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Model name: rbc_cu

1 CONSUMER

1.1 Optimization problem

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

s.t. :

$$C_t = \pi_t + L_t^s W_t \quad (\lambda_t^c) \tag{1.2}$$

1.2 First order conditions

$$\beta - \lambda_t^U = 0 \quad (U_t) \tag{1.3}$$

$$-\lambda_t^c + \mu {C_t}^{-1+\mu} (1-L_t^s)^{1-\mu} \left((1-L_t^s)^{1-\mu} {C_t}^{\mu}\right)^{-\eta} = 0 \quad (C_t) \tag{1.4}$$

$$\lambda_t^c W_t + (-1+\mu)(1-L_t^s)^{-\mu} \left((1-L_t^s)^{1-\mu} {C_t}^{\mu}\right)^{-\eta} {C_t}^{\mu} = 0 \quad (L_t^s) \tag{1.5}$$

2 FIRM

2.1 Optimization problem

$$\max_{K_t, L_t^d, Y_t, I_t, \pi_t, CapUt_t} \Pi_t = \pi_t + {\lambda_t^c}^{-1} \mathrm{E}_t \left[\lambda_{t+1}^c \lambda_{t+1}^U \Pi_{t+1}\right] \tag{2.1}$$

s.t. :

$$Y_t = {L_t^d}^{1-\alpha} {Z_t}^{1-\alpha} (K_{t-1} CapUt_t)^{\alpha} \quad (\lambda_t^{\mathrm{FIRM}^1}) \tag{2.2}$$

$$K_t = I_t + K_{t-1}\left(1 - \delta {CapUt_t}^{\omega}\right) \quad (\lambda_t^{\mathrm{FIRM}^2}) \tag{2.3}$$

$$\pi_t = -I_t - L_t^d W_t + P_t Y_t \quad (\lambda_t^{\mathrm{FIRM}^3}) \tag{2.4}$$

2.2 First order conditions

$$-\lambda_t^{\mathrm{FIRM}^{\Pi}} + {\lambda_{t-1}^c}^{-1} \lambda_t^c \lambda_t^U = 0 \quad (\Pi_t) \tag{2.5}$$

$$-\lambda_t^{\mathrm{FIRM}^2} + \mathrm{E}_t \left[\lambda_{t+1}^{\mathrm{FIRM}^{\Pi}} \left(\lambda_{t+1}^{\mathrm{FIRM}^2} \left(1 - \delta {CapUt_{t+1}}^{\omega}\right) + \alpha \lambda_{t+1}^{\mathrm{FIRM}^1} CapUt_{t+1} {L_{t+1}^d}^{1-\alpha} {Z_{t+1}}^{1-\alpha} \left(K_t CapUt_{t+1}\right)^{-1+\alpha}\right)\right] = 0 \quad (K_t) \tag{2.6}$$

$$-\lambda_t^{\mathrm{FIRM}^3} W_t + \lambda_t^{\mathrm{FIRM}^1} (1-\alpha) {L_t^d}^{-\alpha} {Z_t}^{1-\alpha} (K_{t-1} CapUt_t)^{\alpha} = 0 \quad (L_t^d) \tag{2.7}$$

$$-\lambda_t^{\mathrm{FIRM}^1} + \lambda_t^{\mathrm{FIRM}^3} P_t = 0 \quad (Y_t) \tag{2.8}$$

$$\lambda_t^{\mathrm{FIRM}^2} - \lambda_t^{\mathrm{FIRM}^3} = 0 \quad (I_t) \tag{2.9}$$

$$1 - \lambda_t^{\mathrm{FIRM}^3} = 0 \quad (\pi_t) \tag{2.10}$$

$$-\delta \omega K_{t-1} \lambda_t^{\mathrm{FIRM}^2} {CapUt_t}^{-1+\omega} + \alpha K_{t-1} \lambda_t^{\mathrm{FIRM}^1} {L_t^d}^{1-\alpha} {Z_t}^{1-\alpha} (K_{t-1} CapUt_t)^{-1+\alpha} = 0 \quad (CapUt_t) \tag{2.11}$$

