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ABSTRACT

y . y, , , y . y, , , y , y . - : y y y. y .

1. Introduction

( ) y . - y y y . y, y - ( ). y y - . y ( ) . y y y . Y (2016), (2016), (2016) y, (2017) y , (2019) y . (2013) - , (2016) . (2017) y .

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☆ , _J , , - , y , , , _J , _J , y , , , _J , , , _J , , , - y , , , y , y , , , , , , , , y - , & y, , , , y y . y y _J . y y .

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E-mail addresses: y . . (_J.), . . . (_J).

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y y (2016).[1]

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[1] , , (2012), - yy . (2014), . (2016), . (2017). y -
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(2014), (2015), (2016).

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Related literature: y y. -
(2011), . (2012), (2013), (2019 ,) y , , .
(2011), (2012), . (2016) y ,
. y . (2014), . (2015), . (2016) .
(2019) y . y.
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y . ,
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2. A shadow rate New Keynesian model (SRNKM)

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y y. -
, 3 4 y :
. 2.1 y y -
y. 2.2 . 2.3 2.4
. 2.5,
2.6.

2.1. Standard NK model and its lack of unconventional monetary policy

(. ., , 2008)

$$y_t = -\frac{1}{\sigma}(r_t - \mathbb{E}_t\pi_{t+1} - r) + \mathbb{E}_t y_{t+1}, \tag{2.1}$$

$$\pi_t = \beta\mathbb{E}_t\pi_{t+1} + \kappa(y_t - y_t^n), \tag{2.2}$$

$$s_t = \phi_s s_{t-1} + (1-\phi_s)\ \phi_y(y_t - y_t^n) + \phi_\pi\pi_t + s\ , \tag{2.3}$$

$$r_t = \quad (0, s_t), \tag{2.4}$$

$\mathbb{E}$, , t y-
, . y_t , y_t^n
. π_t , r_t y . . (2.1)
$r_t - \mathbb{E}_t\pi_{t+1}$, σ y . . (2.2)
, y, β , κ
y . s_t y (1993) (2.3). y
, 0 .
, y y y . , $s_t < 0$, y
$r_t = 0$, y y y y ; (2.1).

y , , , y -
y . y ; , (2012),
(2014), (2017). , (2.1)
y :

$$
\begin{aligned}
y_t &= -\frac{1}{\sigma}\sum_{i=1}^{n}\mathbb{E}_t(r_{t+i-1}-\pi_{t+i}-r)+\mathbb{E}_t y_{t+n} \\
&= -\frac{1}{\sigma} n r_{t,t+n} - \frac{1}{\sigma}\sum_{i=1}^{n}\mathbb{E}_t(-\pi_{t+i}-r)+\mathbb{E}_t y_{t+n}.
\end{aligned}
\tag{2.5}
$$

y , $r_{t,t+n}$ t $t+n$. ,
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y y .866 65 -1 0 ( ) ỉ / 1 1 7.9701 04 ỉ / 41 3( ) _[0 0 6.3761 186.7777 551

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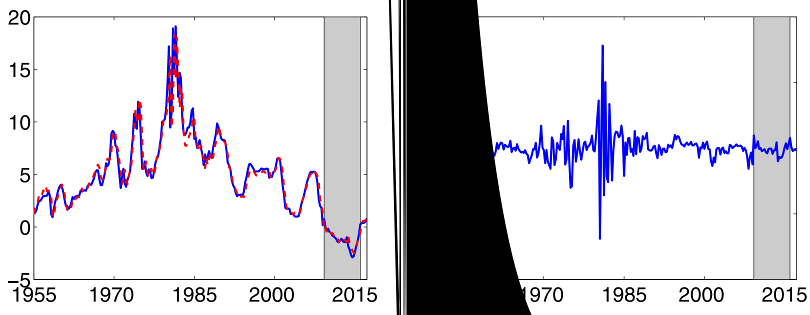

Post-8

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y y : F (-85) 0.48 (1.42),
5% , 2.64 (2.68). , .
(2016) .

