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Model name: `rbc_hf`

1 CONSUMER

1.1 Optimization problem

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

s.t. :

$$C_t + I_t = \pi_t + K_{t-1}^s r_t + L_t^s W_t \quad (\lambda_t^{\mathrm{CONSUMER}^1}) \tag{1.2}$$

$$K_t^s = I_t + K_{t-1}^s (1 - \delta) \quad (\lambda_t^{\mathrm{CONSUMER}^2}) \tag{1.3}$$

$$H_t = C_{t-1} \quad (\lambda_t^{\mathrm{CONSUMER}^3}) \tag{1.4}$$

1.2 First order conditions

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

$$-\lambda_t^{\mathrm{CONSUMER}^1} + \beta \mathrm{E}_t \left[\lambda_{t+1}^{\mathrm{CONSUMER}^3} \right] + \mu (1 - L_t^s)^{1-\mu} (C_t - persH_t)^{-1+\mu} \left((1 - L_t^s)^{1-\mu} (C_t - persH_t)^\mu \right)^{-\eta} = 0 \quad (C_t) \tag{1.6}$$

$$\lambda_t^{\mathrm{CONSUMER}^1} W_t + (-1 + \mu)(1 - L_t^s)^{-\mu} (C_t - persH_t)^\mu \left((1 - L_t^s)^{1-\mu} (C_t - persH_t)^\mu \right)^{-\eta} = 0 \quad (L_t^s) \tag{1.7}$$

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

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

2 FIRM

2.1 Optimization problem

$$\max_{K_t^d, L_t^d, Y_t} \pi_t = Y_t - L_t^d W_t - r_t K_t^d \tag{2.1}$$

s.t. :

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

2.2 First order conditions

$$-r_t + \alpha \lambda_t^{\mathrm{FIRM}^1} Z_t K_t^{d-1+\alpha} L_t^{d\,1-\alpha} = 0 \quad (K_t^d) \tag{2.3}$$

$$-W_t + \lambda_t^{\mathrm{FIRM}^1} Z_t (1 - \alpha) K_t^{d\,\alpha} L_t^{d\,-\alpha} = 0 \quad (L_t^d) \tag{2.4}$$

$$1 - \lambda_t^{\mathrm{FIRM}^1} = 0 \quad (Y_t) \tag{2.5}$$

2.3 First order conditions after reduction

$$-r_t + \alpha Z_t K_t^{d-1+\alpha} L_t^{d\,1-\alpha} = 0 \quad (K_t^d) \tag{2.6}$$

$$-W_t + Z_t (1 - \alpha) K_t^{d\,\alpha} L_t^{d\,-\alpha} = 0 \quad (L_t^d) \tag{2.7}$$

3 EQUILIBRIUM

3.1 Identities

$$K_t^d = K_{t-1}^s \tag{3.1}$$

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

4 EXOG

4.1 Identities

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

5 Equilibrium relationships

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

$$-\lambda_t^{\text{CONSUMER}^1} + \beta \left((1-\delta) \, \mathrm{E}_t \left[\lambda_{t+1}^{\text{CONSUMER}^1} \right] + \mathrm{E}_t \left[\lambda_{t+1}^{\text{CONSUMER}^1} r_{t+1} \right] \right) = 0 \tag{5.2}$$

$$-r_t + \alpha Z_t K_{t-1}^{s\,-1+\alpha} L_t^{s\,1-\alpha} = 0 \tag{5.3}$$

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

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

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

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

$$-\lambda_t^{\text{CONSUMER}^1} - \beta\mu pers \mathrm{E}_t \left[\left(1-L_{t+1}^s\right)^{1-\mu}(C_{t+1} - persH_{t+1})^{-1+\mu} \left(\left(1-L_{t+1}^s\right)^{1-\mu}(C_{t+1} - persH_{t+1})^\mu \right)^{-\eta} \right] + \mu(1-L_t^s)^{1-\mu}(C_t - persH \tag{5.8}$$

$$-C_t - I_t + Y_t = 0 \tag{5.9}$$

$$I_t - K_t^s + K_{t-1}^s (1-\delta) = 0 \tag{5.10}$$

$$U_t - \beta \mathrm{E}_t \left[U_{t+1} \right] - (1-\eta)^{-1} \left((1-L_t^s)^{1-\mu}(C_t - persH_t)^\mu \right)^{1-\eta} = 0 \tag{5.11}$$

