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1 CONSUMER

1.1 Optimisation problem

$$\max_{K^{\mathrm{s}}_t, C_t, L^{\mathrm{s}}_t, I_t} U_t = \beta \mathrm{E}_t \left[U_{t+1} \right] + (1-\eta)^{-1} \left({C_t}^{\mu} (1 - L^{\mathrm{s}}_t)^{1-\mu} \right)^{1-\eta} \tag{1.1}$$

s.t. :

$$C_t + I_t = \pi_t + K^{\mathrm{s}}_{t-1} r_t + L^{\mathrm{s}}_t W_t - \psi K^{\mathrm{s}}_{t-1} \left(-\delta + {K^{\mathrm{s}}_{t-1}}^{-1} I_t \right)^2 \quad (\lambda^{\mathrm{c}}_t) \tag{1.2}$$

$$K^{\mathrm{s}}_t = I_t + K^{\mathrm{s}}_{t-1} (1-\delta) \quad \left(\lambda^{\mathrm{CONSUMER}^2}_t \right) \tag{1.3}$$

1.2 First order conditions

$$-\lambda^{\mathrm{CONSUMER}^2}_t + \beta \left((1-\delta) \mathrm{E}_t \left[\lambda^{\mathrm{CONSUMER}^2}_{t+1} \right] + \mathrm{E}_t \left[\lambda^{\mathrm{c}}_{t+1} \left(r_{t+1} - \psi \left(-\delta + {K^{\mathrm{s}}_t}^{-1} I_{t+1} \right)^2 + 2\psi {K^{\mathrm{s}}_t}^{-1} I_{t+1} \left(-\delta + {K^{\mathrm{s}}_t}^{-1} I_{t+1} \right) \right) \right] \right) = 0 \quad (K^{\mathrm{s}}_t) \tag{1.4}$$

$$-\lambda^{\mathrm{c}}_t + \mu {C_t}^{-1+\mu} (1 - L^{\mathrm{s}}_t)^{1-\mu} \left({C_t}^{\mu} (1 - L^{\mathrm{s}}_t)^{1-\mu} \right)^{-\eta} = 0 \quad (C_t) \tag{1.5}$$

$$\lambda^{\mathrm{c}}_t W_t + (-1+\mu) {C_t}^{\mu} (1 - L^{\mathrm{s}}_t)^{-\mu} \left({C_t}^{\mu} (1 - L^{\mathrm{s}}_t)^{1-\mu} \right)^{-\eta} = 0 \quad (L^{\mathrm{s}}_t) \tag{1.6}$$

$$\lambda^{\mathrm{CONSUMER}^2}_t + \lambda^{\mathrm{c}}_t \left(-1 - 2\psi \left(-\delta + {K^{\mathrm{s}}_{t-1}}^{-1} I_t \right) \right) = 0 \quad (I_t) \tag{1.7}$$

2 FIRM

2.1 Optimisation problem

$$\max_{K^{\mathrm{d}}_t, L^{\mathrm{d}}_t, Y_t, \pi_t} \Pi_t = \pi_t \tag{2.1}$$

s.t. :

$$Y_t = Z_t {K^{\mathrm{d}}_t}^{\alpha} {L^{\mathrm{d}}_t}^{1-\alpha} \quad \left(\lambda^{\mathrm{FIRM}^1}_t \right) \tag{2.2}$$

$$\pi_t = Y_t - L^{\mathrm{d}}_t W_t - r_t K^{\mathrm{d}}_t \quad \left(\lambda^{\mathrm{FIRM}^2}_t \right) \tag{2.3}$$

2.2 First order conditions

$$-\lambda^{\mathrm{FIRM}^2}_t r_t + \alpha \lambda^{\mathrm{FIRM}^1}_t Z_t {K^{\mathrm{d}}_t}^{-1+\alpha} {L^{\mathrm{d}}_t}^{1-\alpha} = 0 \quad \left(K^{\mathrm{d}}_t\right) \tag{2.4}$$

$$-\lambda^{\mathrm{FIRM}^2}_t W_t + \lambda^{\mathrm{FIRM}^1}_t Z_t \left(1-\alpha\right) {K^{\mathrm{d}}_t}^{\alpha} {L^{\mathrm{d}}_t}^{-\alpha} = 0 \quad \left(L^{\mathrm{d}}_t\right) \tag{2.5}$$