2.5. Economic implications

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y y y.
. , y y, .[3] ,
- , .
, 6.
y y - .
, , - - , y
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y:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\eta}}{1+\eta} \right), \tag{3.1}$$

C_t y L_t, η y y, :

$$C_t + \frac{B_t^H}{P_t} = \frac{R_{t-1}^B B_{t-1}^H}{P_t} + W_t L_t + T_t, \tag{3.2}$$

B_{t-1}^H $t-1$ t, R_{t-1}^B. P_t , W_t , T_t - . - $B_t^H \equiv B_t^H / P_t$

$$C_t^{-\sigma} = \beta R_t^B \mathbb{E}_t \left(\frac{C_{t+1}^{-\sigma}}{\Pi_{t+1}} \right), \tag{3.3}$$

$\Pi_{t+1} \equiv P_{t+1}/P_t$ t $t+1$. - $Y_t = C_t$ y :

$$y_t = -\frac{1}{\sigma}\left(r_t^B - \mathbb{E}_t \pi_{t+1} - r^B\right) + \mathbb{E}_t y_{t+1}. \tag{3.4}$$

(2.1)

interest . [redacted]

$$rp_t \equiv r_t^B - r_t, \tag{3.5}$$

y r_t y (2.3) (2.4)

rp_t .

y .

the term . [redacted]

(3.4) (3.5)
(3.7), (2.2) y (2.3) (2.4).

3.2. Shadow rate equivalence for QE

y y (3.4)

$$r_t^B = r_t + rp - \varsigma(b_t^{CB} - b^{CB}). \tag{3.8}$$

, $b_t^{CB} = b^{CB}$, $r_t^B = r_t + rp$, y y y r_t,
s_t. , y , $r_t = 0$, y y
$r_t^B = rp - \varsigma(b_t^{CB} - b^{CB})$.

$$b_t^{CB} = b^{CB} - \frac{s_t}{\varsigma}, \tag{3.9}$$

$$r_t^B = s_t + rp \tag{3.10}$$

y y y .
(3.8) y r_t - y ,
(3.10) s_t . .

Proposition 1. *The shadow rate New Keynesian model represented by the shadow rate IS curve (2.6), New Keynesian Phillips curve (2.2), and shadow rate Taylor rule (2.3) is equivalent to a model where monetary policy is implemented by the conventional Taylor rule during normal times and QE at the ZLB that changes the risk premium through (3.7) if*

$$\begin{cases} r_t = s_t,\ b_t^{CB} = b^{CB} & s_t \geq 0 \\ r_t = 0,\ b_t^{CB} \quad (3.9) & s_t < 0. \end{cases}$$

Proof. . □

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3.3. Quantifying the assumption in Proposition 1

1 b_t^{CB} s_t (3.9). . 4
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s_t b_t^{CB} , −1.83,
y 1%, y 0.0183%. 1
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2.5% . ,
y . 3 ,
2.6 4.2 . 3 1 , 3
. 0.9% .
y y .

3.4. Announcement effect of QE

(2012) . (2011)
. (2012) . . (2011),
, .
, y (3.7) :


2009
2010
2011
2012
2013
201

C_t^E, I_t, L_t y

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \gamma^t \quad C_t^E, \tag{4.2}$$

γ β. y

is equivalent to the model summarized by (2.3)–(2.4) and (4.12)–(4.19), where monetary policy is implemented by the conventional Taylor rule during normal times and lending facility – tax policy at the ZLB if

$$\begin{cases} r_t = s_t,\ \tau_t = 0,\ m_t = m & s_t \geq 0 \\ r_t = 0,\ \tau_t = m_t - m = -s_t & s_t < 0. \end{cases}$$

Proof. . □

, 3 y y (2.6), (4.20) (2.6) - .

5. Partially active monetary policy

, 1 y y y , , y . y - y. y y y ? y, .

Definition 2. y y y

$$y_t = -\frac{1}{\sigma}(\mathcal{S}_t - \mathbb{E}_t\pi_{t+1} - \mathcal{S}) + \mathbb{E}_t y_{t+1}, \tag{5.1}$$

y (2.2), y (2.3),

$$\begin{cases} \mathcal{S}_t = s_t & s_t \geq 0 \\ \mathcal{S}_t = \lambda s_t & s_t < 0, \end{cases} \tag{5.2}$$

$0 \leq \lambda \leq 1$ y y .