2.3 First order conditions after reduction

$$-\lambda_t^{\text{FIRM}^{\Pi}} + {\lambda_{t-1}^c}^{-1}\lambda_t^c\lambda_t^U = 0 \quad (\Pi_t) \tag{2.12}$$

$$-1 + \mathrm{E}_t\left[\lambda_{t+1}^{\text{FIRM}^{\Pi}}\left(1 - \delta {CaqUt_{t+1}}^{\omega} + \alpha\lambda_{t+1}^{\text{FIRM}^1} CaqUt_{t+1} {L_{t+1}^d}^{1-\alpha} {Z_{t+1}}^{1-\alpha}\left(K_t CaqUt_{t+1}\right)^{-1+\alpha}\right)\right] = 0 \quad (K_t) \tag{2.13}$$

$$-W_t + \lambda_t^{\text{FIRM}^1}(1-\alpha)\, L_t^{d-\alpha} {Z_t}^{1-\alpha}(K_{t-1}CaqUt_t)^{\alpha} = 0 \quad (L_t^d) \tag{2.14}$$

$$-\lambda_t^{\text{FIRM}^1} + P_t = 0 \quad (Y_t) \tag{2.15}$$

$$-\delta\omega K_{t-1} {CaqUt_t}^{-1+\omega} + \alpha K_{t-1}\lambda_t^{\text{FIRM}^1} {L_t^d}^{1-\alpha} {Z_t}^{1-\alpha}(K_{t-1}CaqUt_t)^{-1+\alpha} = 0 \quad (CaqUt_t) \tag{2.16}$$

3 EQUILIBRIUM

3.1 Identities

$$P_t = 1 \tag{3.1}$$

$$L_t^d = L_t^s \tag{3.2}$$

4 EXOG

4.1 Identities

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

5 Equilibrium relationships

$$-1 + \lambda_t^{c\,-1}\mathrm{E}_t\left[\lambda_{t+1}^c\lambda_{t+1}^U\left(1 - \delta {CaqUt_{t+1}}^{\omega} + \alpha CaqUt_{t+1} {L_{t+1}^s}^{1-\alpha} {Z_{t+1}}^{1-\alpha}\left(K_t CaqUt_{t+1}\right)^{-1+\alpha}\right)\right] = 0 \tag{5.1}$$

$$\beta - \lambda_t^U = 0 \tag{5.2}$$

$$-\lambda_t^c + \mu {C_t}^{-1+\mu}(1-L_t^s)^{1-\mu}\left((1-L_t^s)^{1-\mu} {C_t}^{\mu}\right)^{-\eta} = 0 \tag{5.3}$$

$$-W_t + (1-\alpha)\, L_t^{s-\alpha} {Z_t}^{1-\alpha}(K_{t-1}CaqUt_t)^{\alpha} = 0 \tag{5.4}$$

$$-Y_t + {L_t^s}^{1-\alpha} {Z_t}^{1-\alpha}(K_{t-1}CaqUt_t)^{\alpha} = 0 \tag{5.5}$$

$$Z_t - e^{\epsilon_t^Z + \phi \log Z_{t-1}} = 0 \tag{5.6}$$

$$\lambda_t^c W_t + (-1+\mu)\,(1-L_t^s)^{-\mu}\left((1-L_t^s)^{1-\mu} {C_t}^{\mu}\right)^{-\eta} {C_t}^{\mu} = 0 \tag{5.7}$$

$$-\delta\omega K_{t-1} {CaqUt_t}^{-1+\omega} + \alpha K_{t-1} {L_t^s}^{1-\alpha} {Z_t}^{1-\alpha}(K_{t-1}CaqUt_t)^{-1+\alpha} = 0 \tag{5.8}$$

