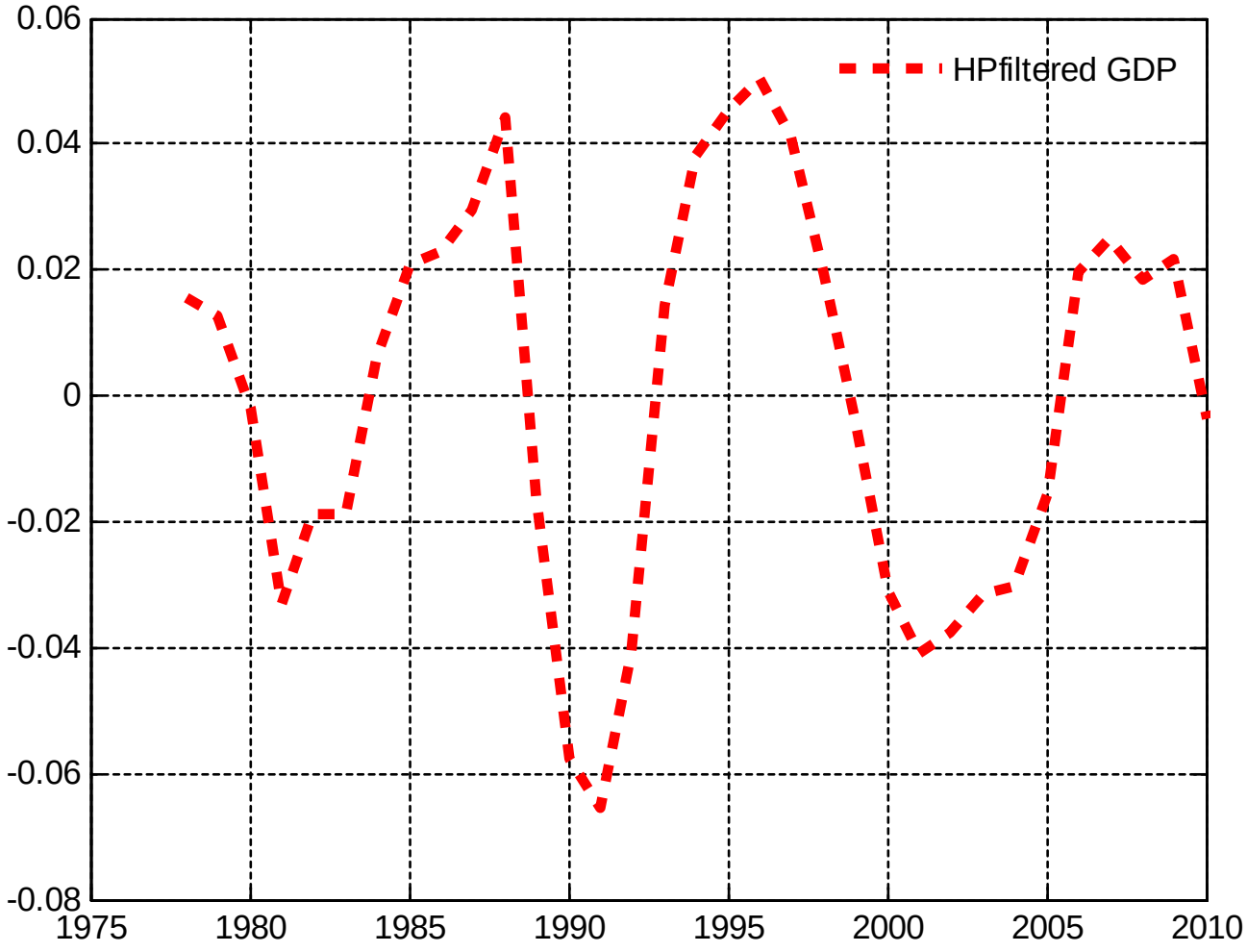
Daoju Peng, Kang Shi and Juanyi Xu

CUHK,CUHK,HKUST

January 2015

Motivation

In the past decades, China economy has grown rapidly and also experienced several significant ups and downs.



Motivation

- Yet there has been little studies on economic fluctuations of Chinese economy.
  - the basic facts on cycles, volatility, cyclical correlation of key aggregate variables
  - and models that explain these facts
- The existing studies did not investigate systematically the issues of Chinese business cycle.
  - Zhu and Brandt (2000,JPE) investigate China's growth and inflation cycle during the period from 1978-2005.
  - Curtis and Mark (2010) showed that naively applying standard small open economy model to China is no more ridiculous than applying it to a developed economy, such as Canada, although the dimension along which the model struggles are different.
- This paper is to fill this important gap with a focus on the role of SOE.

This Paper

- documents three main features of Chinese business cycle.
  - moderate consumption volatility
  - low investment volatility
  - acyclical trade balance
- estimates existing workhorse models on emerging market business cycle and finds they cannot explain Chinese business cycle well.
- builds a small open economy DSGE model with full-fledged SOE sector, introduces three shocks related to SOE sector and estimates the model by Bayesian method.
- Main finding: shocks related to SOE sector matter.

Empirical Facts

- Chinese RBC has three unique features, namely,
  - **moderate** consumption volatility
  - substantially **low** investment volatility
  - **acyclical** trade balance

Table 1: Second moments over business cycle

	China	Emerging Markets	Developed Markets
$\sigma(y)$	3.16	3.47	1.94
$\rho(y)$	0.74	0.40	0.59
$\sigma(c)/\sigma(y)$	0.98	1.23	0.96
$\sigma(i)/\sigma(y)$	2.33	3.81	3.71
$\sigma(TB/y)$	1.675	3.51	1.22
$\rho(TB/y, y)$	$-0.05(0.80)$	-0.61	-0.44
$\rho(c, y)$	0.61(0.00)	0.80	0.84
$\rho(i, y)$	0.80(0.00)	0.85	0.86

p-value is in parentheses.

Existing Theory

Can Emerging Market Real Business Cycle theories explain China's RBC? Two Hypotheses:

- Aguiar and Gopinath (2007), JPE, **Permanent Productivity Shock** (a shock to trend growth) (AG Model)
  Hypothesis: "The Cycle is the Trend".
  The relative importance of the permanent productivity component of the Solow residual is large in emerging markets.
  Explain Mexico real business cycle.

- Garciá-Cicco et al. (2010), AER: **The role of Financial Friction** and reject the hypothesis "The Cycle Is the Trend" (GPU Model)
  "Models should take into account the role of various frictions and policies in explaining the pattern of emerging market business cycle".
  Explain Argentina and Mexico real business cycle.

Why consider SOE sector?

- The emerging market business cycle models cannot explain, so it is natural to consider China specific feature
- An important feature in Chinese economy: SOE vs non-SOE
  - Brandt, Hsieh and Zhu (2008), Song, Storesletten and Zilibotti (2011), Li, Liu, and Wang (2012)
- Any evidence that SOE sector may be important for business cycle?
  - Dramatic reforms on SOE;
  - Cylical pattern.

SOE experiences dramatic reforms

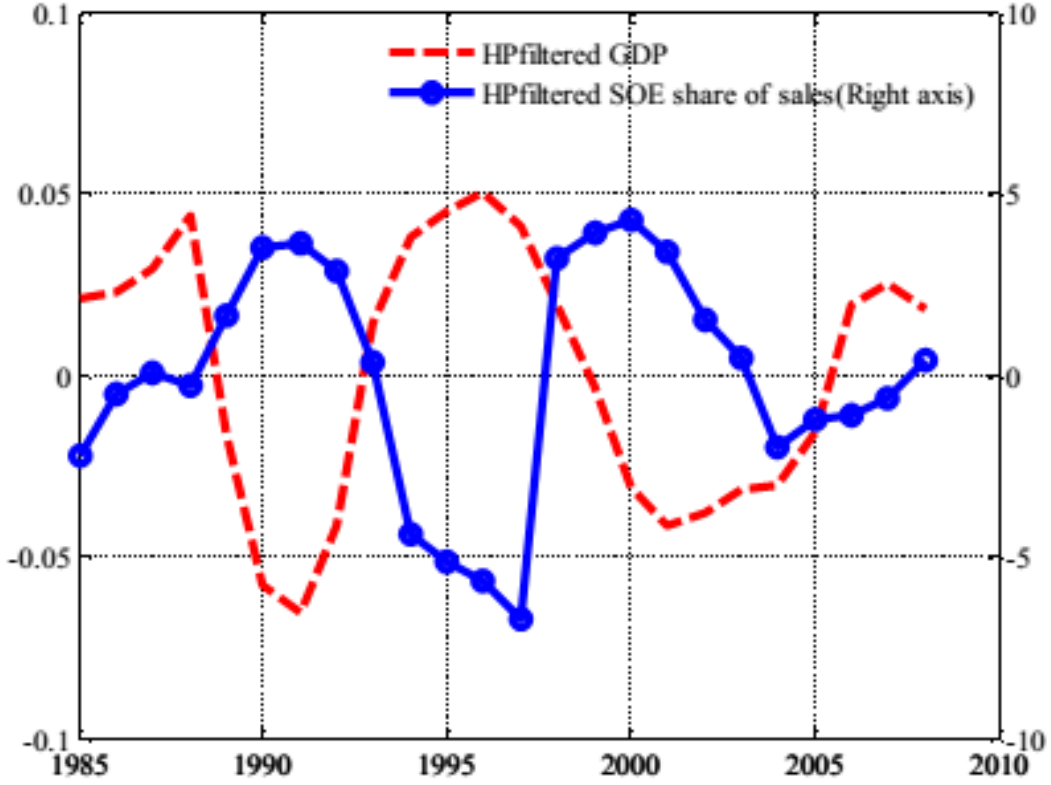
- 1982: profit retention system reform: from "sharing the rice pot" to "contracting responsibility system";
- 1998: "grasping the large and letting the small go";
- 2003: corporate governance reform: from "wholly stated-owned" to "state controlled" and "mixed ownership".