6 Steady state relationships

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

$$-\lambda_{\text{ss}}^{\text{CONSUMER}^1} + \beta \left(\lambda_{\text{ss}}^{\text{CONSUMER}^1} r_{\text{ss}} + \lambda_{\text{ss}}^{\text{CONSUMER}^1} (1-\delta) \right) = 0 \tag{6.2}$$

$$-r_{\text{ss}} + \alpha Z_{\text{ss}} K_{\text{ss}}^{s\,-1+\alpha} L_{\text{ss}}^{s\,1-\alpha} = 0 \tag{6.3}$$

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

$$-Y_{\text{ss}} + Z_{\text{ss}} K_{\text{ss}}^{s\,\alpha} L_{\text{ss}}^{s\,1-\alpha} = 0 \tag{6.5}$$

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

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

$$-\lambda_{\text{ss}}^{\text{CONSUMER}^1} + \mu(1-L_{\text{ss}}^s)^{1-\mu}(C_{\text{ss}} - persH_{\text{ss}})^{-1+\mu} \left((1-L_{\text{ss}}^s)^{1-\mu}(C_{\text{ss}} - persH_{\text{ss}})^\mu \right)^{-\eta} - \beta\mu pers(1-L_{\text{ss}}^s)^{1-\mu}(C_{\text{ss}} - persH_{\text{ss}})^{-1+\mu} \left((1- \tag{6.8}$$

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

$$I_{\text{ss}} - K_{\text{ss}}^s + K_{\text{ss}}^s (1-\delta) = 0 \tag{6.10}$$

$$U_{\text{ss}} - \beta U_{\text{ss}} - (1-\eta)^{-1} \left((1-L_{\text{ss}}^s)^{1-\mu}(C_{\text{ss}} - persH_{\text{ss}})^\mu \right)^{1-\eta} = 0 \tag{6.11}$$

7 Calibrating equations

$$-0.36Y_{\text{ss}} + r_{\text{ss}}K^s_{\text{ss}} = 0 \tag{7.1}$$

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
$\lambda^{\text{CONSUMER}^1}$	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

$$
\begin{array}{c}
\begin{array}{ccc} C_{t-1} & K^s_{t-1} & Z_{t-1} \end{array} \\
\begin{array}{c} C \\ K^s \\ Z \end{array}
\left(
\begin{array}{ccc}
0.5544 & 0.0151 & 0.1764 \\
-0.5092 & 0.9817 & 1.1759 \\
0 & 0 & 0.95
\end{array}
\right)
\end{array}
$$

10.2 Q

$$
\begin{array}{c}
\epsilon^Z \\
\begin{array}{c} C \\ K^s \\ Z \end{array}
\left(
\begin{array}{c}
0.1857 \\
1.2377 \\
1
\end{array}
\right)
\end{array}
$$

3

10.3 R

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

10.4 S

$$
\begin{array}{c}
\epsilon^Z\\
\begin{array}{c} \lambda^{\text{CONSUMER}^1} \\ r \\ H \\ I \\ L^s \\ U \\ W \\ Y \end{array}
\left(\begin{array}{c}
-0.3781 \\
0.0496 \\
0 \\
1.2377 \\
0.1753 \\
12.0524 \\
1.8206 \\
1.4234
\end{array}\right)
\end{array}
$$

11 Statistics of the model

11.1 Moments

	Steady state value	Std. dev.	Variance	Loglinear
$\lambda^{\text{CONSUMER}^1}$	0.7116	0.0383	0.0015	N
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