$$-\lambda^{\mathrm{FIRM}^1}_t + \lambda^{\mathrm{FIRM}^2}_t = 0 \quad \left(Y_t\right) \tag{2.6}$$

$$1 - \lambda^{\mathrm{FIRM}^2}_t = 0 \quad \left(\pi_t\right) \tag{2.7}$$

2.3 First order conditions after reduction

$$-r_t + \alpha Z_t {K^{\mathrm{d}}_t}^{-1+\alpha} {L^{\mathrm{d}}_t}^{1-\alpha} = 0 \quad \left(K^{\mathrm{d}}_t\right) \tag{2.8}$$

$$-W_t + Z_t \left(1-\alpha\right) {K^{\mathrm{d}}_t}^{\alpha} {L^{\mathrm{d}}_t}^{-\alpha} = 0 \quad \left(L^{\mathrm{d}}_t\right) \tag{2.9}$$

3 EQUILIBRIUM

3.1 Identities

$$K^{\mathrm{d}}_t = K^{\mathrm{s}}_{t-1} \tag{3.1}$$

$$L^{\mathrm{d}}_t = L^{\mathrm{s}}_t \tag{3.2}$$

4 EXOG

4.1 Identities

$$Z_t = e^{\epsilon^{\mathrm{Z}}_t + \phi \log Z_{t-1}} \tag{4.1}$$

5 Equilibrium relationships (after reduction)

$$-r_t + \alpha Z_t {K^{\mathrm{s}}_{t-1}}^{-1+\alpha} {L^{\mathrm{s}}_t}^{1-\alpha} = 0 \tag{5.1}$$

$$-W_t + Z_t \left(1-\alpha\right) {K^{\mathrm{s}}_{t-1}}^{\alpha} {L^{\mathrm{s}}_t}^{-\alpha} = 0 \tag{5.2}$$

$$-Y_t + Z_t {K^{\mathrm{s}}_{t-1}}^{\alpha} {L^{\mathrm{s}}_t}^{1-\alpha} = 0 \tag{5.3}$$

$$Z_t - e^{\epsilon^{\mathrm{Z}}_t + \phi \log Z_{t-1}} = 0 \tag{5.4}$$

$$\beta \Bigg(\mu \mathrm{E}_t \Bigg[\Bigg(r_{t+1} - \psi \Big(-\delta + {K^{\mathrm{s}}_t}^{-1} I_{t+1}\Big)^2 + 2\psi {K^{\mathrm{s}}_t}^{-1} I_{t+1} \Big(-\delta + {K^{\mathrm{s}}_t}^{-1} I_{t+1}\Big)\Bigg) {C_{t+1}}^{-1+\mu} (1 - L^{\mathrm{s}}_{t+1})^{1-\mu} \Big({C_{t+1}}^{\mu} (1 - L^{\mathrm{s}}_{t+1})^{1-\mu}\Big)^{-\eta}\Bigg] - \mu (1-\delta) \mathrm{E}_t \Bigg[\Bigg(-1 - 2\psi \Big(-\delta + {K^{\mathrm{s}}_t}^{-1} I_{t+1}\Big)\Bigg) {C_{t+1}}^{-1} \tag{5.5}$$

$$(-1+\mu) {C_t}^{\mu} (1 - L^{\mathrm{s}}_t)^{-\mu} \Big({C_t}^{\mu} (1 - L^{\mathrm{s}}_t)^{1-\mu}\Big)^{-\eta} + \mu W_t {C_t}^{-1+\mu} (1 - L^{\mathrm{s}}_t)^{1-\mu} \Big({C_t}^{\mu} (1 - L^{\mathrm{s}}_t)^{1-\mu}\Big)^{-\eta} = 0 \tag{5.6}$$

$$I_t - K^{\mathrm{s}}_t + K^{\mathrm{s}}_{t-1} (1-\delta) = 0 \tag{5.7}$$

$$U_t - \beta \mathrm{E}_t [U_{t+1}] - (1-\eta)^{-1} \Big({C_t}^{\mu} (1 - L^{\mathrm{s}}_t)^{1-\mu}\Big)^{1-\eta} = 0 \tag{5.8}$$

$$-C_t - I_t + Y_t - \psi K^{\mathrm{s}}_{t-1} \Big(-\delta + {K^{\mathrm{s}}_{t-1}}^{-1} I_t\Big)^2 = 0 \tag{5.9}$$

