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Model name: `rbc_hf`

1 CONSUMER

1.1 Optimisation problem

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

s.t. :

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

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

$$H_t = C_{t-1} \quad \left(\lambda^{\mathrm{CONSUMER}^3}_t \right) \tag{1.4}$$

1.2 First order conditions

$$-\lambda^{\mathrm{CONSUMER}^2}_t + \beta \left((1 - \delta) \mathrm{E}_t \left[\lambda^{\mathrm{CONSUMER}^2}_{t+1} \right] + \mathrm{E}_t \left[\lambda^{\mathrm{CONSUMER}^1}_{t+1} r_{t+1} \right] \right) = 0 \quad (K^{\mathrm{s}}_t) \tag{1.5}$$

$$-\lambda^{\mathrm{CONSUMER}^1}_t + \beta \mathrm{E}_t \left[\lambda^{\mathrm{CONSUMER}^3}_{t+1} \right] + \mu (1 - L^{\mathrm{s}}_t)^{1-\mu} (C_t - pers H_t)^{-1+\mu} \left((1 - L^{\mathrm{s}}_t)^{1-\mu} (C_t - pers H_t)^{\mu} \right)^{-\eta} = 0 \quad (C_t) \tag{1.6}$$

$$\lambda^{\mathrm{CONSUMER}^1}_t W_t + (-1 + \mu) (1 - L^{\mathrm{s}}_t)^{-\mu} (C_t - pers H_t)^{\mu} \left((1 - L^{\mathrm{s}}_t)^{1-\mu} (C_t - pers H_t)^{\mu} \right)^{-\eta} = 0 \quad (L^{\mathrm{s}}_t) \tag{1.7}$$

$$-\lambda^{\mathrm{CONSUMER}^1}_t + \lambda^{\mathrm{CONSUMER}^2}_t = 0 \quad (I_t) \tag{1.8}$$

$$-\lambda^{\mathrm{CONSUMER}^3}_t - \mu pers (1 - L^{\mathrm{s}}_t)^{1-\mu} (C_t - pers H_t)^{-1+\mu} \left((1 - L^{\mathrm{s}}_t)^{1-\mu} (C_t - pers H_t)^{\mu} \right)^{-\eta} = 0 \quad (H_t) \tag{1.9}$$

2 FIRM

2.1 Optimisation problem

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

s.t. :

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

2.2 First order conditions

$$-r_t + \alpha \lambda^{\mathrm{FIRM}^1}_t Z_t {K^{\mathrm{d}}_t}^{-1+\alpha} {L^{\mathrm{d}}_t}^{1-\alpha} = 0 \quad \left(K^{\mathrm{d}}_t\right) \tag{2.3}$$

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

$$1 - \lambda^{\mathrm{FIRM}^1}_t = 0 \quad \left(Y_t\right) \tag{2.5}$$

2.3 First order conditions after reduction

$$-r_t + \alpha Z_t {K^{\mathrm{d}}_t}^{-1+\alpha} {L^{\mathrm{d}}_t}^{1-\alpha} = 0 \quad \left(K^{\mathrm{d}}_t\right) \tag{2.6}$$

$$-W_t + Z_t \left(1 - \alpha\right) {K^{\mathrm{d}}_t}^{\alpha} {L^{\mathrm{d}}_t}^{-\alpha} = 0 \quad \left(L^{\mathrm{d}}_t\right) \tag{2.7}$$

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)

$$C_{t-1} - H_t = 0 \tag{5.1}$$

$$-\lambda^{\mathrm{CONSUMER}^2}_t + \beta \left(\left(1 - \delta\right) \mathrm{E}_t \left[\lambda^{\mathrm{CONSUMER}^2}_{t+1}\right] + \mathrm{E}_t \left[\lambda^{\mathrm{CONSUMER}^2}_{t+1} r_{t+1}\right]\right) = 0 \tag{5.2}$$