(5.2)

$$\mathcal{S}_t = \left(\frac{exp(\varphi s_t)}{1 + exp(\varphi s_t)}(1 - \lambda) + \lambda\right)s_t, \tag{5.3}$$

y $\varphi > 0$ . . , $\lambda < 1$, s_t y , 0 y y . , s_t s_t y y . ,

6. Quantitative analyses

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y -
2.5.

6.1. Model and methodology

Shadow rate vs. standard model. y .
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y - , y
2.5. , $r_t = 0$,
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r_t s_t .
Quantitative model. y (2005) , ,
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y . (2005). , - y -
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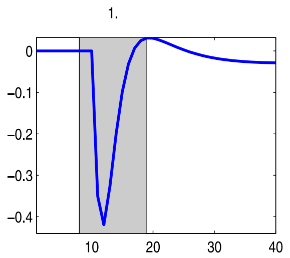
Solution method. y y,
y y y. , -
y y - y .
.4.1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0
−0.1
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10
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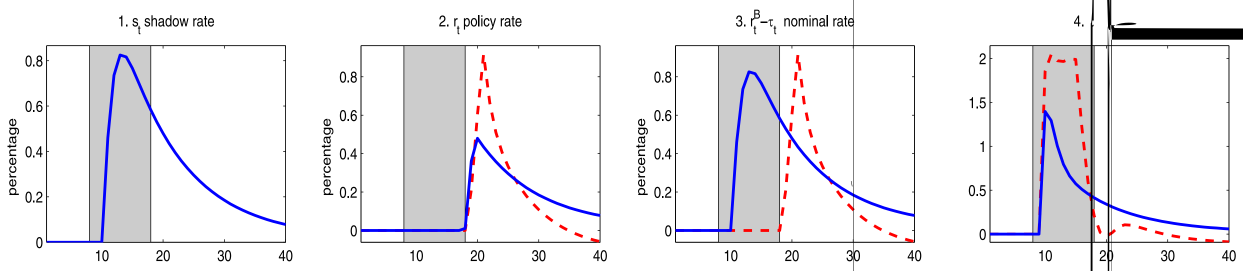
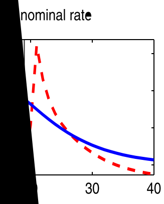
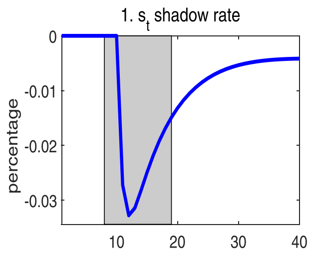


1. s_t shadow rate
2. r_t policy rate
3. $r_t^B-\tau_t$ nominal rate
4.
percentage



[redacted]



1. s_t shadow rate
0
-0.01
-0.02
-0.03
percentage
10
20
30
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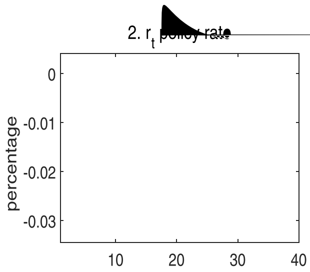

2. r_t policy rate
0
-0.01
-0.02
-0.03
percentage
10
20
30
40

I_t . P_t^E,
$X_t \equiv P_t/P_t^E$.
C_t^E, I_t, L_t y

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \gamma^t \quad C_t^E, \qquad (\ .2)$$

γ β.

$$B_t \le M\mathbb{E}_t\left(\frac{K_t \Pi_{t+1}}{R_t^B}\right), \qquad (\ .3)$$

B_t y t, t
$t+1$ R_t^B. $\Pi_{t+1} \equiv P_{t+1}/P_t$. M - - .

$$\frac{Y_t^E}{X_t} + B_t = \frac{R_{t-1}^B B_{t-1}}{\Pi_t} + W_t L_t + I_t + C_t^E, \qquad (\ .4)$$

W_t . - :

$$W_t = \frac{(1-\alpha)AK_{t-1}^{\alpha}L_t^{-\alpha}}{X_t}, \qquad (\ .5)$$

$$\frac{1}{C_t^E}\left(1 - \frac{M\mathbb{E}_t \Pi_{t+1}}{R_t^B}\right) = \gamma \mathbb{E}_t\left[\frac{1}{C_{t+1}^E}\left(\frac{\alpha Y_{t+1}^E}{X_{t+1}K_t} - M + 1 - \delta\right)\right]. \qquad (\ .6)$$

Households and government. 3.1.
3.1: y (2.3) (2.4) ,
(3.5) (3.7). - $Y_t = C_t + C_t^E + I_t$.

