The central-bank balance sheet as an instrument of monetary policy

V. Cúrdia and M. Woodford

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Lecture 2

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This presentation does not necessarily reflect the views of the Bank of Israel

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Literature review

- Cúrdia and Woodford (2009). Credit frictions and optimal monetary policy, BIS Working Papers 278.
- Cúrdia and Woodford (2010c). Credit spreads and monetary policy. Journal of Money, Credit and Banking 42(s1), 3–35.
- Eggertsson and Woodford (2003). The zero bound on interest rates and optimal monetary policy. Brookings Papers on Economic Activity 2003(1), 139–211.
- Woodford (2003). Interest and prices: foundations of a theory of monetary policy. Princeton University Press, Princeton.

Some questions

- Monetary policy is ordinarily considered solely in terms of the choice of an operating target for a short-term nominal interest rate.
- During the crisis, the appropriate size of the central bank's balance sheet was part of the debate (Fig. 1 and Fig. 2).
- Does it make sense to regard the supply of bank reserves (or perhaps the monetary base) as an alternative or superior operating target for monetary policy ?
- Does this (as some would argue) become the only important monetary policy decision once the overnight rate (the federal funds rate) has reached the zero lower bound ?
- How should this additional potential dimension of policy be used ?

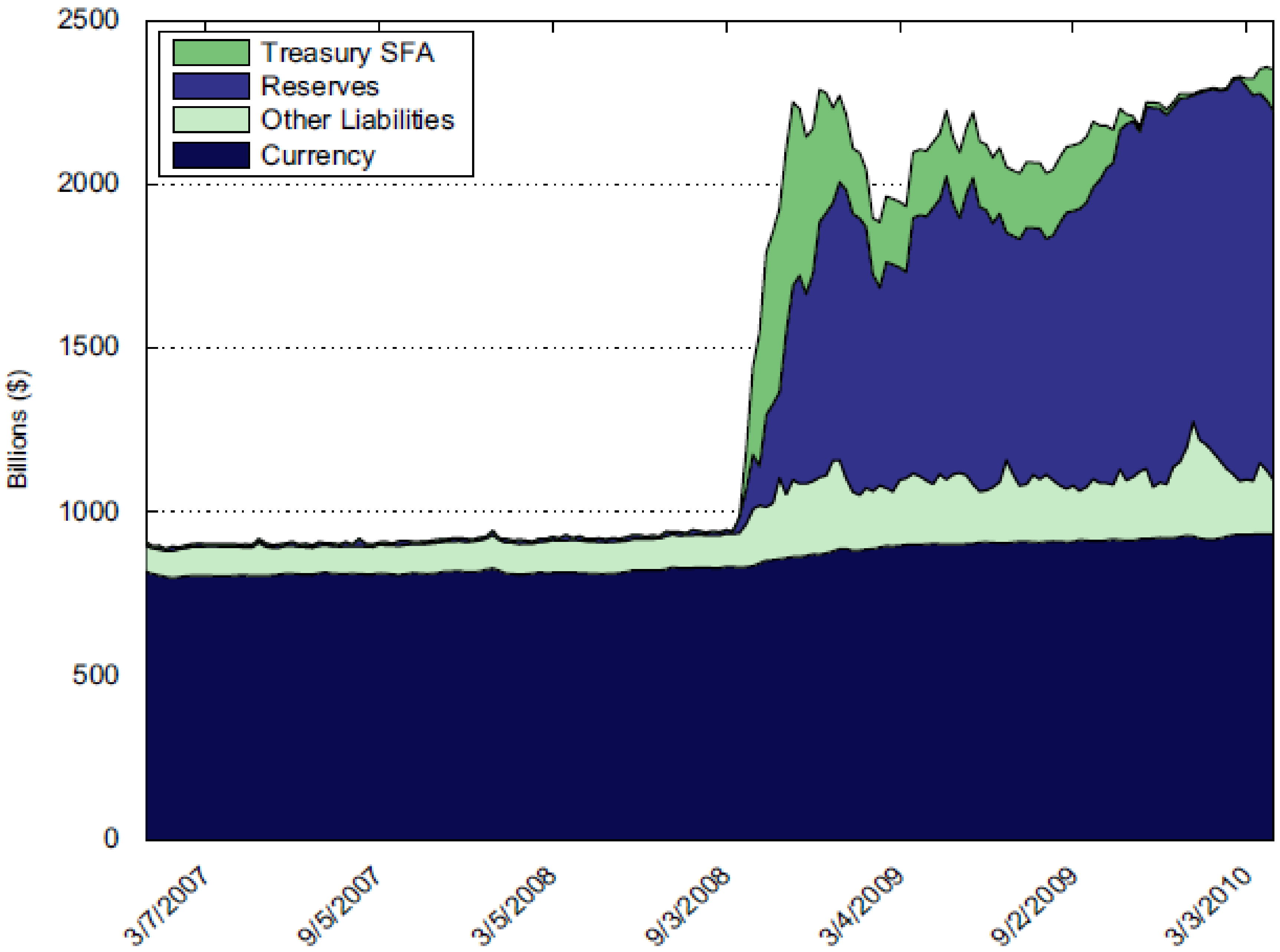

Fig. 1. Liabilities of the Federal Reserve. (Source: Federal Reserve Board.)