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

$$-W_t + Z_t \left(1 - \alpha\right) {K^{\mathrm{s}}_{t-1}}^{\alpha} {L^{\mathrm{s}}_t}^{-\alpha} = 0 \tag{5.4}$$

$$-Y_t + Z_t {K^{\mathrm{s}}_{t-1}}^{\alpha} {L^{\mathrm{s}}_t}^{1-\alpha} = 0 \tag{5.5}$$

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

$$\lambda^{\mathrm{CONSUMER}^2}_{t} W_{t} + \left(-1 + \mu\right) \left(1 - L^{\mathrm{s}}_{t}\right)^{-\mu} {\left(C_{t} - pers H_{t}\right)}^{\mu} \left(\left(1 - L^{\mathrm{s}}_{t}\right)^{1 - \mu} {\left(C_{t} - pers H_{t}\right)}^{\mu}\right)^{-\eta} = 0 \tag{5.7}$$

$$-\lambda^{\mathrm{CONSUMER}^2}_{t} - \beta \mu pers \mathrm{E}_{t}\left[\left(1 - L^{\mathrm{s}}_{t+1}\right)^{1 - \mu} {\left(C_{t+1} - pers H_{t+1}\right)}^{-1 + \mu} \left(\left(1 - L^{\mathrm{s}}_{t+1}\right)^{1 - \mu} {\left(C_{t+1} - pers H_{t+1}\right)}^{\mu}\right)^{-\eta}\right] + \mu \left(1 - L^{\mathrm{s}}_{t}\right)^{1 - \mu} {\left(C_{t} - pers H_{t}\right)}^{-1 + \mu} \left(\left(1 - L^{\mathrm{s}}_{t}\right)^{1 - \mu} {\left(C_{t} - pers H_{t}\right)}^{\mu}\right)^{-\eta} = 0 \tag{5.8}$$

$$-C_{t} - I_{t} + Y_{t} = 0 \tag{5.9}$$

$$I_{t} - K^{\mathrm{s}}_{t} + K^{\mathrm{s}}_{t-1} \left(1 - \delta\right) = 0 \tag{5.10}$$

$$U_{t} - \beta \mathrm{E}_{t}\left[U_{t+1}\right] - \left(1 - \eta\right)^{-1} \left(\left(1 - L^{\mathrm{s}}_{t}\right)^{1 - \mu} {\left(C_{t} - pers H_{t}\right)}^{\mu}\right)^{1 - \eta} = 0 \tag{5.11}$$

6 Steady state relationships (after reduction)

$$C_{\mathrm{ss}} - H_{\mathrm{ss}} = 0 \tag{6.1}$$

$$-\lambda^{\mathrm{CONSUMER}^2}_{\mathrm{ss}} + \beta \left(\lambda^{\mathrm{CONSUMER}^2}_{\mathrm{ss}} r_{\mathrm{ss}} + \lambda^{\mathrm{CONSUMER}^2}_{\mathrm{ss}} \left(1 - \delta\right)\right) = 0 \tag{6.2}$$

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

$$-W_{\mathrm{ss}} + Z_{\mathrm{ss}} \left(1 - \alpha\right) {K^{\mathrm{s}}_{\mathrm{ss}}}^{\alpha} {L^{\mathrm{s}}_{\mathrm{ss}}}^{-\alpha} = 0 \tag{6.4}$$

$$-Y_{\mathrm{ss}} + Z_{\mathrm{ss}} {K^{\mathrm{s}}_{\mathrm{ss}}}^{\alpha} {L^{\mathrm{s}}_{\mathrm{ss}}}^{1 - \alpha} = 0 \tag{6.5}$$