SOE cycle

Do SOE share and return display **cyclical** pattern empirically? Probably **Yes.**

- SOE share of Sales

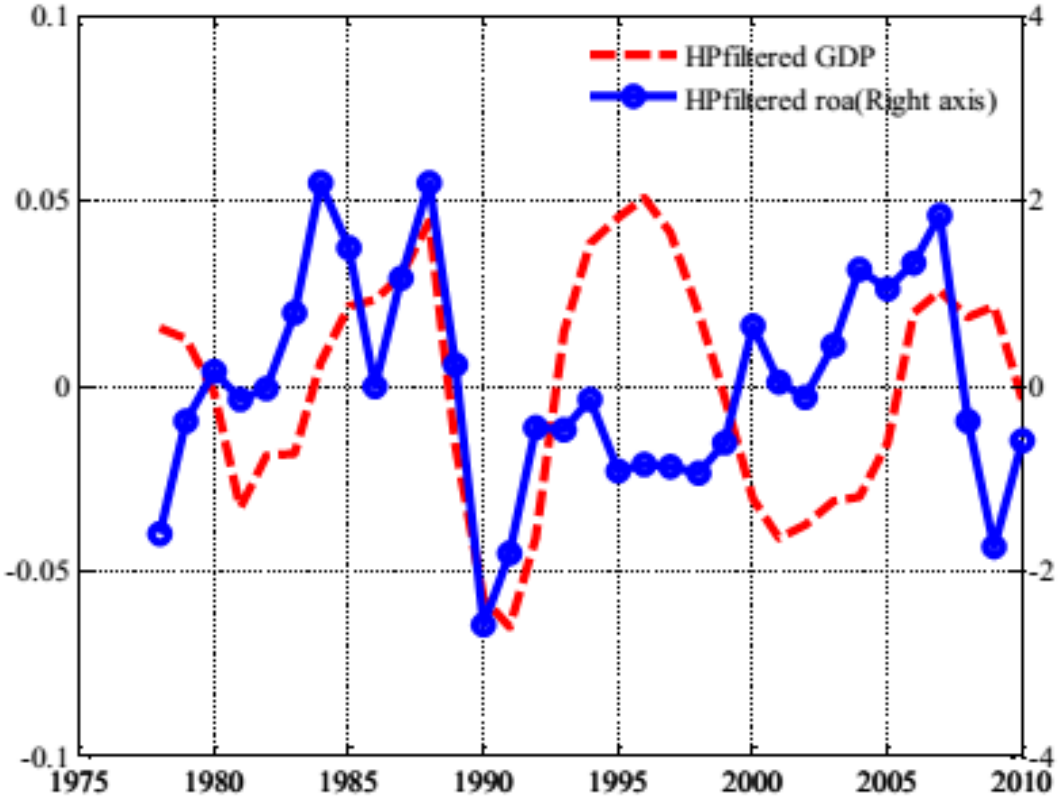
Figure 1: Output and the share of SOE's sales



SOE cycle

- Return on SOE assets

Figure 2: Output and return on asset of SOEs



Main findings

- SOE sector shocks explains most fluctuation of key macro variables.
  - Fluctuation of demand for SOE's product accounts for most of fluctuation of output and consumption.
  - SOE's monopolistic position is largely responsible for movement of investment and trade balance

Main findings

- Other shocks emphasized in the business cycle literature are less important.
  - Permanent productivity shock: only explains less than 20 percent fluctuation of output, consumption, investment and trade balance-to-output ratio. $\rightarrow$Evidence that is less supportive to "The Cycle is the Trend" hypothesis
  - Credit shock does not matter either.
  - Other shocks (preference shock, country risk premium shock) are not important.

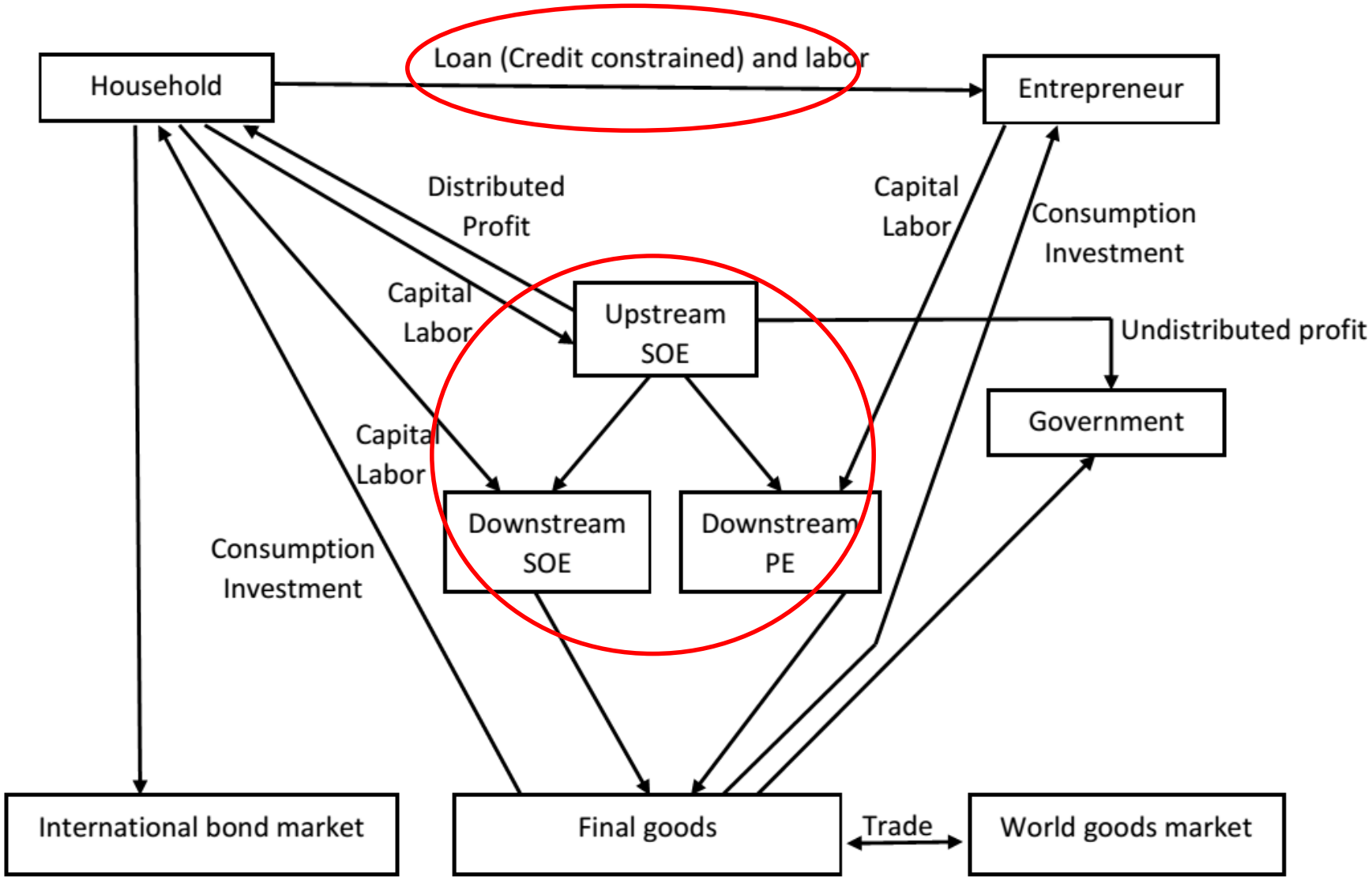
Related literatures

- Chinese business cycle:
  - Zhu and Brandt (2000, 2001), Curtis and Mark (2010), Shi, Wu, Xu(2013)
- SOE:
  - Hsieh and Klenow(2009), Song, Storesletten and Zilibotti (2011), Brandt, Tombe, and Zhu (2013), Li, Liu, and Wang (2012) among others
- Emerging market business cycle literature:
  - Mendoza (1991), Neumeyer and Fabrizio (2005), Aguiar and Gopinath (2007), García-Cicco, Pancrazi and Uribe (2010)
- Small open economy model: Mendoza (1991), Uribe and Schmitt-Grohe(2003)

Model: key ingredients

- Small open economy DSGE model with infinitely-lived household(SOE) and entreprenuer(PE)
- Financial frictions:
  - entrepreneur can only borrow up to a fraction of their discounted present value of capital.
  - entrepreneur don't have access to international financial market
- Vertical structure of production:
  - Upstream intermediate goods sector: a large number of SOE monopolizes (monopolistic competition)
  - Downstream intermediate goods sector: PE and SOE coexist (competitive)
  - Final goods: tradable(competitive)
- Productivity difference: PE is more productive than SOE