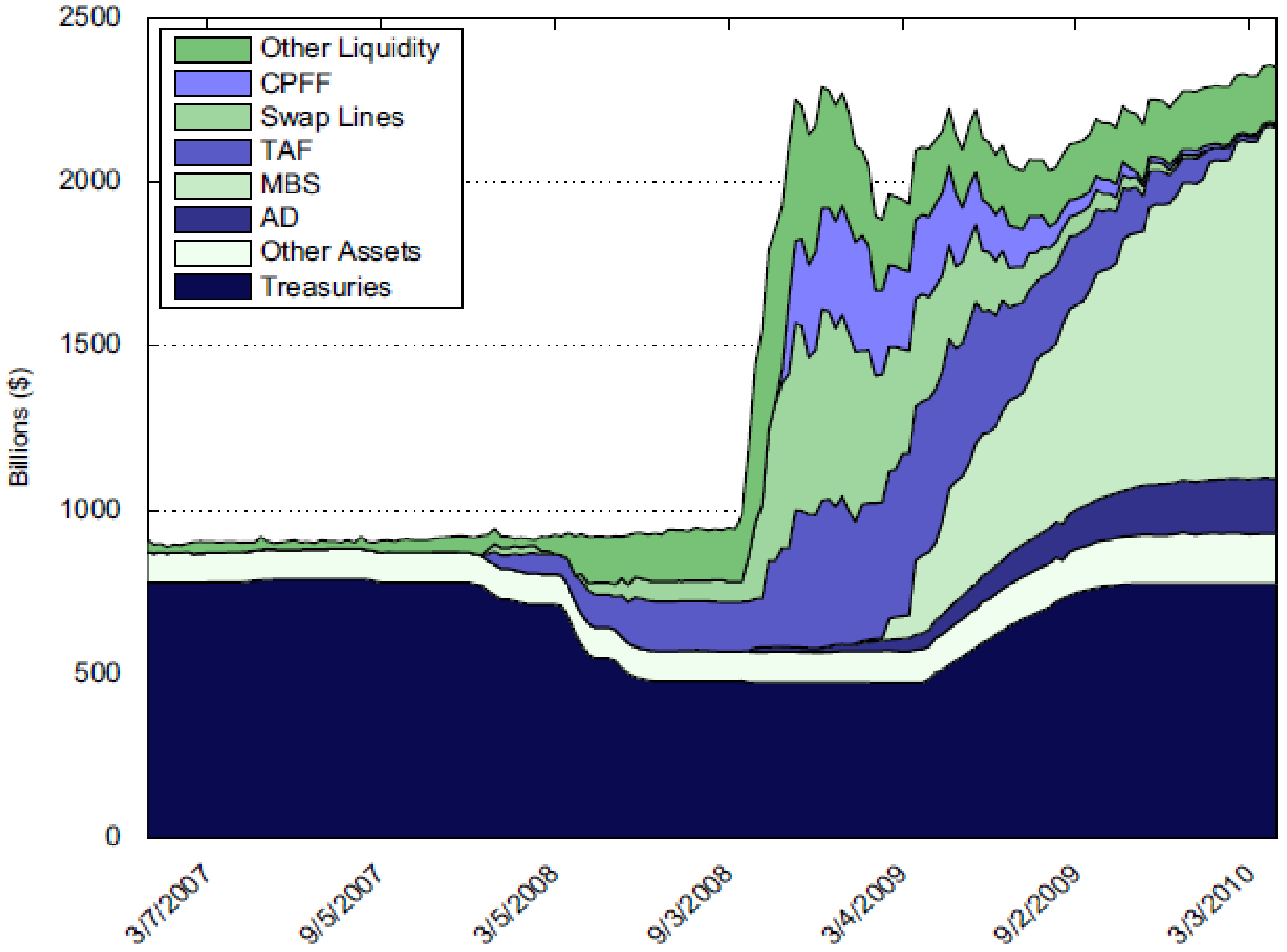

Fig. 2. Assets of the Federal Reserve. (Source: Federal Reserve Board.)

Cúrdia and Woodford: what do they do ?

- They analyze additional dimensions of central bank policy
  - size and composition of the central-bank balance sheet
  - interest rate paid on reserves
  - operating target for the federal funds rate

Cúrdia and Woodford: what do they find ?

- no role for quantitative easing as an additional tool of stabilization policy, even at ZLB.
- there may be a role for central-bank credit policy, or for targeted asset purchases, when private financial markets are sufficiently deteriorated.
- when they are, as indicated by significant increases in interest-rate spreads, one must be cautious in drawing conclusions about the welfare consequences of credit policy.
- ZLB is neither necessary nor sufficient for active credit policy to be welfare-improving.

Assumptions

- No endogenous variations in the capital stock.
- No distinction between the household and firm sectors of the economy
- Instead they treat all private expenditure as the expenditure of infinite-lived household-firms
- No consequences of investment spending for the evolution of the economy's productive capacity
- Instead they treat all private expenditure as if it were non-durable consumer expenditure
- Monopolistic competition in goods markets.
- Sticky prices *à la* Calvo (1983)
- Two household types: savers (s) and borrowers (b).

Representative household

- Households seek to maximize:

$$E_0 \sum_{t=0}^{+\infty} \beta^t \left\{ u^{\tau_t(i)} \left(c_t \left(i \right) ; \xi_t \right) - \int_0^1 v^{\tau_t(i)} \left(h_t \left(i, j \right) ; \xi_t \right) dj \right\} \quad (1)$$

where $\tau_t(i)$ indicates household's type in period t and