Equilibrium. y $\{c_t, c_t^E, y_t, k_t, i_t, b_t, b_t^{CB}\}_{t=0}^{\infty}$
$\{x_t, \pi_t, w_t, r_t^B, r_t, rp_t, s_t\}_{t=0}^{\infty}$ (2.3), (2.4), (3.5), (3.7), y ,

$$c_t = -\frac{1}{\sigma}(r_t^B - \mathbb{E}_t\pi_{t+1} - r^B) + \mathbb{E}_t c_{t+1}, \qquad (\ .7)$$

$$C^E c_t^E = \alpha\frac{Y}{X}(y_t - x_t) + Bb_t - R^B B(r_{t-1}^B + b_{t-1} - \pi_{t-1}) - Ii_t + \Lambda_1, \qquad (\ .8)$$

$$b_t = \mathbb{E}_t(k_t + \pi_{t+1} + m - r_t^B), \qquad (\ .9)$$

$$0 = \left(1 - \frac{M}{R^B}\right)(c_t^E - \mathbb{E}_t c_{t+1}^E) + \frac{\gamma\alpha Y}{XK}\mathbb{E}_t(y_{t+1} - x_{t+1} - k_t) + \frac{M}{R^B}\mathbb{E}_t(\pi_{t+1} - r_t^B) + \Lambda_2, \qquad (\ .10)$$

$$y_t = \frac{\alpha(1+\eta)}{\alpha+\eta}k_{t-1} - \frac{1-\alpha}{\alpha+\eta}(x_t + \sigma c_t) + \frac{1+\eta}{\alpha+\eta}a + \frac{1-\alpha}{\alpha+\eta} \quad (1-\alpha), \qquad (\ .11)$$

$$k_t = (1-\delta)k_{t-1} + \delta i_t - \delta \quad \delta, \qquad (\ .12)$$

$$\pi_t = \beta\mathbb{E}_t\pi_{t+1} - \lambda(x_t - x), \qquad (\ .13)$$

$$y_t = \frac{C}{Y}c_t + \frac{C^E}{Y}c_t^E + \left(1 - \frac{C}{Y} - \frac{C^E}{Y}\right)i_t, \qquad (\ .14)$$

$\Lambda_1 = C^E \quad C^E - \alpha\frac{Y}{X} \quad \frac{Y}{X} - B \quad B + R^B B \quad R^B B + I \quad I$, $\Lambda_2 = -\frac{\gamma\alpha Y}{XK} \quad \frac{Y}{XK} + \frac{M}{R^B} \quad R^B$. Λ_2 (4.15) $\Lambda_2 = \Lambda_2 -$
$\left(\frac{1}{R^B} - \gamma\right)M \quad M$.

Equivalence. , 1

Corollary 1. *The shadow rate New Keynesian model represented by the shadow rate IS curve*

$$c_t = -\frac{1}{\sigma}(s_t - \mathbb{E}_t\pi_{t+1} - s) + \mathbb{E}_t c_{t+1}, \qquad (\ .15)$$

the shadow rate Taylor rule (2.3), together with (A.11)–(A.14) and

$$C^E c_t^E = \alpha\frac{Y}{X}(y_t - x_t) + Bb_t - R^B B(s_{t-1} + rp + b_{t-1} - \pi_{t-1}) - Ii_t + \Lambda_1, \qquad (\ .16)$$

$$b_t = \mathbb{E}_t(k_t + \pi_{t+1} + m - s_t - rp), \tag{.17}$$

$$0 = \left(1 - \frac{M}{R^B}\right)(c_t^E - \mathbb{E}_t c_{t+1}^E) + \frac{\gamma\alpha Y}{XK}\mathbb{E}_t(y_{t+1} - x_{t+1} - k_t) + \frac{M}{R^B}\mathbb{E}_t(\pi_{t+1} - s_t - rp + m) + \Lambda_2 \tag{.18}$$

is equivalent to the model summarized by (2.3), (2.4), (3.5), (3.7), and (A.7)–(A