6 Steady state relationships (after reduction)

$$-r_{\mathrm{ss}} + \alpha Z_{\mathrm{ss}} {K^{\mathrm{s}}_{\mathrm{ss}}}^{-1+\alpha} {L^{\mathrm{s}}_{\mathrm{ss}}}^{1-\alpha} = 0 \tag{6.1}$$

$$-W_{\mathrm{ss}} + Z_{\mathrm{ss}} (1-\alpha) {K^{\mathrm{s}}_{\mathrm{ss}}}^{\alpha} {L^{\mathrm{s}}_{\mathrm{ss}}}^{-\alpha} = 0 \tag{6.2}$$

$$-Y_{\mathrm{ss}} + Z_{\mathrm{ss}} {K^{\mathrm{s}}_{\mathrm{ss}}}^{\alpha} {L^{\mathrm{s}}_{\mathrm{ss}}}^{1-\alpha} = 0 \tag{6.3}$$

$$Z_{\mathrm{ss}} - e^{\phi \log Z_{\mathrm{ss}}} = 0 \tag{6.4}$$

$$\beta \Bigg(\mu \Bigg(r_{\mathrm{ss}} - \psi \Big(-\delta + I_{\mathrm{ss}} {K^{\mathrm{s}}_{\mathrm{ss}}}^{-1}\Big)^2 + 2\psi I_{\mathrm{ss}} {K^{\mathrm{s}}_{\mathrm{ss}}}^{-1} \Big(-\delta + I_{\mathrm{ss}} {K^{\mathrm{s}}_{\mathrm{ss}}}^{-1}\Big)\Bigg) {C_{\mathrm{ss}}}^{-1+\mu} (1 - L^{\mathrm{s}}_{\mathrm{ss}})^{1-\mu} \Big({C_{\mathrm{ss}}}^{\mu} (1 - L^{\mathrm{s}}_{\mathrm{ss}})^{1-\mu}\Big)^{-\eta} - \mu \Big(-1 - 2\psi \Big(-\delta + I_{\mathrm{ss}} {K^{\mathrm{s}}_{\mathrm{ss}}}^{-1}\Big)\Big) (1-\delta) {C_{\mathrm{ss}}}^{-1+\mu} (1 - L^{\mathrm{s}}_{\mathrm{ss}})^{1-\mu} \Big({C_{\mathrm{ss}}}^{\mu} (1 \tag{6.5}$$

$$(-1+\mu) {C_{\mathrm{ss}}}^{\mu} (1 - L^{\mathrm{s}}_{\mathrm{ss}})^{-\mu} \Big({C_{\mathrm{ss}}}^{\mu} (1 - L^{\mathrm{s}}_{\mathrm{ss}})^{1-\mu}\Big)^{-\eta} + \mu W_{\mathrm{ss}} {C_{\mathrm{ss}}}^{-1+\mu} (1 - L^{\mathrm{s}}_{\mathrm{ss}})^{1-\mu} \Big({C_{\mathrm{ss}}}^{\mu} (1 - L^{\mathrm{s}}_{\mathrm{ss}})^{1-\mu}\Big)^{-\eta} = 0 \tag{6.6}$$

$$I_{\mathrm{ss}} - K^{\mathrm{s}}_{\mathrm{ss}} + K^{\mathrm{s}}_{\mathrm{ss}} \left(1 - \delta\right) = 0 \tag{6.7}$$

$$U_{\mathrm{ss}} - \beta U_{\mathrm{ss}} - \left(1 - \eta\right)^{-1} \left({C_{\mathrm{ss}}}^{\mu} \left(1 - L^{\mathrm{s}}_{\mathrm{ss}}\right)^{1-\mu}\right)^{1-\eta} = 0 \tag{6.8}$$

$$-C_{\mathrm{ss}} - I_{\mathrm{ss}} + Y_{\mathrm{ss}} - \psi K^{\mathrm{s}}_{\mathrm{ss}} \left(-\delta + I_{\mathrm{ss}} {K^{\mathrm{s}}_{\mathrm{ss}}}^{-1}\right)^{2} = 0 \tag{6.9}$$

7 Calibrating equations

$$-0.36 Y_{\mathrm{ss}} + r_{\mathrm{ss}} K^{\mathrm{s}}_{\mathrm{ss}} = 0 \tag{7.1}$$