$$u^{\tau_t(i)} \left(c_t \left(i \right) ; \xi_t \right) = \frac{c^{1-\sigma_\tau^{-1}} \left(\bar{C}_t^\tau \right)^{\sigma_\tau^{-1}}}{1 - \sigma_\tau^{-1}} \quad (2)$$

where $\bar{C}_t^\tau$ is an exogenous type-specific disturbance indicating variation in aggregate spending opportunities.

- The index $c_t(i)$ is a Dixit–Stiglitz aggregator of the household's purchases of differentiated goods, with elasticity of substitution θ between any two goods.

Household's types

- Each agent's type $\tau_t(i)$ evolves as an independent two-state Markov chain.
- Each period, an event occurs with probability $1-\delta$ (for $0 \leq \delta < 1$) which results in a new type for the household being drawn; otherwise it remains the same as in the previous period.
- When a new type is drawn, it is b with probability $\pi_b > 0$ and s with probability $\pi_s < 1$, where $\pi_b + \pi_s = 1$.
- $u_c^b(c;\xi) > u_c^s(c;\xi)$ for all levels of expenditure c in the range that occur in equilibrium.
- A change in a household's type changes its relative impatience to consume.
- Current impatience of households to consume is changed by the exogenous disturbances $\bar{C}_t^\tau$.

Representative firm

- Continuum of differentiated goods, each produced by a monopolistically competitive supplier, with a production technology for each good j of the form

$$y_t(i) = A_t h_t(j)^{1/\phi} \tag{3}$$

where ϕ indicates the degree of diminishing returns, and A_t is an exogenous productivity shock, common to all goods.

- The household similarly supplies a continuum of different types of specialized labor, indexed by j, that are hired by firms in different sectors of the economy

$$\upsilon^{\tau_t(i)}\left(h_t(i,j);\xi_t\right) = \frac{\psi_\tau}{1+v} h^{1+v} \bar{H}_t^{-v} \tag{4}$$

where v is the inverse of the Frisch elasticity of labor supply for both types, and $\bar{H}_t$ is an exogenous disturbance, also common to both types.