Model: the structure of economy



Production

Final goods sector

- Final goods is a CES aggregation of downstream goods

$$Y_t = [\eta_t Y_{dt}^{s\,\frac{\lambda-1}{\lambda}} + (1-\eta_t) Y_{dt}^{p\,\frac{\lambda-1}{\lambda}}]^{\frac{\lambda}{\lambda-1}}$$

- The demand for downstream intermediate goods is

$$Y_{dt}^s = \eta_t^\lambda (\frac{P_{dt}^s}{P_t})^{-\lambda} Y_t, \qquad Y_{dt}^p = (1-\eta_t)^\lambda (\frac{P_{dt}^p}{P_t})^{-\lambda} Y_t$$

- There is a stochastic shock to SOE's share η_t:

$$\log(\eta_t) = (1-\rho_\eta)\log(\eta_{ss}) + \rho_\eta \log(\eta_{t-1}) + \epsilon_{\eta t}$$

Production

downstream intermediate goods sector

- Both downstream SOE and PE produce goods according to the same Cobb-Douglas production function

$$Y_{dt}^{i} = (K_{dt}^{i})^{\alpha}(A_{t}^{i}L_{dt}^{i})^{\beta}(Y_{mt}^{i})^{1-\alpha-\beta}$$

- Price for downstream goods is given by its marginal cost

$$P_{dt}^{i} = MC_{dt}^{i} = \frac{(r_{t}^{i})^{\alpha} w_{t}^{\beta} P_{mt}^{1-\alpha-\beta}}{(A_{t}^{i})^{\beta}\Delta}, i = s, p$$

r_t^i, A_t^i affect P_{dt}^i and therefore the demand for downstream intermediate goods.

Production

upstream intermediate sector

- Differentiated upstream intermediate goods are produced by

$$Y_{mt} = \left[\int_0^1 (Y_{mt}^j)^{\varepsilon_t} dj \right]^{\frac{1}{\varepsilon_t}}$$
$$Y_m^j = (K_{mt}^j)^{\gamma} (A_t^s L_{mt}^j)^{1-\gamma}$$

- Price for upstream intermediate goods is a markup over its marginal cost

$$P_{mt} = \frac{1}{\varepsilon_t} \frac{(r_t)^{\gamma} (w_t)^{1-\gamma}}{(A_t^s)^{1-\gamma} \gamma^{\gamma} (1-\gamma)^{(1-\gamma)}}$$

- Markup fluctuates around its steady state

$$\log(\varepsilon_t) = (1-\rho_\varepsilon) \log(\varepsilon_{ss}) + \rho_\varepsilon \log(\varepsilon_{t-1}) - \epsilon_{\varepsilon t}$$

Production

- Productivity difference

$$\chi = A_t^p / A_t^s > 1$$

- Technology for both firms are nonstationary. There is stochastic shock to its growth rate.

$$g_t = A_t^s / A_{t-1}^s, \quad \log g_t = (1 - \rho_g) \log(g_{ss}) + \rho_g \log g_{t-1} + \epsilon_{gt}$$

Household

- Household has following preference

$$U^h = E_0 \sum_{t=0}^{\infty} v_t \rho^t [\ln(C_t^h) - \nu \frac{L_t^{1+\kappa}}{1+\kappa}]$$

- Household maximizes its utility subject to following budget constraint

$$P_t C_t^h + D_{t+1} + P_t I_t^h + B_{t+1} = w_t L_t + (1 + r_t^d) D_t + r_t K_t^h + \omega_t \Pi_t^h + (1 + r_t^b) B_t - T_t$$

Household

- Preference shock is introduced to break down the intertemporal condition

$$\log(v_t) = \rho_v \log(v_{t-1}) + \epsilon_{vt}$$

- The country risk-premium household takes the following form

$$r_t^b = r_t^* + \varphi^b(e^{\frac{B_t}{A_{st}} - \bar{b}} - 1) + e^{\mu_t - 1} - 1$$

- Fluctuation in variable μ_t captures the tightness of international credit market

$$\log(\mu_t) = \rho_\mu \log(\mu_{t-1}) + \epsilon_{\mu t}$$

- Household receives the distributed SOE's profit $\omega_t \Pi_t^h$. The dividend payment subject to a stochastic shock

$$\log(\omega_t) = (1 - \rho_\omega)\log(\omega_{ss}) + \rho_\omega \log(\omega_{t-1}) + \epsilon_{\omega t}$$

Household

- Household's optimal conditions

$$P_t \Lambda_t [1 + \varphi^k (\frac{K^h_{t+1}}{A^s_t} - \overline{k^h})] = \rho E_t [P_{t+1} \Lambda_{t+1} \frac{v_{t+1}}{v_t} (\frac{r_{t+1}}{P_{t+1}} + 1 - \delta)]$$

$$\Lambda_t = \rho E_t [\Lambda_{t+1} \frac{v_{t+1}}{v_t} (1 + r^b_{t+1})]$$

$$\Lambda_t = \rho E_t [\Lambda_{t+1} \frac{v_{t+1}}{v_t} (1 + r^d_{t+1})]$$

$$\frac{w_t}{P_t} = \nu L^\kappa_t C^h_t$$

Entrepreneur

- has log preference:

$$U^e = E_0 \sum_{t=0}^{\infty} v_t (\rho\varsigma)^t \ln C_t^e$$

- Credit Constraint: entrepreneur can only borrow up to ϕ_t of present value of its asset.

$$D_{t+1} \leq \phi_t P_t K_{dt+1}^p$$

- The tightness of credit constraint fluctuates according to following stochastic process

$$\log(\phi_t) = (1 - \rho_\phi) \log(\phi_{ss}) + \rho_\phi \log(\phi_{t-1}) + \epsilon_{\phi t}$$

Entrepreneur

- The optimization problem for entrepreneur is as follows

$$V(D_t, K^p_{dt}) = \max_{C_t, D_{t+1}, K^p_{dt+1}, L^p_{dt}} v_t \ln C^e_t + \rho(1-\varsigma) E_t V(D_{t+1}, K^p_{dt+1})$$

$$P_t C^e_t + P_t I^p_{dt} + (1 + r^d_t) D_t = P^p_{dt} Y^p_{dt} - w_t L^p_{dt} - P_{mt} Y^p_{mt} + D_{t+1}$$

$$K^p_{dt+1} = (1-\delta) K^p_{dt} + I^p_{dt} - \frac{\varphi^k}{2} P_t \left(\frac{K^p_{t+1}}{A^p_t} - \overline{k^p}\right)^2 A^p_t$$

$$D_{t+1} \leq \phi_t P_t K^p_{dt+1}$$

Entrepreneurs

- The optimal conditions are

$$\frac{v_t}{C_t^e}\left[1+\varphi^k\left(\frac{K_{t+1}^p}{A_t^p}-\overline{k^p}\right)\right]=\rho(1-\varsigma)E_t\frac{v_{t+1}}{C_{t+1}^e}\left[\frac{r_{t+1}^k}{P_{t+1}}+(1-\delta))\right]$$
$$+\Omega_t P_t \phi_t$$
$$\frac{v_t}{C_t^e}\frac{1}{P_t}=\rho(1-\varsigma)E_t\frac{v_{t+1}}{C_{t+1}^e}\frac{1}{P_{t+1}}\left[1+r_{t+1}^d\right]+\Omega_t$$
$$w_t=\beta\frac{P_{dt}^p Y_{dt}^p}{L_{dt}^p}$$

Government

- Government collect tax from household and consume

$$G_t = T_t$$

- There is stochastic shock to detrended government spending $gc_t = G_t / A^s_{t-1}$,

$$\log(gc_t) = (1 - \rho_{gc}) \log(gc_{ss}) + \rho_{gc} \log(gc_{t-1}) + \epsilon_{gc,t}$$

Market clearing condition

- Final goods

$$Y_t = C_t^h + C_t^e + I_t^h + I_{dt}^p + (1-\omega_t)\Pi_t^h + G_t + TB_t$$

- Undistributed SOE's profit is used to buy consumption goods and investment goods.

$$C_t = C_t^h + C_t^e + (1-\theta)(1-\omega_t)\Pi_t^h$$
$$I_t = I_t^h + I_{dt}^p + \theta(1-\omega_t)\Pi_t^h$$

- Labor market

$$L_t = L_{mt} + L_{dt}^s + L_{dt}^p$$

Calibration & Estimation

The model parameters are divided into three subsets.