8 Parameter settings

$$\beta = 0.99 \tag{8.1}$$

$$\delta = 0.025 \tag{8.2}$$

$$\eta = 2 \tag{8.3}$$

$$\mu = 0.3 \tag{8.4}$$

$$\phi = 0.95 \tag{8.5}$$

$$\psi = 0.8 \tag{8.6}$$

9 Steady-state values

	Steady-state values
r	0.0351
C	0.7422
I	0.2559
K^{s}	10.2368
L^{s}	0.2695
U	-136.2372
W	2.3706
Y	0.9981
Z	1

10 The solution of the perturbation

10.1 P

$$\begin{array}{c} \\ K^{\mathrm{s}} \\ Z \end{array} \begin{array}{c} \begin{array}{cc} K^{\mathrm{s}}_{t-1} & Z_{t-1} \end{array} \\ \begin{pmatrix} 0.9658 & 0.0863 \\ 0 & 0.95 \end{pmatrix} \end{array}$$

10.2 Q

$$\begin{array}{c} \\ K^{\mathrm{s}} \\ Z \end{array} \begin{array}{c} \epsilon^{\mathrm{Z}} \\ \begin{pmatrix} 0.0908 \\ 1 \end{pmatrix} \end{array}$$

10.3 R

$$\begin{array}{c} \\ r \\ C \\ I \\ L^{\mathrm{s}} \\ U \\ W \\ Y \end{array} \begin{array}{c} \begin{array}{cc} K^{\mathrm{s}}_{t-1} & Z_{t-1} \end{array} \\ \begin{pmatrix} -0.7408 & 1.2972 \\ 0.4748 & 0.5545 \\ -0.3661 & 3.4511 \\ -0.1575 & 0.5426 \\ -0.0418 & -0.0644 \\ 0.4167 & 0.7547 \\ 0.2592 & 1.2972 \end{pmatrix} \end{array}$$

10.4 S

$$\begin{array}{c} \\ r \\ C \\ I \\ L^{\mathrm{s}} \\ U \\ W \\ Y \end{array} \begin{array}{c} \epsilon^{\mathrm{Z}} \\ \begin{pmatrix} 1.3655 \\ 0.5837 \\ 3.6328 \\ 0.5711 \\ -0.0678 \\ 0.7944 \\ 1.3655 \end{pmatrix} \end{array}$$

11 Statistics of the model

11.1 Moments

	Steady-state value	Std. dev.	Variance	Loglinear
r	0.0351	0.1814	0.0329	Y
C	0.7422	0.0783	0.0061	Y
I	0.2559	0.4741	0.2248	Y
K^s	10.2368	0.0422	0.0018	Y
L^s	0.2695	0.0749	0.0056	Y
U	-136.2372	0.009	0.0001	Y
W	2.3706	0.1047	0.011	Y
Y	0.9981	0.1781	0.0317	Y
Z	1	0.1303	0.017	Y

11.2 Correlation matrix

	r	C	I	K^s	L^s	U	W	Y	Z
r	1	0.9082	0.9901	0.0897	0.9965	-0.9321	0.9422	0.9726	0.9851
C	0.9082	1	0.9579	0.4983	0.9402	-0.9981	0.996	0.9806	0.9667
I	0.9901	0.9579	1	0.2284	0.9984	-0.9736	0.9798	0.9956	0.9995
K^s	0.0897	0.4983	0.2284	1	0.1733	-0.4445	0.4184	0.3187	0.2599
L^s	0.9965	0.9402	0.9984	0.1733	1	-0.9592	0.967	0.9887	0.9961
U	-0.9321	-0.9981	-0.9736	-0.4445	-0.9592	1	-0.9996	-0.9907	-0.9805
W	0.9422	0.996	0.9798	0.4184	0.967	-0.9996	1	0.9942	0.9858
Y	0.9726	0.9806	0.9956	0.3187	0.9887	-0.9907	0.9942	1	0.9981
Z	0.9851	0.9667	0.9995	0.2599	0.9961	-0.9805	0.9858	0.9981	1

11.3 Autocorrelations

	$t-1$	$t-2$	$t-3$	$t-4$	$t-5$
r	0.7103	0.4664	0.2655	0.1042	-0.0215
C	0.7446	0.5209	0.3292	0.1686	0.0376
I	0.7115	0.4684	0.2679	0.1066	-0.0193
K^s	0.9598	0.8626	0.7281	0.5723	0.4082
L^s	0.7098	0.4657	0.2647	0.1034	-0.0223
U	0.7346	0.505	0.3106	0.1498	0.0204
W	0.7304	0.4983	0.3028	0.1419	0.0131
Y	0.7179	0.4786	0.2798	0.1186	-0.0083
Z	0.7133	0.4711	0.2711	0.1098	-0.0163