Summarizing the economy (1)

$$\lambda_t^b = \left(1 + i_t^d\right)(1 + \omega_t)\,\beta E_t \left[\begin{array}{c} (\delta + (1-\delta)\,\pi_b)\,\frac{\lambda_{t+1}^b}{\Pi_{t+1}} \\ + (1-\delta)(1-\pi_b)\,\frac{\lambda_{t+1}^s}{\Pi_{t+1}} \end{array} \right] \quad (5)$$

where λ_t^b is the marginal utility of expenditure of borrowers, i_t^b is the deposit/policy rate, $\omega_t = \frac{i_t^b - i_t^d}{1+i_t^d}$ is the spread between borrowing and deposit rates, Π_t is the gross inflation rate, and λ_t^s is marginal utility of expenditure of savers defined as

$$\lambda_t^s = \left(1 + i_t^d\right)\beta E_t \left[\begin{array}{c} (1-\delta)\,\pi_b \frac{\lambda_{t+1}^b}{\Pi_{t+1}} \\ + (\delta + (1-\delta)(1-\pi_b))\,\frac{\lambda_{t+1}^s}{\Pi_{t+1}} \end{array} \right] \quad (6)$$

Summarizing the economy (2)

$$K_t = \frac{\Lambda\left(\lambda_t^b, \lambda_t^s\right)}{\tilde{\lambda}\left(\lambda_t^b, \lambda_t^s\right)} \mu^p \left(1+\omega_y\right) \psi \mu_t^w \bar{H}_t^{-v} \left(\frac{Y_t}{A_t}\right)^{1+\omega_y} + \alpha\beta E_t \left[\Pi_{t+1}^{\theta(1+\omega_y)} K_{t+1}\right] \quad (7)$$

where K_t is an artificial variable used in recursive version of inflation dynamics, Λ and $\tilde{\lambda}$ are different weighted average functions, and μ_t^w is the wage markup.

$$F_t = \Lambda\left(\lambda_t^b, \lambda_t^s\right)\left(1-\tau_t\right) Y_t + \alpha\beta E_t \left[\Pi_{t+1}^{\theta-1} F_{t+1}\right] \quad (8)$$

where F_t is an artificial variable used in recursive version of inflation dynamics, and τ_t is the marginal tax rate.

Summarizing the economy (3)

Real per capita private debt evolves according to

$$(1+\pi_b\omega_t)\, b_t = \pi_b\pi_s B\left(\lambda_t^b, \lambda_t^s, Y_t, \Delta_t; \xi_t\right) - \pi_b b_t^g + \delta\left[b_{t-1}\left(1+\omega_{t-1}\right) + \pi_b b_{t-1}^g\right]\frac{1+i_{t-1}^d}{\Pi_t} \quad (9)$$

$$Y_t = \pi_b \bar{C}_t^b \left(\lambda_t^b\right)^{-\sigma_b} + \pi_s \bar{C}_t^s \left(\lambda_t^s\right)^{-\sigma_s} + G_t + \Xi_t \quad (10)$$

where b_t^g is the total outstanding real public debt, G_t represents government consumption, and Ξ_t is the total intermediation resource costs, including both private and central bank.

$$\Delta_t = \alpha\Delta_{t-1}\Pi_t^{\theta(1+\omega_y)} + (1-\alpha)\left(\frac{1-\alpha\Pi_t^{\theta-1}}{1-\alpha}\right)^{\frac{\theta(1+\omega_y)}{\theta-1}} \quad (11)$$

where Δ_t measures price dispersion.

Summarizing the economy (4)

$$\frac{1-\alpha\Pi_t^{\theta-1}}{1-\alpha} = \left(\frac{F_t}{K_t}\right)^{\frac{\theta-1}{1+\theta\omega y}} \tag{12}$$

$$\omega_t = (1+\varkappa)\,\tilde{\chi}_t\left(b_t - L_t^{cb}\right)^{\varkappa} + \tilde{\chi}_t^{+} + \eta\tilde{\Xi}_t\left(b_t - L_t^{cb}\right)^{\eta-1} + \tilde{\Xi}_t^{+} \tag{13}$$

where L_t^{cb} is the real quantity of lending by the central bank to the private sector, $\tilde{\chi}_t$ ($\tilde{\chi}_t^{+}$) is a multiplicative (additive) shock to default rate, $\tilde{\Xi}_t$ ($\tilde{\Xi}_t^{+}$) is a multiplicative (additive) private intermediation resource cost shock.

$$\Xi_t = \tilde{\Xi}_t\left(b_t - L_t^{cb}\right)^{\eta} + \tilde{\Xi}_t^{+}\left(b_t - L_t^{cb}\right) + \tilde{\Xi}_t^{cb}L_t^{cb} \tag{14}$$

where $\tilde{\Xi}_t^{cb}$ is a resource cost function.