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

11.3 Autocorrelations

	$t-1$	$t-2$	$t-3$	$t-4$	$t-5$
$\lambda^{\text{CONSUMER}^1}$	0.7839	0.5831	0.4015	0.2416	0.1044
r	0.7068	0.4619	0.2614	0.1009	-0.0236
C	0.9106	0.7381	0.5368	0.3373	0.1559
H	0.9106	0.7381	0.5368	0.3373	0.1559
I	0.6672	0.4127	0.2174	0.0686	-0.0426
K^s	0.9552	0.8509	0.7099	0.5498	0.3838
L^s	0.7157	0.4728	0.2708	0.1076	-0.0201
U	0.7373	0.5093	0.3157	0.1551	0.0252
W	0.7395	0.5115	0.3169	0.1551	0.0241
Y	0.7236	0.4858	0.2864	0.1237	-0.005
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
$\lambda^{\text{CONSUMER}^1}$	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-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}
$\lambda^{\text{CONSUMER}^1}$	0.1875	0.0606	-0.1099	-0.3294	-0.6024	-0.9318	-0.7777	-0.6273	-0.4851	-0.3544	-0.2372
r	0.1255	0.2446	0.3879	0.5562	0.7491	0.9645	0.6134	0.3309	0.1092	-0.0591	-0.1815
C	-0.2439	-0.1308	0.0247	0.2285	0.4854	0.7994	0.8668	0.8036	0.6775	0.5273	0.3755
H	-0.3204	-0.2439	-0.1308	0.0247	0.2285	0.4854	0.7994	0.8668	0.8036	0.6775	0.5273
I	0.0693	0.1926	0.3445	0.5267	0.7398	0.9826	0.6219	0.3489	0.1427	-0.0109	-0.1222
K^s	-0.4586	-0.39	-0.2781	-0.115	0.1073	0.3959	0.5704	0.6596	0.6854	0.6651	0.6122
L^s	0.0764	0.2003	0.3524	0.5342	0.7461	0.9869	0.668	0.4016	0.1854	0.0157	-0.1125
U	-0.0768	0.0534	0.2219	0.4325	0.6881	0.99	0.7536	0.5453	0.3656	0.2138	0.0887
W	-0.0727	0.0575	0.2257	0.4357	0.6904	0.9909	0.7554	0.5461	0.3647	0.2112	0.0847
Y	-0.005	0.1237	0.2864	0.4858	0.7236	1	0.7236	0.4858	0.2864	0.1237	-0.005
Z	0.0283	0.1554	0.3142	0.507	0.7349	0.9976	0.6975	0.4461	0.2401	0.0758	-0.0512

13 Impulse response functions

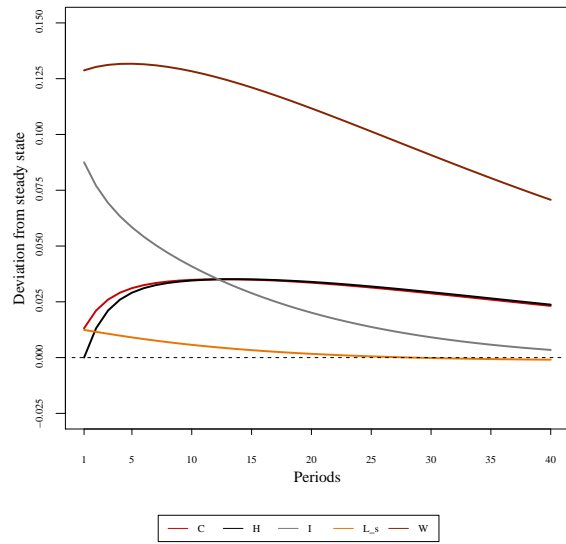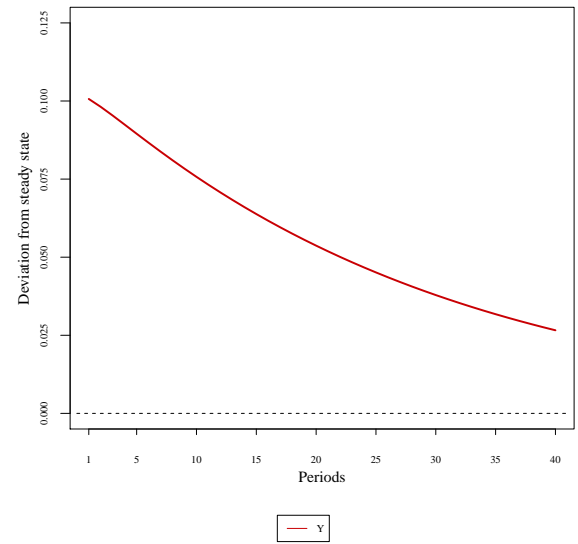## 13.1 Shock ϵ^Z

Figure 1: Impulse response function for ϵ^Z shock

Figure 2: Impulse response function for ϵ^Z shock