$$I_t - K_t + K_{t-1}\left(1 - \delta {CaqUt_t}^{\omega}\right) = 0 \tag{5.9}$$

$$U_t - \beta\mathrm{E}_t\left[U_{t+1}\right] - (1-\eta)^{-1}\left((1-L_t^s)^{1-\mu} {C_t}^{\mu}\right)^{1-\eta} = 0 \tag{5.10}$$

$$-C_t + \Pi_t - \lambda_t^{c\,-1}\mathrm{E}_t\left[\lambda_{t+1}^c\lambda_{t+1}^U\Pi_{t+1}\right] + L_t^s W_t = 0 \tag{5.11}$$

$$-I_t - \Pi_t + Y_t + \lambda_t^{c\,-1}\mathrm{E}_t\left[\lambda_{t+1}^c\lambda_{t+1}^U\Pi_{t+1}\right] - L_t^s W_t = 0 \tag{5.12}$$

6 Steady state relationships

$$-1+\lambda_{\mathrm{ss}}^{U}\left(1-\delta CaqUt_{\mathrm{ss}}{}^{\omega}+\alpha CaqUt_{\mathrm{ss}}L_{\mathrm{ss}}^{s\ 1-\alpha}Z_{\mathrm{ss}}{}^{1-\alpha}(CaqUt_{\mathrm{ss}}K_{\mathrm{ss}})^{-1+\alpha}\right)=0 \tag{6.1}$$

$$\beta-\lambda_{\mathrm{ss}}^{U}=0 \tag{6.2}$$

$$-\lambda_{\mathrm{ss}}^{c}+\mu C_{\mathrm{ss}}{}^{-1+\mu}(1-L_{\mathrm{ss}}^{s})^{1-\mu}\left(C_{\mathrm{ss}}{}^{\mu}(1-L_{\mathrm{ss}}^{s})^{1-\mu}\right)^{-\eta}=0 \tag{6.3}$$

$$-W_{\mathrm{ss}}+(1-\alpha)\,L_{\mathrm{ss}}^{s\ -\alpha}Z_{\mathrm{ss}}{}^{1-\alpha}(CaqUt_{\mathrm{ss}}K_{\mathrm{ss}})^{\alpha}=0 \tag{6.4}$$

$$-Y_{\mathrm{ss}}+L_{\mathrm{ss}}^{s\ 1-\alpha}Z_{\mathrm{ss}}{}^{1-\alpha}(CaqUt_{\mathrm{ss}}K_{\mathrm{ss}})^{\alpha}=0 \tag{6.5}$$

$$Z_{\mathrm{ss}}-e^{\phi\log Z_{\mathrm{ss}}}=0 \tag{6.6}$$

$$\lambda_{\mathrm{ss}}^{c}W_{\mathrm{ss}}+(-1+\mu)\,C_{\mathrm{ss}}{}^{\mu}(1-L_{\mathrm{ss}}^{s})^{-\mu}\left(C_{\mathrm{ss}}{}^{\mu}(1-L_{\mathrm{ss}}^{s})^{1-\mu}\right)^{-\eta}=0 \tag{6.7}$$

$$-\delta\omega K_{\mathrm{ss}}CaqUt_{\mathrm{ss}}{}^{-1+\omega}+\alpha K_{\mathrm{ss}}L_{\mathrm{ss}}^{s\ 1-\alpha}Z_{\mathrm{ss}}{}^{1-\alpha}(CaqUt_{\mathrm{ss}}K_{\mathrm{ss}})^{-1+\alpha}=0 \tag{6.8}$$

$$I_{\mathrm{ss}}-K_{\mathrm{ss}}+K_{\mathrm{ss}}\left(1-\delta CaqUt_{\mathrm{ss}}{}^{\omega}\right)=0 \tag{6.9}$$