Financial intermediaries (1)

The private intermediaries resource cost, given the satiation of reserves, is given by:

$$\Xi_t^p \left(L; \xi_t\right) = \tilde{\Xi}_t L_t^\eta + \tilde{\Xi}_t^+ L \tag{15}$$

where L is the amount of privately intermediated credit, and $\eta \geq 1$.
Fraudulent credit loss is

$$\chi \left(L; \xi_t\right) = \tilde{\chi}_t L_t^{1+\varkappa} + \tilde{\chi}_t^+ L \tag{16}$$

where $\varkappa \geq 0$.
Central bank lending resource cost

$$\Xi_t^{cb} \left(L^{cb}\right) = \tilde{\Xi}_t^{cb} L^{\eta_{cb}} \tag{17}$$

where $\eta_{cb} \geq 1$.

Financial intermediaries (2)

Intermediary chooses d_t such that

$$\left(1+i_t^d\right) d_t = \left(1+i_t^b\right) L_t + \left(1+i_t^m\right) m_t \tag{18}$$

where m_t is the quality of real reserves held at the central bank paying a nominal interest yield i_t^m.

Deposits not used to finance either loans or the acquisition of reserve balances are distributed as earnings to its shareholders

$$d_t - m_t - L_t - \chi_t\left(L_t\right) - \Xi_t^p\left(L_t; m_t\right) \tag{19}$$

Market-clearing in the credit market requires that

$$b_t = L_t^{cb} + L_t \tag{20}$$

Financial intermediaries (3)

F.O.C. $/L_t$

$$\frac{\partial \Xi_t^p (L_t; m_t)}{\partial L_t} + \frac{\partial \chi_t (L_t)}{\partial L_t} = \omega_t = \frac{i_t^b - i_t^d}{1 + i_t^d} \tag{21}$$

F.O.C. $/m_t$

$$-\frac{\partial \Xi_t^p (L_t; m_t)}{\partial m_t} = \delta_t^m = \frac{i_t^b - i_t^m}{1 + i_t^d} \tag{22}$$

Eq. 22 determines the equilibrium differential between the interest paid on deposits and that paid on reserves at the central bank.

Dimensions of central-bank policy

- In the model, central bank's liabilities consist of the reserves M_t (which is also the monetary base in the simple model).
- Central bank's holdings of government debt is $m_t - L_t^{cb}$ (two variables chosen by the central bank) where $0 \leq L_t^{cb} \leq m_t$
- Positive quantity of public debt remains in the portfolios of households[2] : $m_t \leq L_t^{cb} + b_t^g$
- Strong assumption: i_t^m is assumed to be equal to the one private sector request reserves (i.e. the central bank receives the market-determined yield). Then, at equilibrium, $i_t^m = i_t^b$. In other words, the central bank cannot use this instrument in the model.

[2] This constraint is never binding.

Instruments of central-bank policy

- i_t^d is determined at each period by the system

$$\begin{cases} m_t \geq m_t^d \left(L_t; \delta_t^m\right) \\ \delta_t^m \geq 0 \end{cases} \tag{23}$$

where $m_t^d \left(L; \delta_t^m\right)$ represents the demand for reserves which equals the satiation level $\left(\bar{m}_t \left(L\right)\right)$ when $\delta_t^m = 0$.

- For institutional reasons, it is not possible for the central bank to pay a negative interest rate on reserves, thus implying that $0 \leq i_t^m \leq i_t^d$.
- To summarize, the central bank can play with the **quantity of reserves** M_t that are supplied, with the **interest rate paid on those reserves** i_t^m (disabled here), and with the **breakdown of central-bank assets** between government debt and lending L_t^{cb} to the private sector.