- 10 parameters in the first subset are calibrated:

Parameter	Name	Value
ρ	Discount factor	0.98
ς	Exiting probability	0.033
δ	Depreciation rate	0.1
κ	labor-supply elasticity	0.6
g_{ss}	Steady state growth rate of productivity	1.083
TBy_{ss}	Steady state value of trade balance-to-output ratio	0.019
by_{ss}	Steady state value of foreign bond-to-output ratio	$\frac{0.019}{g_{ss}-g_{ss}/\rho}$
α	Capital share in downstream sector	$\alpha = 0.5 - 0.174(\gamma\varepsilon_{ss}+1-\varepsilon_{ss})$
β	Labor share in downstream sector	$1-\alpha-0.174$
χ	Labor productivty difference	$2^{\frac{1}{\beta}}$

Calibration & Estimation

- 26 parameters in the second and third subsets are estimated:
  - 10 structural parameters: $\{\varphi^b, \varphi^k, \lambda, \nu, \gamma, \theta, \varepsilon_{ss}, \phi_{ss}, \omega_{ss}, \eta_{ss}\}$
  - standard deviation and serial correlation of exogenous shocks: $\{\rho_i, \sigma_i\}$ with $i = \{g, \phi, \varepsilon, \eta, \omega, G, \mu, v\}$
- Data: 5 observable variables from 1979 to 2010: $g^Y, g^C, g^I, g^{GC}, TB/y$
- Bayesian estimation method: overcome small sample issue

Estimation Procedure

- We first form prior belief on distribution of parameter.
- Given data we have, we update the prior distribution based on Bayes' theorem.
  - Use Metropolis–Hastings algorithm to sample parameters which has the ergodic distribution of posterior distribution
- Based on posterior distribution, we can perform inference like point estimation or model comparison

Posterior results

Table 3: Prior and Posterior distribution of the parameters in SOE and No-SOE model

Param	Prior Mean	Prior std	Prior density	SOE Post. Mean	SOE 5%	SOE 95%	NO-SOE Post.Mean	NO-SOE 5%	NO-SOE 95%
φ^b	3	1	G	2.94	1.48	4.37	2.62	1.17	3.92
γ	0.5	0.1	B	0.51	0.36	0.66	0.57	0.41	0.71
λ	5	1	G	5.15	3.66	6.58	4.58	2.83	6.17
ν	0.6	0.2	G	0.63	0.32	0.95	0.58	0.27	0.87
ε_{ss}	0.6	0.2	B	0.73	0.55	0.92	0.71	0.50	0.95
ϕ_{ss}	0.4	0.1	B	0.27	0.17	0.37	0.34	0.20	0.47
ω_{ss}	0.3	0.1	B	0.26	0.11	0.38	0.30	0.14	0.47
η_{ss}	0.4	0.1	B	0.39	0.30	0.48	0.59	0.43	0.73
φ^k	2	1	G	1.74	0.56	2.78	2.83	1.13	4.35
θ	0.7	0.1	B	0.74	0.64	0.85	0.68	0.52	0.85
ρ_g	0.5	0.2	B	0.38	0.10	0.63	0.53	0.33	0.75
ρ_ϕ	0.5	0.2	B	0.52	0.19	0.84	0.53	0.19	0.85
ρ_ε	0.5	0.2	B	0.87	0.80	0.95			
ρ_η	0.5	0.2	B	0.67	0.50	0.84			
ρ_ω	0.5	0.2	B	0.51	0.21	0.85			
ρ_{gc}	0.5	0.2	B	0.66	0.45	0.89	0.68	0.49	0.89
ρ_μ	0.5	0.2	B	0.61	0.33	0.89	0.57	0.25	0.88
ρ_v	0.5	0.2	B	0.61	0.33	0.92	0.63	0.44	0.82
ϵ_g	0.03	∞	$invg$	0.011	0.007	0.015	0.016	0.011	0.020
ϵ_ϕ	0.03	∞	$invg$	0.013	0.007	0.018	0.013	0.006	0.021
ϵ_ε	0.03	∞	$invg$	0.316	0.215	0.426			
ϵ_η	0.03	∞	$invg$	0.028	0.017	0.040			
ϵ_ω	0.03	∞	$invg$	0.027	0.007	0.052			
ϵ_{gc}	0.03	∞	$invg$	0.041	0.032	0.050	0.045	0.035	0.055
ϵ_μ	0.03	∞	$invg$	0.013	0.007	0.019	0.018	0.007	0.029
ϵ_v	0.03	∞	$invg$	0.025	0.007	0.043	0.070	0.041	0.100
Measurement Error									
$g^{Y,ME}$	0.002	∞	$invg$	0.001	0.001	0.002	0.016	0.011	0.020
$g^{C,ME}$	0.003	∞	$invg$	0.002	0.001	0.004	0.032	0.024	0.041
$g^{I,ME}$	0.007	∞	$invg$	0.004	0.002	0.005	0.023	0.009	0.037
$g^{G,ME}$	0.005	∞	$invg$	0.005	0.001	0.008	0.006	0.001	0.013
$g^{TBy,ME}$	0.002	∞	$invg$	0.001	0.001	0.001	0.002	0.001	0.003
Log Data Density				378.47			300.85		

Posterior results

- The measurement error in SOE model is substantially lower than NO-SOE model.
- The log marginal likelihood in SOE model is significantly higher than NO-SOE model. (378 VS 301)
- The model fitness of SOE model in terms of second moments is also better than that of the NO-SOE model. (Model fitness part)
- All suggest the data favors SOE models over NO-SOE model.

Posterior results

Posterior mean of structural parameter in SOE model

- SOE sector:
  - Upstream SOEs pay 26% of its profit back to household (Data:30%)
  - Its markup is 137% (Data: 117-128 for US)
  - Downstream SOE consists 39% of downstream sector's sales (Data:51%)
- Entrepreneur can only borrow up to 27% of their current asset value. (Data: 15-20%)

Posterior results

Posterior distribution on shocks in SOE model

- The markup shock are quite volatile and persistent ($\rho_\varepsilon = 0.87$, $e_\varepsilon = 0.316$). It is ten times more volatile than other shocks.
- The standard deviation for all other shocks are located in domain $[0.01, 0.05]$. (Data: around 0.03)
- All other shocks are less persistent. Permanent productivity shock is the least persistent ($\rho_g = 0.38$). (Data: 0.53 and 0.31 for growth rate of output and consumption)

Model fitness

Table 4: Moments predicted by SOE and NO-SOE model (HP filtered)

Statistic	Y	C	I	G	TBy
Standard deviation					
SOE Model	3.0	3.2	7.0	4.0	1.8
NO-SOE Model	2.1	2.4	5.1	4.9	1.8
Data	3.2	3.1	7.4	3.9	1.7
Correlation with output					
SOE Model		0.18	0.73	0.29	0.29
NO-SOE Model		0.04	0.51	0.58	0.30
Data		0.61	0.80	0.14	−0.05
		(0.00)	(0.00)	(0.44)	(0.80)
Correlation with trade balance					
SOE Model		−0.23	−0.24	0.06	
NO-SOE Model		−0.27	−0.49	0.20	
Data		−0.24	−0.48	−0.26	
		(0.18)	(0.01)	(0.15)	
Serial correlation					
SOE Model	0.57	0.54	0.56	0.37	0.35
NO-SOE Model	0.75	0.52	0.37	0.45	0.36
Data	0.74	0.68	0.63	0.35	0.42

SOE model prediction

- Moderate consumption volatility ($\frac{\sigma(c)}{\sigma(y)} = 1.06$ versus 0.98 in data)
- Low volatility of investment ($\frac{\sigma(i)}{\sigma(y)} = 2.33$ versus 2.33 in data)
- Procyclical trade balance ($\rho(TB/y, y)$=0.29 versus -0.05 in data)
- Does not do well in predicting the correlation between consumption and output. ($\rho(c, y)$=0.18 versus 0.61 in data)
  - This is simply due to *KPR* separable preference setting, which leads to lower correlation between consumption and output, and then in turn increases the correlation between trade balance and output.

Model comparison

Table 4: Posterior distribution of parameter in AG and GPU model

Param	Prior Mean	Prior std	Prior density	AG Model Post. Mean	AG Model 5%	AG Model 95%	GPU Model Post. Mean	GPU Model 5%	GPU Model 95%
g_{ss}	0.083	0.02	G	0.071	0.063	0.080	0.084	0.077	0.092
α	0.5	0.1	B	0.447	0.356	0.530	0.371	0.348	0.394
τ	1.174	0.5	G	1.248	0.473	1.952	1.818	0.931	2.683
ψ^k	2	1.0	G	0.900	0.476	1.347	2.182	1.131	3.302
ψ^b	1.5	1	G				0.400	0.032	0.774
ρ_g	0.5	0.2	B	0.833	0.705	0.965	0.415	0.150	0.685
ρ_z	0.5	0.2	B	0.675	0.569	0.790	0.774	0.647	0.902
ρ_{gc}	0.5	0.2	B	0.714	0.527	0.923	0.575	0.330	0.823
ρ_v	0.5	0.2	B				0.918	0.873	0.968
ρ_μ	0.5	0.2	B				0.923	0.852	0.992
ϵ_g	0.03	∞	$invg$	0.012	0.008	0.016	0.014	0.007	0.020
ϵ_z	0.03	∞	$invg$	0.016	0.013	0.020	0.015	0.012	0.019
ϵ_{gc}	0.03	∞	$invg$	0.043	0.033	0.055	0.036	0.027	0.045
ϵ_v	0.03	∞	$invg$				0.393	0.226	0.555
ϵ_μ	0.03	∞	$invg$				0.020	0.010	0.031
Measurement Error									
$g^{Y,ME}$	0.002	∞	$invg$	0.001	0.001	0.003	0.001	0.001	0.002
$g^{C,ME}$	0.003	∞	$invg$	0.022	0.017	0.026	0.003	0.001	0.005
$g^{I,ME}$	0.007	∞	$invg$	0.025	0.020	0.031	0.004	0.002	0.006
$g^{G,ME}$	0.005	∞	$invg$	0.007	0.001	0.016	0.005	0.001	0.009
$g^{TBy,ME}$	0.002	∞	$invg$	0.001	0.001	0.004	0.001	0.001	0.001
Log Data Density				324.43			359.55		

AG: Aguiar and Gopinath (2007)

GPU:Garciá-Cicco et al. (2010)

SOE VS AG and GPU Model

- Measurement error in AG Model is substantial, it absorbs about 64% of variance in data.
- Log marginal likelihood is smaller for AG and GPU model than SOE model.