12 Statistics of the model

12.1 Moments relative to moments of the reference variable

	Steady-state value relative to Y	Std. dev. relative to Y	Variance relative to Y	Loglinear
r	0.0352	1.0184	1.0372	Y
C	0.7436	0.4395	0.1931	Y
I	0.2564	2.6621	7.0869	Y
K^s	10.2561	0.2368	0.0561	Y
L^s	0.27	0.4205	0.1768	Y
U	-136.4937	0.0504	0.0025	Y
W	2.3751	0.5877	0.3453	Y
Y	1	1	1	Y
Z	1.0019	0.7319	0.5357	Y

12.2 Correlations with the reference variable

	Y_{t-5}	Y_{t-4}	Y_{t-3}	Y_{t-2}	Y_{t-1}	Y_t	Y_{t+1}	Y_{t+2}	Y_{t+3}	Y_{t+4}	Y_{t+5}
r	0.1089	0.228	0.3727	0.5446	0.7446	0.9726	0.6308	0.3527	0.1323	-0.0369	-0.1614
C	-0.1067	0.0213	0.1894	0.4025	0.665	0.9806	0.7609	0.5644	0.3923	0.2448	0.1212
I	0.039	0.1636	0.3192	0.5084	0.7335	0.9956	0.6875	0.4309	0.222	0.0566	-0.0702
K^{s}	-0.4795	-0.4216	-0.3213	-0.1704	0.0399	0.3187	0.5039	0.6124	0.6595	0.6589	0.6227
L^{s}	0.0671	0.1898	0.3414	0.5242	0.7397	0.9887	0.6664	0.4006	0.1865	0.0192	-0.1069
U	0.0765	-0.0517	-0.2183	-0.4279	-0.6842	-0.9907	-0.7507	-0.54	-0.3589	-0.2065	-0.0814
W	-0.0621	0.066	0.2318	0.4393	0.6925	0.9942	0.7449	0.5278	0.3426	0.1881	0.0624
Y	-0.0083	0.1186	0.2798	0.4786	0.7179	1	0.7179	0.4786	0.2798	0.1186	-0.0083
Z	0.0226	0.1481	0.3058	0.4986	0.7288	0.9981	0.6988	0.4479	0.2423	0.0782	-0.0488

13 Impulse response functions

13.1 Shock ϵ^Z

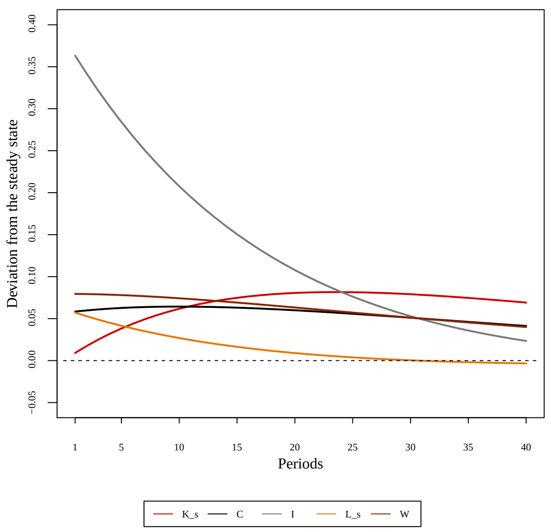

Figure 1: Impulse response function for ϵ^Z shock

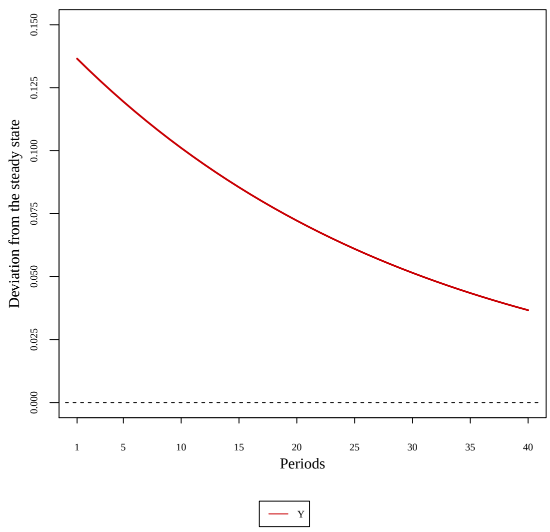

Figure 2: Impulse response function for ϵ^Z shock