$$U_{\mathrm{ss}}-\beta U_{\mathrm{ss}}-(1-\eta)^{-1}\left(C_{\mathrm{ss}}{}^{\mu}(1-L_{\mathrm{ss}}^{s})^{1-\mu}\right)^{1-\eta}=0 \tag{6.10}$$

$$-C_{\mathrm{ss}}+\Pi_{\mathrm{ss}}-\lambda_{\mathrm{ss}}^{U}\Pi_{\mathrm{ss}}+L_{\mathrm{ss}}^{s}W_{\mathrm{ss}}=0 \tag{6.11}$$

$$-I_{\mathrm{ss}}-\Pi_{\mathrm{ss}}+Y_{\mathrm{ss}}+\lambda_{\mathrm{ss}}^{U}\Pi_{\mathrm{ss}}-L_{\mathrm{ss}}^{s}W_{\mathrm{ss}}=0 \tag{6.12}$$

7 Parameter settings

$$\alpha=0.36 \tag{7.1}$$

$$\beta=0.99 \tag{7.2}$$

$$\delta=0.025 \tag{7.3}$$

$$\eta=2 \tag{7.4}$$

$$\mu=0.3 \tag{7.5}$$

$$\omega=1.45 \tag{7.6}$$

$$\phi=0.95 \tag{7.7}$$

8 Steady state values

	Steady state values
λ^c	0.547
λ^U	0.99
C	0.7449
$CaqUt$	0.9284
I	0.246
K	10.96
L^s	0.2673
Π	11.0707
U	-135.8123
W	2.3722
Y	0.9909
Z	1

9 The solution of the perturbation

9.1 P

$$\begin{array}{c} \\ K \\ Z \end{array} \begin{array}{c} \begin{array}{cc} K_{t-1} & Z_{t-1} \end{array} \\ \begin{pmatrix} 0.9758 & 0.0705 \\ 0 & 0.95 \end{pmatrix} \end{array}$$

9.2 Q

$$\begin{array}{c} \\ K \\ Z \end{array} \begin{array}{c} \begin{array}{c} \epsilon^Z \end{array} \\ \begin{pmatrix} 0.0742 \\ 1 \end{pmatrix} \end{array}$$

9.3 R

$$\begin{array}{c} \\ \lambda^c \\ \lambda^U \\ C \\ CapUt \\ I \\ L^s \\ \Pi \\ U \\ W \\ Y \end{array} \begin{array}{c} \begin{array}{cc} K_{t-1} & Z_{t-1} \end{array} \\ \begin{pmatrix} -0.4335 & -0.3499 \\ 0 & 0 \\ 0.2823 & 0.4185 \\ -0.74 & 1.0041 \\ -1.1491 & 4.5972 \\ -0.2604 & 0.7601 \\ 0.9893 & 0.0146 \\ -0.0446 & -0.0408 \\ 0.1873 & 0.6958 \\ -0.0731 & 1.456 \end{pmatrix} \end{array}$$

9.4 S

$$\begin{array}{c} \\ \lambda^c \\ \lambda^U \\ C \\ CapUt \\ I \\ L^s \\ \Pi \\ U \\ W \\ Y \end{array} \begin{array}{c} \begin{array}{c} \epsilon^Z \end{array} \\ \begin{pmatrix} -0.3683 \\ 0 \\ 0.4405 \\ 1.057 \\ 4.8392 \\ 0.8001 \\ 0.0153 \\ -0.0429 \\ 0.7325 \\ 1.5326 \end{pmatrix} \end{array}$$

10 Statistics of the model

10.1 Moments

	Steady state value	Std. dev.	Variance	Loglinear
λ^c	0.547	0.035	0.0012	Y
λ^U	0.99	0	0	Y
C	0.7449	0.0408	0.0017	Y
$CaqUt$	0.9284	0.1001	0.01	Y
I	0.246	0.4485	0.2011	Y
K	10.96	0.0245	0.0006	Y
L^s	0.2673	0.0744	0.0055	Y
Π	11.0707	0.0242	0.0006	Y
U	-135.8123	0.004	0	Y
W	2.3722	0.0674	0.0045	Y
Y	0.9909	0.1414	0.02	Y
Z	1	0.0922	0.0085	Y