Welfare objective

- Optimal policy is considered: the objective of policy is the maximization of average expected utility such as

$$E_{t_0} \sum_{t=t_0}^{+\infty} \beta^{t-t_0} U_t \tag{24}$$

  where U_t refers to the household's utility function used in Eq. 1.
- See the paper for the demonstration why arguments $U_t = U\left(Y_t, \Omega_t, \Xi_t, \Delta_t; \tilde{\xi}_t\right)$, where $\Omega_t = \lambda_t^b / \lambda_t^s$, suffice to determine welfare, and the way each of them affects welfare.

Summary

- Optimal policy with regard to the supply of reserves: taking as given (for now) the way in which the central bank chooses its operating target for the policy rate i_t^d, and the state-contingent level of central-bank lending to the private sector (L_t^{cb}).
- Simple result: optimal policy requires that intermediaries be satiated in reserves, i.e., that $\forall t \; M_t / P_t \geq \bar{m}_t \left(L_t\right)$.

Is a reserve supply target needed?

- Efficient condition: $i_t^m = i_t^d$ i.e. $\delta_t^m = 0$
- When the central bank acts to implement its target for the policy rate through open-market operations, it will automatically have to adjust the supply of reserves so as to satisfy $\delta_t^m = 0$.
- No need of FOMC decision, bank's staff in charge of carrying out the necessary interventions is sufficient.

Is there a role for quantitative easing?

- By construction, the model implies that it is desirable to ensure that the supply of reserves never falls below a certain satiation level: $\bar{m}_t\left(L_t\right)$.
- It then implies that there is no benefit from supplying reserves beyond that level.
- However, it can be desirable to supply reserves beyond $\bar{m}_t\left(L_t\right)$ if this is necessary in order to make the optimal quantity of central bank lending to the private sector consistent with $0 \leq L_t^{cb} \leq m_t$.
- See Fig. 3.