Model fitness (growth rate)

Table 6: Moments predicted by SOE, NO-SOE, AG and GPU model (Growth rate)

Statistic	g^Y	g^C	g^I	g^G	TBy
Standard deviation					
SOE Model	3.0	3.3	6.9	4.7	2.7
NO-SOE Model	1.9	2.6	6.0	5.3	2.7
AG Model	3.4	2.7	6.8	5.3	21.5
GPU Model	3.0	4.7	6.8	4.3	3.0
Data	2.5	2.7	6.7	4.5	2.9
Correlation with output					
SOE Model		0.31	0.66	0.26	−0.13
NO-SOE Model		−0.10	0.43	0.50	−0.21
AG Model		0.97	0.65	0.25	−0.06
GPU Model		0.69	0.58	0.03	−0.15
Data		0.54	0.76	0.14	0.09
		(0.00)	(0.00)	(0.44)	(0.61)
Correlation with trade balance					
SOE Model		0.04	−0.44	−0.11	
NO-SOE Model		−0.29	−0.33	−0.09	
AG Model		−0.03	−0.09	−0.07	
GPU Model		−0.24	−0.27	−0.08	
Data		−0.22	−0.08	0.07	
		(0.24)	(0.68)	(0.72)	
Serial correlation					
SOE Model	0.11	0.04	0.13	−0.14	0.70
NO-SOE Model	0.50	0.07	−0.15	−0.06	0.71
AG Model	0.19	0.08	−0.04	0.04	1.00
GPU Model	0.17	0.09	−0.03	−0.12	0.73
Data	0.53	0.31	0.37	−0.03	0.79

Model fitness (HP filtered)

Table 5: Moments predicted by SOE, NO-SOE, AG and GPU model (HP filtered)

Statistic	Y	C	I	G	TBy
Standard deviation					
SOE Model	3.0	3.2	7.0	4.0	1.8
NO-SOE Model	2.1	2.4	5.1	4.9	1.8
AG Model	2.9	2.4	5.9	4.7	1.8
GPU Model	2.6	4.2	5.9	3.8	1.8
Data	3.2	3.1	7.4	3.9	1.7
Correlation with output					
SOE Model		0.18	0.73	0.29	0.29
NO-SOE Model		0.04	0.51	0.58	0.30
AG Model		0.97	0.63	0.26	0.13
GPU Model		0.67	0.58	0.05	−0.06
Data		0.61	0.80	0.14	−0.05
		(0.00)	(0.00)	(0.44)	(0.80)
Correlation with trade balance					
SOE Model		−0.23	−0.24	0.06	
NO-SOE Model		−0.27	−0.49	0.20	
AG Model		−0.01	−0.66	−0.13	
GPU Model		−0.33	−0.59	−0.03	
Data		−0.24	−0.48	−0.26	
		(0.18)	(0.01)	(0.15)	
Serial correlation					
SOE Model	0.57	0.54	0.56	0.37	0.35
NO-SOE Model	0.75	0.52	0.37	0.45	0.36
AG Model	0.51	0.47	0.43	0.47	0.45
GPU Model	0.52	0.51	0.44	0.39	0.32
Data	0.74	0.68	0.63	0.35	0.42

Comparison of model fitness

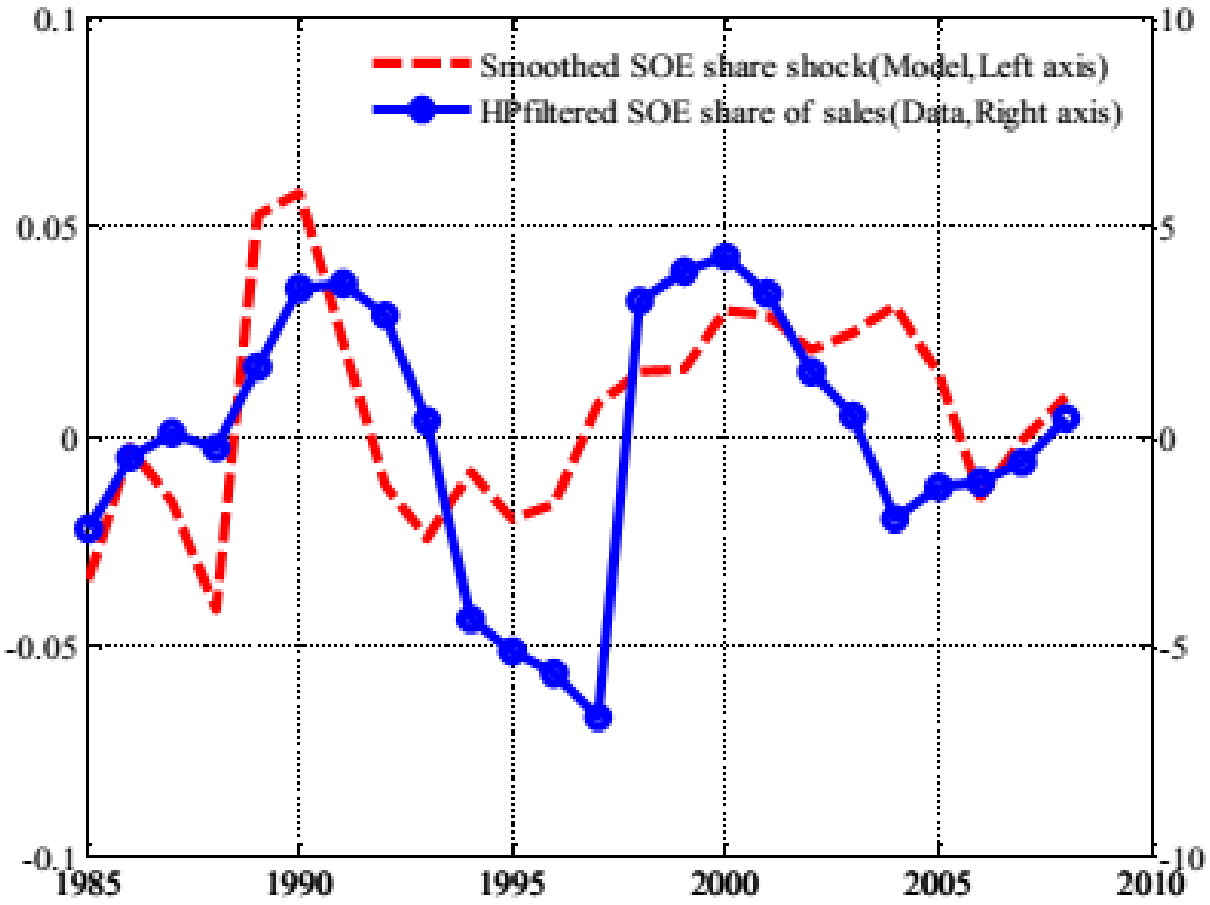
- AG model predicts enormous trade balance volatility and a nearly random walk process of trade balance. (Growth rate data)
- GPU model predicts excess consumption volatility. (HP filtered and growth rate data)
- AG and GPU model predict higher correlation between consumption and output and similar correlation between trade balance and output (growth rate data)

Estimated shocks

To verify the estimated shocks are reasonable, we compare

- estimated share shock and HP-filterd SOE's share of sales

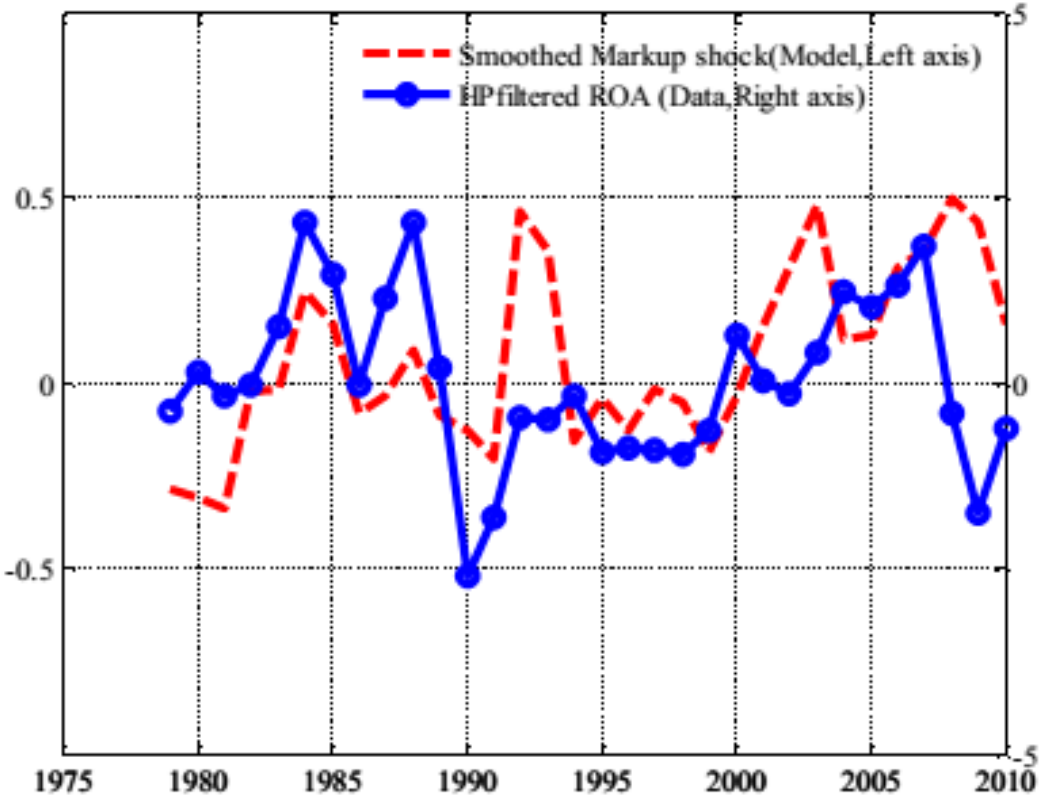
Figure 3: Smoothed Share Shock and HP-filtered SOE share of sales



Estimated shocks

- markup shock and HP-filterd SOE's ROA.