10.2 Correlation matrix

	λ^c	λ^U	C	$CaqUt$	I	K	L^s	Π	U	W	Y	Z
λ^c	1	0	-0.9905	-0.8825	-0.9322	-0.5097	-0.9236	-0.3055	0.9994	-0.9714	-0.9491	-0.953
λ^U	0	0	0	0	0	0	0	0	0	0	0	0
C	-0.9905	0	1	0.9387	0.973	0.3867	0.9675	0.1719	-0.9947	0.9948	0.9834	0.9856
$CaqUt$	-0.8825	0	0.9387	1	0.9929	0.0452	0.9954	-0.1781	-0.8984	0.9689	0.9857	0.9835
I	-0.9322	0	0.973	0.9929	1	0.1636	0.9997	-0.0599	-0.9442	0.9915	0.9987	0.998
K	-0.5097	0	0.3867	0.0452	0.1636	1	0.1408	0.975	-0.4794	0.2908	0.2128	0.2251
L^s	-0.9236	0	0.9675	0.9954	0.9997	0.1408	1	-0.0829	-0.9364	0.9882	0.9973	0.9963
Π	-0.3055	0	0.1719	-0.1781	-0.0599	0.975	-0.0829	1	-0.2722	0.0707	-0.0099	0.0027
U	0.9994	0	-0.9947	-0.8984	-0.9442	-0.4794	-0.9364	-0.2722	1	-0.9791	-0.9595	-0.963
W	-0.9714	0	0.9948	0.9689	0.9915	0.2908	0.9882	0.0707	-0.9791	1	0.9967	0.9977
Y	-0.9491	0	0.9834	0.9857	0.9987	0.2128	0.9973	-0.0099	-0.9595	0.9967	1	0.9999
Z	-0.953	0	0.9856	0.9835	0.998	0.2251	0.9963	0.0027	-0.963	0.9977	0.9999	1

10.3 Autocorrelations

	$t-1$	$t-2$	$t-3$	$t-4$	$t-5$
λ^c	0.7487	0.5276	0.3371	0.1768	0.0454
λ^U	NaN	NaN	NaN	NaN	NaN
C	0.7277	0.494	0.2979	0.137	0.0087
$CaqUt$	0.7137	0.4719	0.272	0.1107	-0.0155
I	0.7115	0.4684	0.2679	0.1066	-0.0193
K	0.9603	0.8642	0.731	0.5765	0.4135
L^s	0.7114	0.4682	0.2676	0.1063	-0.0196
Π	0.9636	0.8695	0.7371	0.5827	0.4193
U	0.7427	0.518	0.3259	0.1654	0.0349
W	0.7174	0.4777	0.2787	0.1176	-0.0092
Y	0.7128	0.4703	0.2701	0.1089	-0.0172
Z	0.7133	0.4711	0.2711	0.1098	-0.0163

11 Statistics of the model

11.1 Moments relative to moments of the reference variable

	Steady state value relative to Y	Std. dev. relative to Y	Variance relative to Y	Loglinear
λ^c	0.552	0.2476	0.0613	Y
λ^U	0.9991	0	0	Y
C	0.7517	0.2886	0.0833	Y
$CapUt$	0.9369	0.7079	0.5011	Y
I	0.2483	3.1723	10.0637	Y
K	11.0607	0.1733	0.03	Y
L^s	0.2698	0.5261	0.2768	Y
Π	11.1724	0.1711	0.0293	Y
U	-137.0598	0.0286	0.0008	Y
W	2.394	0.4768	0.2274	Y
Y	1	1	1	Y
Z	1.0092	0.652	0.4251	Y