Proof for Proposition 4. - $\frac{exp(\varphi s_t)}{1+exp(\varphi s_t)}$ (5.3):

$$\frac{exp(\varphi s_t)}{1+exp(\varphi s_t)} = \frac{exp(\varphi s)}{1+exp(\varphi s)} + \frac{exp(\varphi s)}{1+exp(\varphi s)}\varphi s_t - \frac{exp(2\varphi s)}{(1+exp(\varphi s))^2}\varphi s_t, \qquad (.3)$$

$s_t = s_t - s.$ (5.3)

$$\frac{exp(\varphi s)}{1+exp(\varphi s)} = \frac{\frac{\mathcal{S}}{s} - \lambda}{1-\lambda} \qquad (.4)$$

ω , $1-\omega$,

$$\mathcal{S}/s = \omega + (1-\omega)\lambda. \qquad (.5)$$

y (.4), $\frac{exp(\varphi s)}{1+exp(\varphi s)} = \omega.$ y (.3) (5.3).

$$\mathcal{S}_t = \left(\left[1+\varphi(1-\omega)s_t\right]\omega(1-\lambda)+\lambda\right)s_t. \qquad (.6)$$

,

$$\begin{aligned}\mathcal{S}_t + \mathcal{S} &= \left(\left[1+\varphi(1-\omega)s_t\right]\omega(1-\lambda)+\lambda\right)(s_t+s)\\ &= \left(\left[1+\varphi(1-\omega)s_t\right]\omega(1-\lambda)+\lambda\right)s_t + \left(\left[1+\varphi(1-\omega)s_t\right]\omega(1-\lambda)+\lambda\right)s\\ &= \omega(1-\lambda)s_t + \lambda s_t + \omega(1-\lambda)s + \varphi s(1-\omega)\omega(1-\lambda)s_t + \lambda s\end{aligned}$$

y (.5),

$$\mathcal{S}_t = \omega(1-\lambda)+\lambda+\varphi s(1-\omega)\omega(1-\lambda)\ s_t, \qquad (.7)$$

(5.4). □

Proof for Proposition 5. (5.6), (5.4)

$$\mathcal{S}_t = s_t. \qquad (.8)$$

□

Appendix C. Quantitative model

C.1. Setup

C.1.1. Patient households

(P) y:

$$\mathbb{E}_0\sum_{t=0}^{\infty}\left(\prod_{i=1}^{t}\beta_i\right)\left[\quad C_t^P + j \quad H_t^P - (L_t^P)^{1+\eta}/(1+\eta) + \chi_{\mathcal{M}} \quad (\mathcal{M}_t^P/P_t)\right],$$

β_t β $\beta_t/\beta = (\beta_{t-1}/\beta)^{\rho_\beta}\varepsilon_{\beta,t}$. C_t^P - , j y , H_t^P , L_t^P , $\mathcal{M}_t^P/P_t$ y .

$t-1$ B_{t-1}^P, $R_{t-1}^B/\mathcal{T}_{t-1}$ t. R_t^B y R_t y RP_t $R_t^B = R_t RP_t$. $\mathcal{T}_{t-1}$ $t-1$. :

$$C_t^P + Q_t\Delta H_t^P + \frac{B_t^P}{P_t} = \frac{R_{t-1}^B B_{t-1}^P}{\mathcal{T}_{t-1}P_t} + W_t^P L_t^P + \mathcal{D}_t + T_t^P - \frac{\Delta\mathcal{M}_t^P}{P_t} - \mathcal{T}_t^P, \qquad (.1)$$

Δ . Q_t , W_t^P , $\Pi_t \equiv P_t/P_{t-1}$. $\mathcal{D}_t$ - , T_t^P , $\mathcal{T}_t^P$ - .