Figure 4: Smoothed Markup Shock and HP-filtered ROA

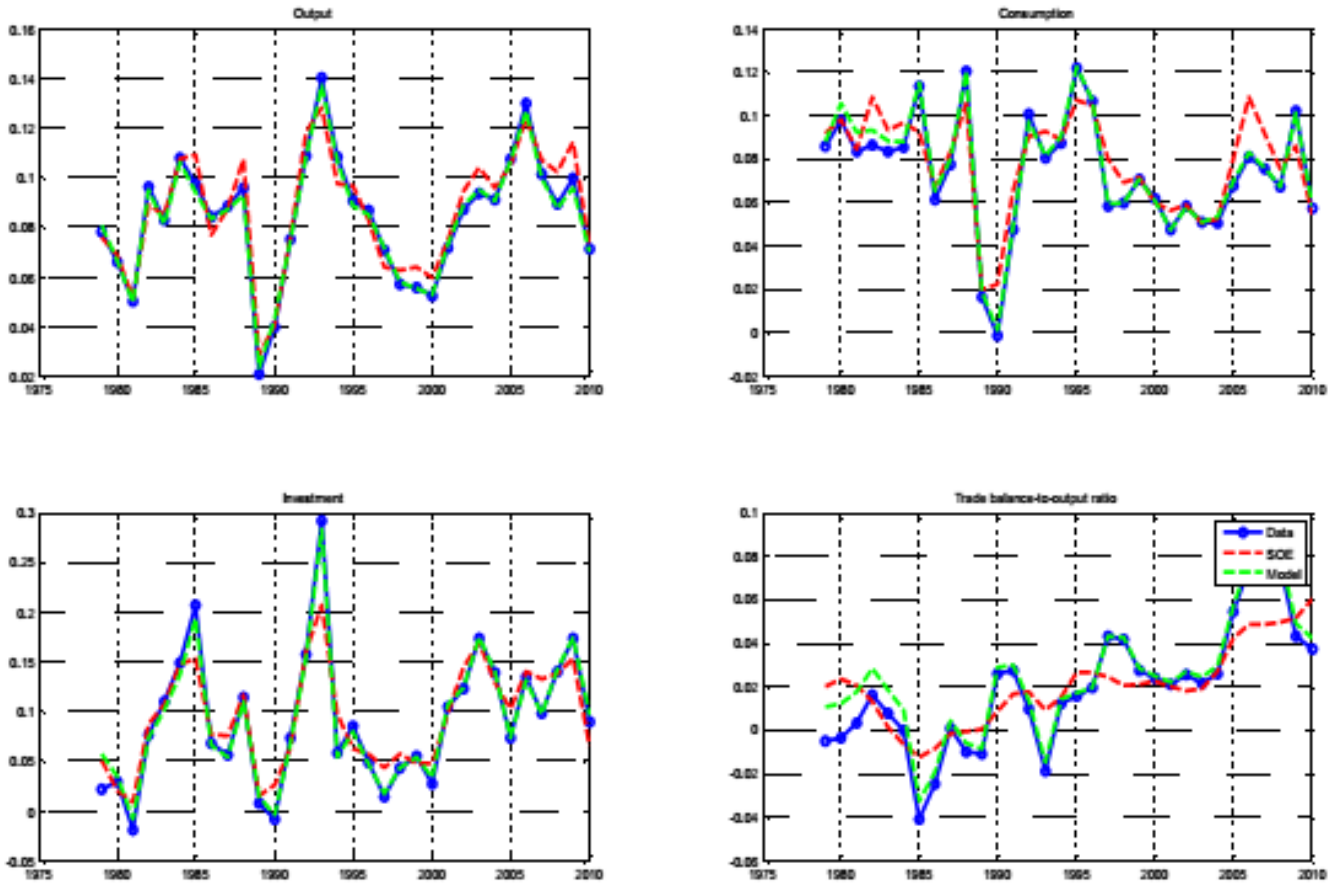


The results are obtained without using any sectoral-level data!

Role of SOE shocks

We shut down other shocks and examine role of SOE sector shocks only

Figure 5: SOE Model's prediction



Variance decomposition

Table 6: Variance decomposition by SOE model

Shocks	Perm. prod. shock	Cred. shock	Markup shock	Share shock	Divid. shock	Gov.sped. shock	Risk prem. shock	Prefer. shock
Observ.	g	ϕ	ϵ	η	ω	gc	μ	v
g^Y	5.6	4.5	17.5	67.9	0.0	1.6	2.4	0.5
g^C	3.0	7.8	10.6	68.4	0.0	2.5	4.0	3.6
g^I	8.0	16.2	46.6	25.2	0.0	0.0	1.6	2.4
g^G	5.3	0.0	0.0	0.0	0.0	94.7	0.0	0.0
TBy	15.6	10.2	45.9	11.1	0.0	1.1	11.6	4.6

Variance decomposition

- SOE matters: markup shock and share shock, as a whole, can explain **most variations in** output, consumption, investment and trade balance
- Share shock alone is responsible for nearly 70% fluctuations in output and consumption
- Markup shock alone contribute **over half** of fluctuation in investment and trade balance
- Dividend shock's role is nil
- Permanent productivity shock is less important
- Other shocks considered in emerging market business cycle literature is not important
- Credit shock is not important

Mechanism

- Moderate consumption volatility:
  - Due to the productivity differences between SOE and PE, share shock leads to endogenous and transitory TFP fluctuations. Household smooth his consumption over its life time and thus consumption volatility is reduced.
- Substantially low investment volatility:
  - In face to markup shock, the response of investment for PE firms and SOE firms will be opposite. This implies that, aggregate investment will be less volatile.
- Acyclical trade balance:
  - Markup shock introduce negative wealth effect on labor supply. Labor supply and output increase, but consumption decrease. Trade balance tends to be procyclical. This effect will cancel out the countercyclical trade balance generated by other shocks.

Results under different assumptions

Table 8: Posterior distribution of parameter in alternative models

Param	Prior Mean	Prior std	Prior density	NoVer Post. Mean	NoVer 5%	NoVer 95%	NoCredit Post. Mean	NoCredit 5%	NoCredit 95%	NoProddiff Post. Mean	NoProddiff 5%	NoProddiff 95%
φ^b	3	1	G	2.77	1.15	4.24	2.60	1.17	3.92	3.22	1.90	4.41
γ	0.5	0.1	G				0.49	0.32	0.66	0.40	0.26	0.52
α	0.3	0.1	B	0.47	0.45	0.50						
λ	5	1	G	4.60	3.03	6.15	5.03	3.45	6.54	5.39	3.86	7.13
ν	0.6	0.2	G	0.57	0.28	0.87	0.54	0.22	0.82	0.57	0.26	0.84
ε_{ss}	0.6	0.2	B				0.38	0.19	0.56	0.85	0.73	0.98
ϕ_{ss}	0.4	0.1	B	0.28	0.16	0.40	0.41	0.24	0.56	0.32	0.22	0.43
ω_{ss}	0.3	0.1	B				0.38	0.21	0.54	0.18	0.08	0.29
η_{ss}	0.4	0.1	B				0.40	0.26	0.52	0.26	0.19	0.34
φ^k	2	1	G	2.82	1.37	4.42	3.28	1.09	5.38	2.08	0.73	3.19
θ	0.7	0.1	B				0.62	0.45	0.78	0.83	0.75	0.92
ρ_g	0.5	0.2	B	0.73	0.57	0.91	0.71	0.55	0.88	0.43	0.18	0.72
ρ_ϕ	0.5	0.2	B	0.57	0.26	0.90	0.48	0.15	0.81	0.51	0.21	0.86
ρ_ε	0.5	0.2	B				0.56	0.25	0.98	0.84	0.77	0.91
ρ_η	0.5	0.2	B	0.90	0.81	0.99	0.87	0.78	0.98	0.58	0.35	0.75
ρ_ω	0.5	0.2	B				0.51	0.21	0.86	0.52	0.20	0.85
ρ_{gc}	0.5	0.2	B	0.77	0.60	0.95	0.74	0.54	0.93	0.63	0.41	0.85
ρ_μ	0.5	0.2	B	0.58	0.27	0.90	0.61	0.33	0.90	0.57	0.26	0.85
ρ_v	0.5	0.2	B	0.69	0.52	0.87	0.65	0.46	0.84	0.64	0.38	0.94
ϵ_g	0.03	∞	$invg$	0.014	0.011	0.018	0.014	0.011	0.017	0.011	0.008	0.015
ϵ_ϕ	0.03	∞	$invg$	0.012	0.006	0.018	0.025	0.007	0.045	0.012	0.007	0.017
ϵ_ε	0.03	∞	$invg$				0.030	0.007	0.061	0.222	0.175	0.280
ϵ_η	0.03	∞	$invg$	0.026	0.015	0.036	0.034	0.016	0.052	0.048	0.029	0.069
ϵ_ω	0.03	∞	$invg$				0.028	0.007	0.049	0.034	0.008	0.070
ϵ_{gc}	0.03	∞	$invg$	0.047	0.036	0.056	0.048	0.037	0.058	0.040	0.032	0.049
ϵ_μ	0.03	∞	$invg$	0.011	0.007	0.014	0.015	0.007	0.024	0.014	0.007	0.021
ϵ_v	0.03	∞	$invg$	0.071	0.036	0.105	0.061	0.027	0.095	0.023	0.007	0.042
Measurement Error												
$g^{Y,ME}$	0.002	∞	$invg$	0.001	0.001	0.002	0.001	0.010	0.002	0.001	0.001	0.002
$g^{C,ME}$	0.003	∞	$invg$	0.002	0.001	0.004	0.002	0.001	0.003	0.002	0.001	0.003
$g^{I,ME}$	0.007	∞	$invg$	0.004	0.002	0.005	0.004	0.002	0.006	0.004	0.002	0.006
$g^{G,ME}$	0.005	∞	$invg$	0.008	0.001	0.015	0.008	0.001	0.014	0.004	0.001	0.008
$g^{TBy,ME}$	0.002	∞	$invg$	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Log Data Density				357.33			364.46			371.24		