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

$$\lambda^{\mathrm{CONSUMER}^2}_{\mathrm{ss}} W_{\mathrm{ss}} + \left(-1 + \mu\right) \left(1 - L^{\mathrm{s}}_{\mathrm{ss}}\right)^{-\mu} {\left(C_{\mathrm{ss}} - pers H_{\mathrm{ss}}\right)}^{\mu} \left(\left(1 - L^{\mathrm{s}}_{\mathrm{ss}}\right)^{1 - \mu} {\left(C_{\mathrm{ss}} - pers H_{\mathrm{ss}}\right)}^{\mu}\right)^{-\eta} = 0 \tag{6.7}$$

$$-\lambda^{\mathrm{CONSUMER}^2}_{\mathrm{ss}} + \mu \left(1 - L^{\mathrm{s}}_{\mathrm{ss}}\right)^{1 - \mu} {\left(C_{\mathrm{ss}} - pers H_{\mathrm{ss}}\right)}^{-1 + \mu} \left(\left(1 - L^{\mathrm{s}}_{\mathrm{ss}}\right)^{1 - \mu} {\left(C_{\mathrm{ss}} - pers H_{\mathrm{ss}}\right)}^{\mu}\right)^{-\eta} - \beta \mu pers \left(1 - L^{\mathrm{s}}_{\mathrm{ss}}\right)^{1 - \mu} {\left(C_{\mathrm{ss}} - pers H_{\mathrm{ss}}\right)}^{-1 + \mu} \left(\left(1 - L^{\mathrm{s}}_{\mathrm{ss}}\right)^{1 - \mu} {\left(C_{\mathrm{ss}} - pers H_{\mathrm{ss}}\right)}^{\mu}\right)^{-\eta} = 0 \tag{6.8}$$

$$-C_{\mathrm{ss}} - I_{\mathrm{ss}} + Y_{\mathrm{ss}} = 0 \tag{6.9}$$

$$I_{\mathrm{ss}} - K^{\mathrm{s}}_{\mathrm{ss}} + K^{\mathrm{s}}_{\mathrm{ss}} \left(1 - \delta\right) = 0 \tag{6.10}$$

$$U_{\mathrm{ss}} - \beta U_{\mathrm{ss}} - \left(1 - \eta\right)^{-1} \left(\left(1 - L^{\mathrm{s}}_{\mathrm{ss}}\right)^{1 - \mu} {\left(C_{\mathrm{ss}} - pers H_{\mathrm{ss}}\right)}^{\mu}\right)^{1 - \eta} = 0 \tag{6.11}$$

7 Calibrating equations

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

8 Parameter settings

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

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

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

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

$$pers = 0.57 \tag{8.5}$$

$$\phi = 0.95 \tag{8.6}$$

9 Steady-state values

	Steady-state values
$\lambda^{\text{CONSUMER}^2}$	0.7116
r	0.0351
C	0.7494
H	0.7494
I	0.2584
K^{s}	10.3356
L^{s}	0.2721
U	-175.4236
W	2.3706
Y	1.0078
Z	1

10 The solution of the perturbation

10.1 P

$$\begin{array}{c} \\ C \\ K^{\text{s}} \\ Z \end{array} \begin{array}{c} \begin{array}{ccc} C_{t-1} & K^{\text{s}}_{t-1} & Z_{t-1} \end{array} \\ \begin{pmatrix} 0.5544 & 0.0151 & 0.1764 \\ -0.5092 & 0.9817 & 1.1759 \\ 0 & 0 & 0.95 \end{pmatrix} \end{array}$$

10.2 Q

$$\begin{array}{c} \\ C \\ K^{\text{s}} \\ Z \end{array} \begin{array}{c} \epsilon^{\text{Z}} \\ \begin{pmatrix} 0.1857 \\ 1.2377 \\ 1 \end{pmatrix} \end{array}$$

10.3 R

$$\begin{array}{c} \\ \lambda^{\text{CONSUMER}^2} \\ r \\ H \\ I \\ L^{\text{s}} \\ U \\ W \\ Y \end{array} \begin{array}{c} \begin{array}{ccc} C_{t-1} & K^{\text{s}}_{t-1} & Z_{t-1} \end{array} \\ \begin{pmatrix} 0.0599 & -0.0494 & -0.3592 \\ 0.0016 & -0.0026 & 0.0471 \\ 1 & 0 & 0 \\ -0.5092 & 0.0067 & 1.1759 \\ 0.0191 & -0.0056 & 0.1666 \\ -0.9309 & 0.7188 & 11.4498 \\ -0.0598 & 0.1002 & 1.7296 \\ 0.0452 & 0.0218 & 1.3522 \end{pmatrix} \end{array}$$