11.2 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}
λ^c	0.1893	0.0649	-0.1047	-0.3261	-0.6056	-0.9491	-0.759	-0.5852	-0.4297	-0.2936	-0.1769
λ^U	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C	-0.1167	0.01	0.1782	0.3932	0.66	0.9834	0.7485	0.5426	0.3656	0.2168	0.0945
$CapUt$	0.0755	0.1973	0.3474	0.5279	0.7405	0.9857	0.6585	0.3894	0.1736	0.0056	-0.1203
I	0.0103	0.1355	0.2939	0.4889	0.7231	0.9987	0.6988	0.4477	0.2423	0.0785	-0.0479
K	-0.5404	-0.4988	-0.413	-0.273	-0.0682	0.2128	0.4076	0.5307	0.5952	0.6134	0.5959
L^s	0.0229	0.1476	0.3046	0.497	0.7273	0.9973	0.6917	0.4369	0.2292	0.0645	-0.062
Π	-0.5491	-0.5352	-0.4842	-0.3865	-0.232	-0.0099	0.2549	0.436	0.5477	0.6029	0.6138
U	0.1712	0.046	-0.1236	-0.3437	-0.6205	-0.9595	-0.7577	-0.5754	-0.4142	-0.2746	-0.1563
W	-0.0614	0.0655	0.2305	0.438	0.6923	0.9967	0.7315	0.5043	0.3136	0.1572	0.0323
Y	-0.0172	0.1089	0.2701	0.4703	0.7128	1	0.7128	0.4703	0.2701	0.1089	-0.0172
Z	-0.0242	0.1021	0.264	0.4655	0.7099	0.9999	0.716	0.4759	0.2771	0.1165	-0.0095

12 Impulse response functions

12.1 Shock ϵ^Z

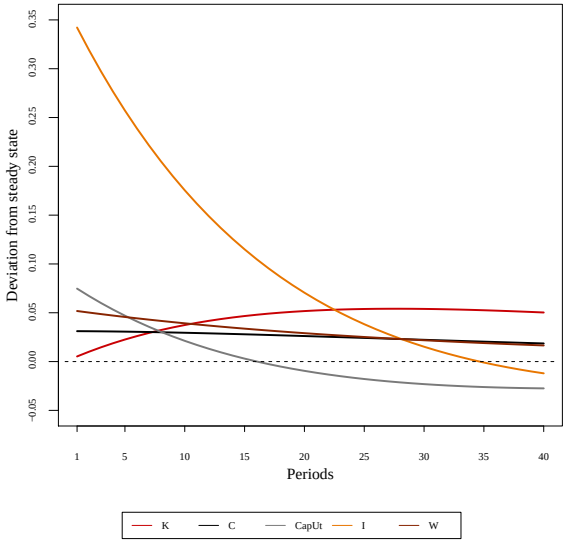

Figure 1: Impulse response function for ϵ^Z shock

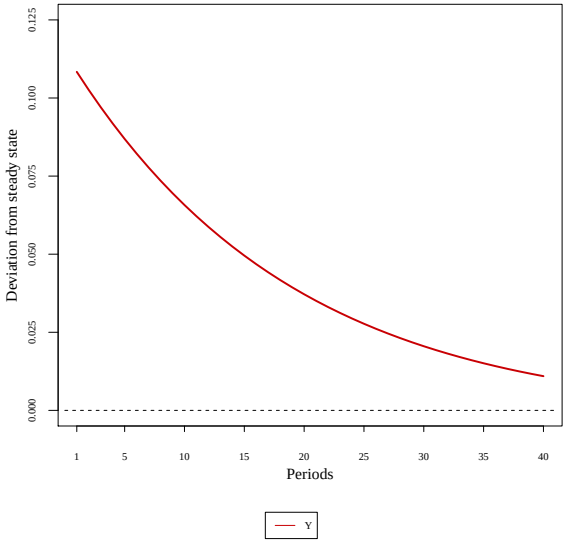

Figure 2: Impulse response function for ϵ^Z shock