Model fitness under different assumptions

Table 9: Moments predicted by alternative models (HP filtered)

Statistic	Y	C	I	G	TBy
Standard deviation					
SOE Model	3.0	3.2	7.0	4.0	1.8
NoVer	3.5	5.0	6.3	5.0	1.9
NoCredit	3.2	4.5	6.1	5.0	1.6
NoProddiff	2.6	3.2	5.6	4.0	1.7
Data	3.2	3.1	7.4	3.9	1.7
Correlation with output					
SOE Model		0.18	0.73	0.29	0.29
NoVer		0.63	0.49	0.39	0.29
NoCredit		0.64	0.54	0.36	0.15
NoProddiff		0.35	0.66	0.29	0.23
Data		0.61	0.80	0.14	−0.05
		(0.00)	(0.00)	(0.44)	(0.80)
Correlation with trade balance					
SOE Model		−0.23	−0.24	0.06	
NoVer		−0.01	−0.41	0.17	
NoCredit		−0.06	−0.49	0.21	
NoProddiff		−0.26	−0.35	0.14	
Data		−0.24	−0.48	−0.26	
		(0.18)	(0.01)	(0.15)	
Serial correlation					
SOE Model	0.57	0.54	0.56	0.37	0.35
NoVer	0.63	0.54	0.48	0.51	0.43
NoCredit	0.64	0.57	0.40	0.45	0.22
NoProddiff	0.50	0.52	0.48	0.37	0.35
Data	0.74	0.68	0.63	0.35	0.42

Conclusion

- This paper examines the role of SOE in explaining Chinese business cycle.
- Compared to NO-SOE model and existing models, the SOE model does a better job in replicating business cycle moments in Chinese economy.
- SOE sector shocks matter: fluctuation in SOE's share in sales in downstream sector and its monopolistic power in upstream production can explain most fluctuations in macroeconomic aggregates. But other shocks are less important.
- Our findings show that Chinese real business cycle might be affected substantially by government policies, which lead to resource reallocation between SOE and PE.

Appendix: Sensitivity_JR preference

- We consider *JR* preference (Jaimovich and Rebelo 2009)

$$U = E_0 \sum_{t=0}^{\infty} \rho^t \frac{(C_t - \nu L^{\kappa} X_t)^{1-\sigma} - 1}{1-\sigma}$$

where

$$X_t = C_t^h X_{t-1}^{1-h}$$

- $h = 0$, *GHH* preference (Greenwood, Hercowitz, and Huffman, 1988)
- $h = 1$, *KPR* preference (King, Plosser, Rebelo, 1988)
- $\sigma = 1$ to compatible with balance growth

Appendix: Sensitivity_JR preference

- The estimation results show that data from 1979 to 2010 favor KPR preference over GHH preference: $h = 0.67$
- The *JR* model generates excess consumption volatility.
- Preference shocks are more important in explaining consumption volatility, but also lead to excess consumption volatility.

Appendix: Sensitivity_JR preference

Table 7: Prior and Posterior distribution of the parameters in JR model

Param	Prior Mean	Prior std	Prior density	Post. Mean	5%	95%
φ^b	3	1	G	3.40	2.00	4.72
γ	0.5	0.1	B	0.53	0.37	0.69
λ	5	1	G	4.91	3.35	6.40
ν	0.6	0.2	G	0.58	0.29	0.89
ε_{ss}	0.6	0.2	B	0.76	0.61	0.92
ϕ_{ss}	0.4	0.1	B	0.36	0.24	0.46
ω_{ss}	0.3	0.1	B	0.26	0.12	0.39
η_{ss}	0.4	0.1	B	0.41	0.32	0.51
φ^k	2	1	G	1.84	0.63	2.83
θ	0.75	0.1	B	0.71	0.60	0.82
h	0.2	0.2	B	0.66	0.48	0.84
ρ_g	0.5	0.2	B	0.41	0.12	0.65
ρ_ϕ	0.5	0.2	B	0.45	0.17	0.77
ρ_ε	0.5	0.2	B	0.87	0.77	0.95
ρ_η	0.5	0.2	B	0.66	0.50	0.83
ρ_ω	0.5	0.2	B	0.49	0.17	0.82
ρ_{gc}	0.5	0.2	B	0.61	0.41	0.82
ρ_μ	0.5	0.2	B	0.58	0.27	0.87
ρ_v	0.5	0.2	B	0.58	0.28	0.88
ϵ_g	0.03	∞	$invg$	0.010	0.006	0.013
ϵ_ϕ	0.03	∞	$invg$	0.014	0.008	0.021
ϵ_ε	0.03	∞	$invg$	0.283	0.175	0.384
ϵ_η	0.03	∞	$invg$	0.026	0.016	0.035
ϵ_ω	0.03	∞	$invg$	0.031	0.008	0.057
ϵ_{gc}	0.03	∞	$invg$	0.040	0.031	0.047
ϵ_μ	0.03	∞	$invg$	0.013	0.007	0.019
ϵ_v	0.03	∞	$invg$	0.018	0.007	0.030
Measurement Error						
$g^{Y,ME}$	0.002	∞	$invg$	0.001	0.001	0.002
$g^{C,ME}$	0.003	∞	$invg$	0.002	0.001	0.004
$g^{I,ME}$	0.007	∞	$invg$	0.004	0.002	0.006
$g^{G,ME}$	0.005	∞	$invg$	0.004	0.001	0.009
$g^{TBy,ME}$	0.002	∞	$invg$	0.001	0.001	0.001
Log Data Density				379.07		

Appendix: Sensitivity_JR preference

Table 8: Moments predicted by JR model

Statistic	Y	C	I	G	TBy
Standard deviation					
JR Model	2.9	4.2	6.5	3.8	1.9
Data	3.2	3.1	7.4	3.9	1.7
Correlation with output					
JR Model		0.30	0.66	0.13	0.27
Data		0.62	0.80	0.14	−0.05
		(0.00)	(0.00)	(0.44)	(0.80)
Correlation with trade balance					
JR Model		−0.33	−0.24	0.13	
Data		−0.24	−0.48	−0.26	
		(0.18)	(0.01)	(0.15)	
Serial correlation					
JR Model	0.52	0.62	0.49	0.34	0.45
Data	0.74	0.68	0.63	0.35	0.42

Appendix: Sensitivity_JR preference

Table 9: Variance decomposition predicted by JR model

Shocks	Perm. prod. shock	Cred. shock	Markup shock	Share shock	Divid. shock	Gov.sped. shock	Risk prem. shock	Prefer. shock
Observ.	g	ϕ	ϵ	η	ω	gc	μ	v
g^Y	10.4	1.5	23.6	62.1	0.0	0.6	1.4	0.4
g^C	6.1	4.8	27.6	27.0	0.0	6.1	6.7	21.7
g^I	22.0	2.8	34.8	17.8	0.0	0.6	14.4	7.7
g^G	5.8	0.0	0.0	0.0	0.0	94.2	0.0	0.0
TBy	18.7	6.9	42.1	2.7	0.0	2.2	17.0	10.5

Appendix: Sensitivity_Labor wedge

- We add labor market friction by introducing a labor wedge τ_l

$$\frac{w_t}{p_t} = v\tau_l L_t^{\kappa} C_t^h$$

$$\log(\tau_{l,t}) = \rho_{\tau_l} \log(\tau_{l,t-1}) + e_{\tau_l,t}$$

- However, Introducing labor wedge shock does not improve model fitness.