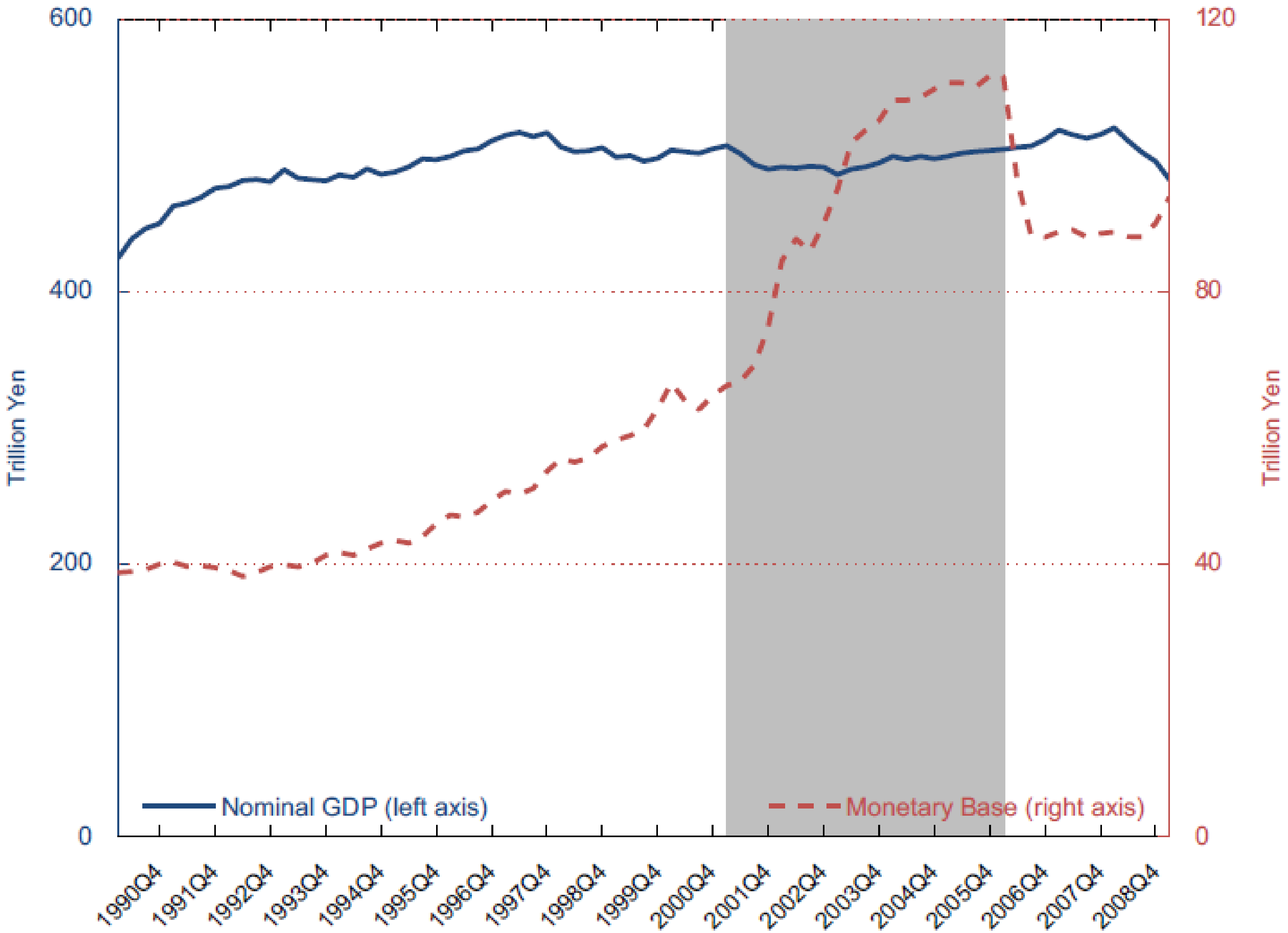

Fig. 3. The monetary base and nominal GDP for Japan (both seasonally adjusted), 1990–2009. The shaded region shows the period of "quantitative easing," from March 2001 through March 2006. (Sources: IMF International Financial Statistics and Bank of Japan.)

An other dimension of central-bank policy

Adjustment of the composition of the asset side of the central bank's balance sheet (taking as given the overall size of the balance sheet)

$$\bar{\Xi}_t^p(L_t) = \Xi_t^p(L_t; \bar{m}_t(L_t)) \quad (25)$$

$$\bar{\omega}_t(L_t) = \omega_t(L_t; \bar{m}_t(L_t)) \quad (26)$$

Specifying the evolution of Ξ_t^p and ω_t as functions of the evolution of aggregate private credit, the equilibrium conditions of the model do not refer to the quantity of reserves or to the interest rate paid on reserves.

"Treasuries only"

- According to the traditional doctrine of "Treasuries only", the central bank should not vary the composition of its balance sheet as a policy tool;
- Instead, it should avoid both balance-sheet risk and the danger of politicization by only holding (essentially riskless) Treasury securities at all times, while varying the size of its balance sheet to achieve its stabilization goals for the aggregate economy.

Eggertsson and Woodford (2003)

- Eggertsson and Woodford (2003) show that assets purchased by the central bank have no consequences for the equilibrium evolution of output, inflation or asset prices.
- This irrelevance result does not hold, however, in the presence of credit frictions of the kind assumed here.
- Proof: the difference between the economy's evolution under an optimal credit policy and under the constraint of "Treasuries only" (Fig. 6 to Fig. 12).

Relaxing the "Treasuries only" restriction (1)

- What is the marginal increase in the value of the welfare objective (Eq. 24) that is achieved by a marginal increase in L_t^{cb} above zero in some period.
- The marginal cost of central-bank lending required for "Treasuries only" to be optimal ($\Xi_t^{cb,crit}$) is reported in figures such as

$$\Xi_t^{cb,crit} = \bar{\Xi}_t^{p'}\left(L_t\right) + \frac{\varphi_{\omega,t}}{\varphi_{\Xi,t}}\left[\bar{\Xi}_t^{p''}\left(L_t\right) + \chi_t^{''}\left(L_t\right)\right] \qquad (27)$$

where $\bar{\Xi}_t^{p'}$ is the marginal resource cost of lending by private intermediaries.

Relaxing the "Treasuries only" restriction (2)

- Four different possible purely financial disturbances, each of which will be assumed to increase the value of $\bar{\omega}_t(\bar{L})$ by the same number of percentage points:
  - Additive shock: translates the schedule $\bar{\omega}_t(L_t)$ vertically by a constant amount;
  - Multiplicative shock: multiply the entire schedule $\bar{\omega}_t(L_t)$ by some constant factor greater than 1.
  - Ξ shock: disturbances that change the function $\bar{\Xi}_t(L_t)$;
  - χ shock: disturbances that change the function $\chi_t(L_t)$.
- Fig. 4 shows that the degree to which a financial disturbance provides a justification for active central-bank credit policy depends very much on the reason for the increase in spreads.
- Fig. 5 shows how optimal vs. Taylor rules react, with or without ZLB.