- , y,

1

C.1.2. Impatient households

(I) β^I , -

. y C_t^I,

H_t^I, y L_t^I, y $\Delta\mathcal{M}_t^I/P_t$ y y

$$\mathbb{E}_0\sum_{t=0}^{\infty}(\beta^I)^t\big[\quad C_t^I + j \quad H_t^I - (L_t^I)^{1+\eta}/(1+\eta) + \chi_{\mathcal{M}} \quad (\mathcal{M}_t^I/P_t)\big].$$

$$C_t^I + Q_t\Delta H_t^I + \frac{R_{t-1}^B B_{t-1}^I}{\mathcal{T}_{t-1}P_t} = \frac{B_t^I}{P_t} + W_t^I L_t^I + T_t^I - \frac{\Delta\mathcal{M}_t^I}{P_t} - \mathcal{T}_t^I \qquad (.5)$$

$$B_t^I/P_t \leq \widetilde{M}_t M_t^I \mathbb{E}_t(Q_{t+1}H_t^I\Pi_{t+1}/R_t^B), \qquad (.6)$$

B_t^I y , W_t^I , T_t^I , $\mathcal{T}_t^I$

- . $\widetilde{M}_t M_t^I$ - - y . $\widetilde{M}_t$

1, $\widetilde{M}_t = (\widetilde{M}_{t-1})^{\rho_m}\varepsilon_{m,t}$, $\varepsilon_{m,t}$ y . M_t^I y,

$M_t^I = M^I$. - y

:

$$W_t^I = (L_t^I)^{\eta}C_t^I \qquad (.7)$$

$$\frac{Q_t}{C_t^I} = \frac{j}{H_t^I} + \mathbb{E}_t\left[\beta^I\frac{Q_{t+1}}{C_{t+1}^I}\left(1 - \frac{\widetilde{M}_t M_t^I}{\mathcal{T}_t}\right) + \frac{\widetilde{M}_t M_t^I Q_{t+1}\Pi_{t+1}}{C_t^I R_t^B}\right]. \qquad (.8)$$

C.1.3. Entrepreneurs

(y E) Y

y - :

$$G_t = T_t^G + \mathcal{T}_t^P + \mathcal{T}_t^I, \quad (.22)$$

G_t , :

$$\frac{G_t}{G} = \left(\frac{G_{t-1}}{G}\right)^{\rho_g} \varepsilon_{g,t}, \quad (.23)$$

$\varepsilon_{g,t}$ - , $\mathcal{T}_t^P(\mathcal{T}_t^I)$ - ( ) .
- y , y:

$$\mathcal{T}_t^P = \alpha(G_t - T_t^G) \quad (.24)$$

$$\mathcal{T}_t^I = (1-\alpha)(G_t - T_t^G). \quad (.25)$$

C.1.6. Equilibrium

$\{H_t^E, H_t^P, H_t^I, L_t^E, L_t^P, L_t^I, Y_t, C_t^E, C_t^P, C_t^I, I_t, K_t, B_t^E, B_t^P, B_t^I, B_t^{CB}, G_t, \Delta\mathcal{M}_t^{CB}, \Delta\mathcal{M}_t^P, \Delta\mathcal{M}_t^I, T_t^P, T_t^I, T_t^G, \mathcal{T}_t^P, \mathcal{T}^I{}_t\}_{t=0}^{\infty}$, $\{W_t^P, W_t^I, S_t, P_t, P_t^*, X_t, Q_t\}_{t=0}^{\infty}$,
- : $H_t^E + H_t^P + H_t^I = H$, $C_t^E + C_t^P + C_t^I + I_t + G_t = Y_t$, $B_t^P + B_t^{CB} = B_t^E + B_t^I$, (.20), (.22).

C.2. Calibration

.1 . y (2005), -V . (2015), (2019) (2007). .
y- 1.005, 2% ' . y-
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2003 2007, 2%. y- 1 y
. y 0.9% 3.6%
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Table C.1