Appendix: Sensitivity_Labor wedge

Table 10: Prior and Posterior distribution of the parameters in model with labor wedge

Param	Prior Mean	Prior std	Prior density	Post. Mean	5%	95%
φ^b	3	1	G	2.96	1.42	4.40
γ	0.5	0.1	B	0.52	0.37	0.67
λ	5	1	G	5.23	3.41	6.61
ν	0.6	0.2	G	0.64	0.33	0.97
ε_{ss}	0.6	0.2	B	0.76	0.58	0.96
ϕ_{ss}	0.4	0.1	B	0.27	0.17	0.36
ω_{ss}	0.3	0.1	B	0.25	0.12	0.38
η_{ss}	0.4	0.1	B	0.39	0.28	0.49
φ^k	2	1	G	1.64	0.57	2.72
θ	0.7	0.1	B	0.75	0.64	0.87
ρ_g	0.5	0.2	B	0.37	0.11	0.63
ρ_ϕ	0.5	0.2	B	0.51	0.20	0.85
ρ_ε	0.5	0.2	B	0.86	0.79	0.94
ρ_η	0.5	0.2	B	0.68	0.51	0.85
ρ_ω	0.5	0.2	B	0.50	0.18	0.82
ρ_{gc}	0.5	0.2	B	0.65	0.41	0.87
ρ_μ	0.5	0.2	B	0.61	0.32	0.91
ρ_v	0.5	0.2	B	0.59	0.32	0.87
ρ_{τ_l}	0.5	0.2	B	0.74	0.53	0.98
ϵ_g	0.03	∞	$invg$	0.011	0.007	0.015
ϵ_ϕ	0.03	∞	$invg$	0.013	0.007	0.018
ϵ_ε	0.03	∞	$invg$	0.296	0.193	0.400
ϵ_η	0.03	∞	$invg$	0.029	0.017	0.043
ϵ_ω	0.03	∞	$invg$	0.024	0.008	0.044
ϵ_{gc}	0.03	∞	$invg$	0.041	0.031	0.050
ϵ_μ	0.03	∞	$invg$	0.013	0.007	0.018
ϵ_v	0.03	∞	$invg$	0.020	0.008	0.033
ϵ_{τ_l}	0.03	∞	$invg$	0.007	0.005	0.008
Measurement Error						
$g^{Y,ME}$	0.002	∞	$invg$	0.001	0.001	0.002
$g^{C,ME}$	0.003	∞	$invg$	0.002	0.001	0.003
$g^{I,ME}$	0.007	∞	$invg$	0.003	0.002	0.005
$g^{G,ME}$	0.005	∞	$invg$	0.003	0.001	0.005
$g^{TBy,ME}$	0.002	∞	$invg$	0.001	0.001	0.002
Log Data Density				366.06		

Appendix: Sensitivity_Labor wedge

Table 11: Moments predicted by model with labor wedge

Statistic	Y	C	I	G	TBy
Standard deviation					
Labor wedge Model	2.8	3.4	6.4	4.1	1.7
Data	3.2	3.1	7.4	3.9	1.7
Correlation with output					
Labor wedge Model		0.23	0.68	0.21	0.29
Data		0.62	0.80	0.14	−0.05
		(0.00)	(0.00)	(0.44)	(0.80)
Correlation with trade balance					
Labor wedge Model		−0.19	−0.26	0.04	
Data		−0.24	−0.48	−0.26	
		(0.18)	(0.01)	(0.15)	
Serial correlation					
Labor wedge Model	0.54	0.53	0.52	0.37	0.32
Data	0.74	0.68	0.63	0.35	0.42

Appendix: Sensitivity_Labor wedge

Table 12: Variance decomposition predicted by model with labor wedge

Shocks	Perm. prod. shock	Cred. shock	Markup shock	Share shock	Divid. shock	Gov.sped. shock	Risk prem. shock	Prefer. shock	Lab. shock
Observ.	g	ϕ	ϵ	η	ω	gc	μ	v	τ_l
g^Y	4.2	2.7	14.5	76.0	0.0	1.2	0.8	0.7	0.0
g^C	2.1	4.6	8.5	75.2	0.0	0.0	1.8	1.3	4.9
g^I	7.3	11.6	43.2	33.2	0.0	0.0	0.7	4.0	0.0
g^G	5.2	0.0	0.0	0.0	0.0	94.8	0.0	0.0	0.0
TBy	15.2	8.1	44.7	17.0	0.0	1.1	5.1	8.4	0.5

Appendix: Sensitivity_habit formation

Period utility function:

$$U^h = ln(C_t^h - \sigma C_{t-1}^h) - \frac{vL^{1+\kappa}}{1+\kappa}$$

$$U^e = ln(C_t^e - \sigma C_{t-1}^e)$$

Appendix: Sensitivity_habit formation

Table C1: Prior and Posterior distribution of the parameters in model with habit formation

Param	Prior Mean	Prior std	Prior density	Post. Mean	5%	95%
φ^b	3	1	G	2.61	1.41	3.86
γ	0.5	0.1	B	0.52	0.37	0.66
λ	5	1	G	5.29	3.60	6.86
ν	0.6	0.2	G	0.68	0.37	1.00
ε_{ss}	0.6	0.2	B	0.73	0.54	0.90
ϕ_{ss}	0.4	0.1	B	0.25	0.15	0.34
ω_{ss}	0.3	0.1	B	0.27	0.13	0.41
η_{ss}	0.4	0.1	B	0.41	0.32	0.49
φ^k	2	1	G	1.57	0.53	2.56
θ	0.7	0.1	B	0.76	0.67	0.87
σ	0.5	0.2	B	0.41	0.19	0.59
ρ_g	0.5	0.2	B	0.39	0.12	0.65
ρ_ϕ	0.5	0.2	B	0.48	0.17	0.81
ρ_ε	0.5	0.2	B	0.88	0.79	0.96
ρ_η	0.5	0.2	B	0.75	0.61	0.90
ρ_ω	0.5	0.2	B	0.50	0.17	0.82
ρ_{gc}	0.5	0.2	B	0.63	0.43	0.85
ρ_μ	0.5	0.2	B	0.58	0.29	0.90
ρ_v	0.5	0.2	B	0.54	0.21	0.83
ϵ_g	0.03	∞	$invg$	0.010	0.007	0.014
ϵ_ϕ	0.03	∞	$invg$	0.016	0.007	0.023
ϵ_ε	0.03	∞	$invg$	0.321	0.209	0.438
ϵ_η	0.03	∞	$invg$	0.033	0.020	0.044
ϵ_ω	0.03	∞	$invg$	0.054	0.007	0.184
ϵ_{gc}	0.03	∞	$invg$	0.039	0.031	0.048
ϵ_μ	0.03	∞	$invg$	0.013	0.007	0.019
ϵ_v	0.03	∞	$invg$	0.022	0.007	0.037
Measurement Error						
$g^{Y,ME}$	0.002	∞	$invg$	0.001	0.001	0.002
$g^{C,ME}$	0.003	∞	$invg$	0.002	0.001	0.003
$g^{I,ME}$	0.007	∞	$invg$	0.004	0.002	0.006
$g^{G,ME}$	0.005	∞	$invg$	0.004	0.001	0.008
$g^{TBy,ME}$	0.002	∞	$invg$	0.001	0.001	0.001
Log Data Density				380.24		

Appendix: Sensitivity_habit formation

Table C2: Moments predicted by model with habit formation (HP filtered)

Statistic	Y	C	I	G	TBy
Standard deviation					
Habit Formation	3.1	3.3	6.9	3.9	1.8
Data	3.2	3.1	7.4	3.9	1.7
Correlation with output					
Habit Formation		0.14	0.76	0.28	0.33
Data		0.62	0.80	0.14	−0.05
		(0.00)	(0.00)	(0.44)	(0.80)
Correlation with trade balance					
Habit Formation		−0.38	−0.14	0.12	
Data		−0.24	−0.48	−0.26	
		(0.18)	(0.01)	(0.15)	
Serial correlation					
Habit Formation	0.57	0.70	0.57	0.38	0.43
Data	0.74	0.68	0.63	0.35	0.42

Appendix: Sensitivity_habit formation

Table 27: Variance decomposition predicted by model with habit formation

Shocks	Perm. prod. shock	Cred. shock	Markup shock	Share shock	Divid. shock	Gov.sped. shock	Risk prem. shock	Prefer. shock
Observ.	g	ϕ	ϵ	η	ω	gc	μ	v
g^Y	9.5	1.8	21.3	61.6	0.0	2.4	1.7	1.7
g^C	4.8	0.8	17.9	69.1	0.0	1.5	0.7	5.3
g^I	8.0	3.0	49.2	34.3	0.0	0.0	1.3	4.2
g^G	8.2	0.0	0.0	0.0	0.0	91.8	0.0	0.0
TBy	23.8	3.0	41.0	15.8	0.0	1.5	5.2	9.7

Appendix: Sensitivity_World price shock

World Price Shock

$$\log(\pi) = \rho_\pi \log(\pi(-1)) + e_\pi$$

Table 23: Variance decomposition predicted by model with world price shock

Shocks	Perm. prod. shock	Cred. shock	Markup shock	Share shock	Divid. shock	Gov.sped. shock	Risk prem. shock	Prefer. shock	World.P shock
Observ.	g	ϕ	ϵ	η	ω	gc	μ	v	π
g^Y	12.1	2.6	19.8	46.4	0.0	2.0	2.0	1.4	13.8
g^C	7.8	4.2	18.4	27.6	0.0	3.0	2.5	10.1	26.4
g^I	11.8	3.1	48.2	17.7	0.0	0.0	3.5	9.7	5.9
g^G	8.4	0.0	0.0	0.0	0.0	90.9	0.0	0.0	0.0
TBy	16.7	2.6	29.9	2.1	0.0	0.6	5.9	6.2	35.8