10.4 S

$$\begin{array}{c} \\ \lambda^{\text{CONSUMER}^2} \\ r \\ H \\ I \\ L^{\text{s}} \\ U \\ W \\ Y \end{array} \begin{array}{c} \epsilon^{\text{Z}} \\ \begin{pmatrix} -0.3781 \\ 0.0496 \\ 0 \\ 1.2377 \\ 0.1753 \\ 12.0524 \\ 1.8206 \\ 1.4234 \end{pmatrix} \end{array}$$

11 Statistics of the model

11.1 Moments

	Steady-state value	Std. dev.	Variance	Loglinear
r	0.0351	0.0046	0	N
C	0.7494	0.0333	0.0011	N
H	0.7494	0.0333	0.0011	N
I	0.2584	0.1077	0.0116	N
K^{s}	10.3356	0.3633	0.132	N
L^{s}	0.2721	0.0164	0.0003	N
U	-175.4236	1.1325	1.2825	N
W	2.3706	0.1719	0.0295	N
Y	1.0078	0.1325	0.0175	N
Z	1	0.0922	0.0085	N

11.2 Correlation matrix

	r	C	H	I	K^{s}	L^{s}	U	W	Y	Z
$\lambda^{\mathrm{CONSUMER}^2}$	-0.8032	-0.9421	-0.7242	-0.8546	-0.7018	-0.861	-0.9737	-0.9722	-0.9318	-0.9048
r	1	0.6233	0.2627	0.9934	0.1395	0.9944	0.9178	0.9204	0.9645	0.9804
C	0.6233	1	0.9106	0.6739	0.826	0.7011	0.8666	0.8652	0.7994	0.7579
H	0.2627	0.9106	1	0.3154	0.8989	0.358	0.5836	0.5818	0.4854	0.4287
I	0.9934	0.6739	0.3154	1	0.2315	0.9968	0.9495	0.9511	0.9826	0.9925
K^{s}	0.1395	0.826	0.8989	0.2315	1	0.2426	0.5211	0.5157	0.3959	0.3318
L^{s}	0.9944	0.7011	0.358	0.9968	0.2426	1	0.9542	0.9562	0.9869	0.9956
U	0.9178	0.8666	0.5836	0.9495	0.5211	0.9542	1	1	0.99	0.978
W	0.9204	0.8652	0.5818	0.9511	0.5157	0.9562	1	1	0.9909	0.9793
Y	0.9645	0.7994	0.4854	0.9826	0.3959	0.9869	0.99	0.9909	1	0.9976
Z	0.9804	0.7579	0.4287	0.9925	0.3318	0.9956	0.978	0.9793	0.9976	1

11.3 Autocorrelations

	$t-1$	$t-2$	$t-3$	$t-4$
r	0.7068	0.4619	0.2614	0.1009
C	0.9106	0.7381	0.5368	0.3373
H	0.9106	0.7381	0.5368	0.3373
I	0.6672	0.4127	0.2174	0.0686
K^{s}	0.9552	0.8509	0.7099	0.5498
L^{s}	0.7157	0.4728	0.2708	0.1076
U	0.7373	0.5093	0.3157	0.1551
W	0.7395	0.5115	0.3169	0.1551
Y	0.7236	0.4858	0.2864	0.1237
Z	0.7133	0.4711	0.2711	0.1098