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			V
β		(2005)	0.99
β^I		(2005)	0.95
γ		(2005)	0.98
j	y-	(2005)	0.1
η	y	(2005)	0.01
μ		(2005)	0.3
ν		(2005)	0.03
δ		(2005)	0.03
X	y	(2005)	1.05
θ	y -	(2005)	0.75
α		(2005)	0.64
M^E	- -	(2005)	0.89
M^I	- -	(2005)	0.55
ϕ_s		(2005)	0.73
ϕ_y		(2005)	0.27
ϕ_π		(2005)	0.13
$\frac{G}{Y}$	y- - - -	-V . (2015)	0.20
ρ_a	y	-V . (2015)	0.90
ρ_g	-	-V . (2015)	0.80
ρ_β		-V . (2015)	0.80
ρ_M	y	(2019)	0.98
ξ_p		(2007)	0.24
Π	y- 2%		1.005
$\frac{B^{CB}}{B^E+B^I}$	y-		0.02
$\mathcal{T}$	y- (y) (y)		1
rp	y- 3.6%	y	1.009

C.3. Steady state

y- , ,
:

$$R^B = \Pi/\beta \qquad (.26)$$

$$S = R = R^B/RP \qquad (.27)$$

$$RR^B = 1/\beta. \qquad (.28)$$

- , ,
, - - , - - :

$$\frac{QH^E}{Y} = \frac{\gamma\nu}{X(1-\gamma^e)} \qquad (.29)$$

$$\frac{B^E}{Y} = \beta M^E \frac{QH^E}{Y} \qquad (.30)$$

$$\frac{C^E}{Y} = \left[\mu + \nu - \frac{\delta\gamma\mu}{1-\gamma(1-\delta)} - (1-\beta)M^E X \frac{QH^E}{Y}\right]\frac{1}{X}, \qquad (.31)$$

$\gamma^e = (1-M^E)\gamma + M^E\beta.$

, , -
, - - , - - :

$$\frac{QH^I}{C^I} = \frac{j}{1-\beta^I(1-M^I) - \frac{M^I}{RR^B}} \qquad (.32)$$

$$\frac{B^I}{QH^I} = \frac{M^I\Pi}{R^B} \qquad (.33)$$

$$\frac{C^I}{Y} = \frac{s^I - \alpha\frac{G-T^G}{Y}}{1 + \frac{QH^I}{C^I}(RR^B-1)\frac{B^I}{QH^I}}, \qquad (.34)$$

$s^I = \frac{(1-\alpha)(1-\mu-\nu)}{X}$.
y , , , (.20)

$$T^G = \left(\frac{R^B}{\Pi} - 1\right)B^{CB}. \qquad (.35)$$

- - , , -
y

$$\frac{B^P}{Y} = \frac{B^E}{Y} + \frac{B^I}{Y} - \frac{B^{CB}}{Y} \qquad (.36)$$

$$\frac{C^P}{Y} = s^P - (1-\alpha)\frac{G-T^G}{Y} + (RR^B-1)\frac{B^P}{Y} \qquad (.37)$$

$$\frac{QH^P}{C^P} = \frac{j}{1-\beta} \qquad (.38)$$

$$\frac{QH^P}{Y} = \frac{QH^P}{C^P}\frac{C^P}{Y}, \qquad (.39)$$

$s^P = \alpha(1-\mu-\nu) + X - 1\ /X$

.
:

$$\frac{H^E}{H^P} = \frac{QH^E}{Y}\Big/\frac{QH^P}{Y} \qquad (.40)$$

$$\frac{H^I}{H^P} = \frac{QH^I}{Y}\Big/\frac{QH^E}{Y}. \qquad (.41)$$

- :

$$\frac{I}{Y} = 1 - \frac{C^E}{Y} - \frac{C^I}{Y} - \frac{C^P}{Y} - \frac{G}{Y} \quad (.42)$$

C.4. Log-linearized model

.4.1. , y
.4.2 .4.3. .4.4
y y.

C.4.1. Shadow rate representation

, y , , S_t -
y 3. y .
:

1. :

$$\widehat{y}_t = \frac{C^E}{Y}\widehat{c}_t^E + \frac{C^P}{Y}\widehat{c}_t^P + \frac{C^I}{Y}\widehat{c}_t^I + \frac{I}{Y}\widehat{i}_t + \frac{G}{Y}\widehat{g}_t \quad (.43)$$

$$\widehat{c}_t^P = \mathbb{E}_t(\widehat{c}_{t+1}^P - \widehat{s}_t + \widehat{\pi}_{t+1} - \widehat{\beta}_{t+1}) \quad (.44)$$

$$\widehat{i}_t - \widehat{k}_{t-1} = \gamma\left(\mathbb{E}_t\widehat{i}_{t+1} - \widehat{k}_t\right) + \frac{1-\gamma(1-\delta)}{\psi}\left[\mathbb{E}_t(\widehat{y}_{t+1} - \widehat{x}_{t+1}) - \widehat{k}_t\right] + \frac{1}{\psi}\left(\widehat{c}_t^E - \mathbb{E}_t\widehat{c}_{t+1}^E\right) \quad (.45)$$

2. / :

$$\begin{aligned}\widehat{q}_t = {} & \gamma^e\mathbb{E}_t\widehat{q}_{t+1} + (1-\gamma^e)\left(\mathbb{E}_t\widehat{y}_{t+1} - \mathbb{E}_t\widehat{x}_{t+1} - \widehat{h}_t^E\right) + \left(1 - M^E\beta\right)\left(\widehat{c}_t^E - \mathbb{E}_t\widehat{c}_{t+1}^E\right) \\ & + M^E\beta(\mathbb{E}_t\widehat{\pi}_{t+1} - \widehat{s}_t) + (\beta-\gamma)M^E\widehat{\widehat{m}}_t \quad (.46)\end{aligned}$$

$$\widehat{q}_t = \gamma^h\mathbb{E}_t\widehat{q}_{t+1} - \left(1-\gamma^h\right)\widehat{h}_t^I + M^I\beta(\mathbb{E}_t\widehat{\pi}_{t+1} - \widehat{s}_t) + \left(1 - \frac{M^I\beta}{\mathcal{T}}\right)\widehat{c}_t^I - \beta^I\left(1-M^I\right)\mathbb{E}_t\widehat{c}_{t+1}^I + (\beta-\beta^I)M^I\widehat{\widehat{m}}_t \quad (.47)$$

$$\widehat{q}_t = \beta\mathbb{E}_t(\widehat{q}_{t+1} + \widehat{\beta}_{t+1}) + \left(\widehat{c}_t^P - \beta\mathbb{E}_t\widehat{c}_{t+1}^P\right) + (1-\beta)\frac{H^E}{H^P}\widehat{h}_t^E - (1-\beta)\frac{H^I}{H^P}\widehat{h}_t^I, \quad (.48)$$

$$\varkappa = (1-\theta)(1-\beta\theta)/\theta$$

5. / :

$$\widehat{k}_t = \delta\widehat{i}_t + (1-\delta)\widehat{k}_{t-1} \qquad (.53)$$

$$\frac{B^E}{Y}\widehat{b}_t^E = \frac{C^E}{Y}$$

Appendix D.

, ., , ., , ., 2011. ? J . y 119 (1), 78 121.
, ., , ., , ., 2015. . . . J7 (1), 110 167.
, . ., , J., 2016. . y ,
, . ., , J., 2017. y y y . . . 58 (4), 1317 1354.
, . ., , J., 2017. . y ,
, V., , ., 2011. - y y. J y . 58, 54 79.
, ., , ., , ., y , ., 2016. ? y .
Y , . 520.
, ., , ., , . ., , ., 2017. y, y, . .
, ., , . ., , ., 2015. . Y , . 574.
-V , J , ., - , - , J., 2015. . J . y . 57,
182 204.
, 2015. J .
, J , ., , J , ., 2011. - . . J . . 7, 3 43.
, J2008. y y, , y : y . y , J y.
, J , ., , ., 2016. y y ? -
22311
, ., , ., 2011. y y. J y . 58, 17 34.
, ., , ., 2013. 1 . 2 . 3...: y - y y . . J . . 9 (1),
5 53.
, ., , ., 2015. y y , y. J7 (1), 44 76.
, ., , ., 2012. y . . . . 102 (4), 1692 1720.
, ., , ., 2015. : y y y. J y . 70, 22 38.
, J , . ., - , ., ., . ., 2017. - . . . 107 (7), 1971 2006.
, . ., , . ., 2014. y y . y .
, J., , J., 2012. y y . J y . 44 (1),
3 46.
, ., 2005. , , y y y . . . . 95 (3), 739 764.
y, ., V / 22 1 2.5477 08 - 4.6055 0 0 074/ 1 1/ 2