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
$\lambda^{\mathrm{CONSUMER}^2}$	0.7061	0.2894	0.0838	N
r	0.0348	0.0351	0.0012	N
C	0.7436	0.2514	0.0632	N
H	0.7436	0.2514	0.0632	N
I	0.2564	0.8132	0.6612	N
K^{s}	10.2561	2.7424	7.521	N
L^{s}	0.27	0.124	0.0154	N
U	-174.0741	8.5496	73.0965	N
W	2.3524	1.2977	1.6841	N
Y	1	1	1	N
Z	0.9923	0.6958	0.4842	N

12.2 Correlations with the reference variable

	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}
$\lambda^{\mathrm{CONSUMER}^2}$	0.0606	-0.1099	-0.3294	-0.6024	-0.9318	-0.7777	-0.6273	-0.4851	-0.3544
r	0.2446	0.3879	0.5562	0.7491	0.9645	0.6134	0.3309	0.1092	-0.0591
C	-0.1308	0.0247	0.2285	0.4854	0.7994	0.8668	0.8036	0.6775	0.5273
H	-0.2439	-0.1308	0.0247	0.2285	0.4854	0.7994	0.8668	0.8036	0.6775
I	0.1926	0.3445	0.5267	0.7398	0.9826	0.6219	0.3489	0.1427	-0.0109
K^{s}	-0.39	-0.2781	-0.115	0.1073	0.3959	0.5704	0.6596	0.6854	0.6651
L^{s}	0.2003	0.3524	0.5342	0.7461	0.9869	0.668	0.4016	0.1854	0.0157
U	0.0534	0.2219	0.4325	0.6881	0.99	0.7536	0.5453	0.3656	0.2138
W	0.0575	0.2257	0.4357	0.6904	0.9909	0.7554	0.5461	0.3647	0.2112
Y	0.1237	0.2864	0.4858	0.7236	1	0.7236	0.4858	0.2864	0.1237
Z	0.1554	0.3142	0.507	0.7349	0.9976	0.6975	0.4461	0.2401	0.0758

13 Impulse response functions

13.1 Shock ϵ^{Z}

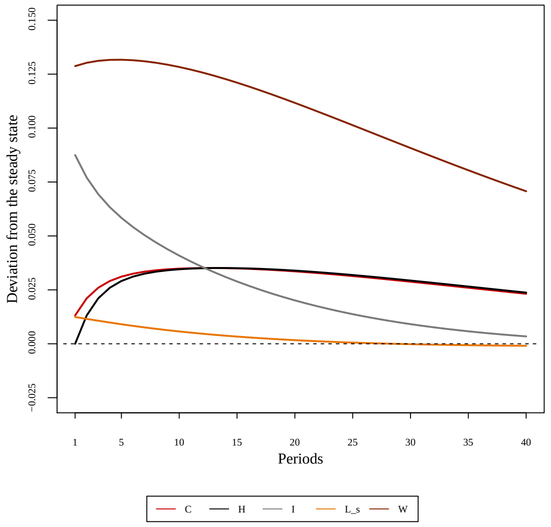

Figure 1: Impulse response function for ϵ^{Z} shock

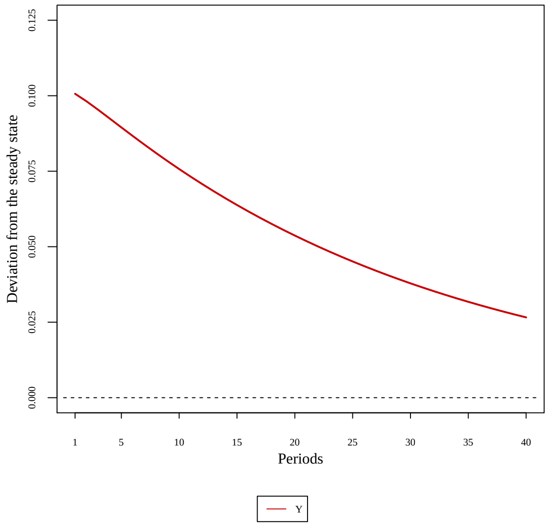

Figure 2: Impulse response function for ϵ^{Z} shock