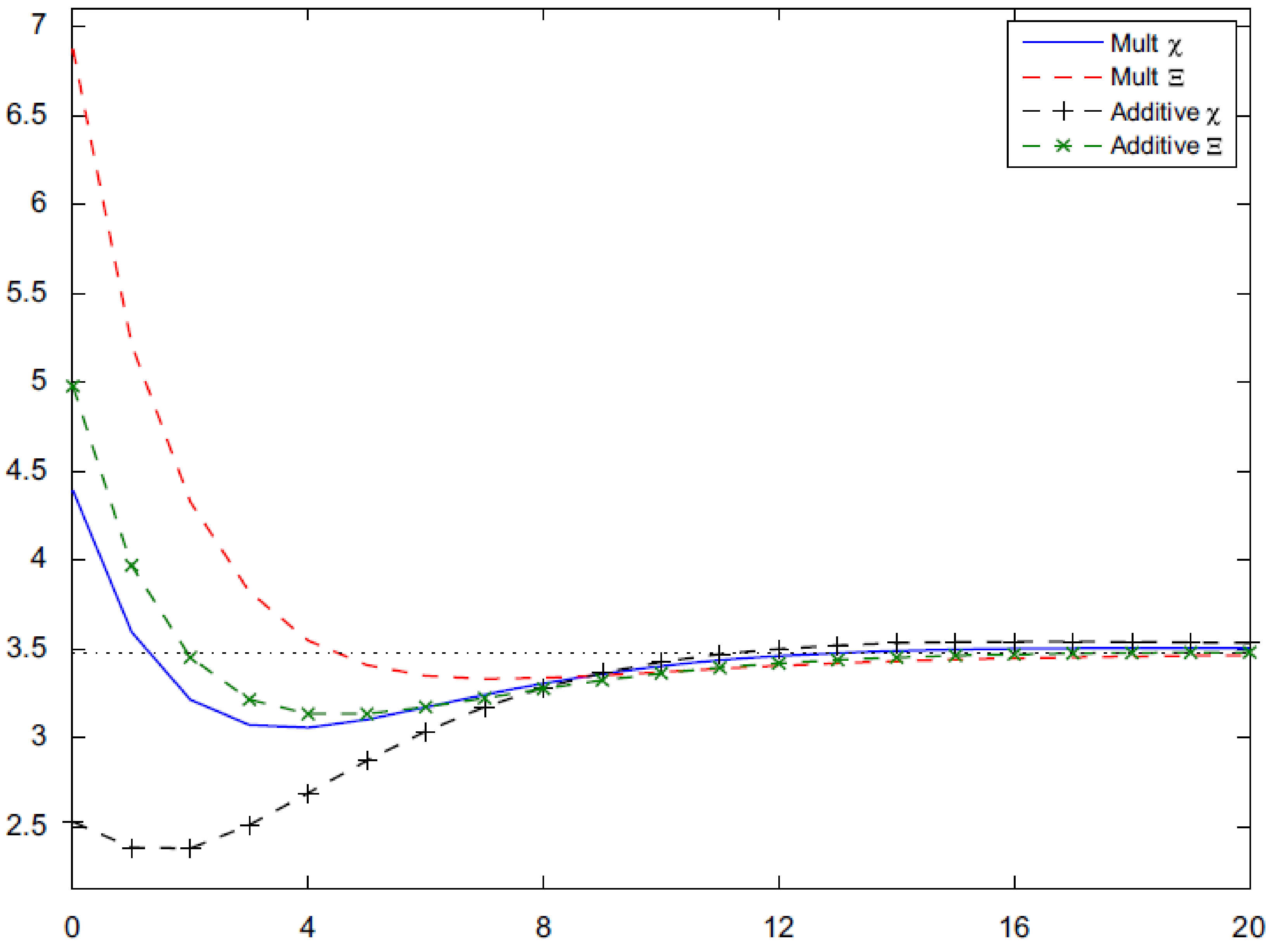

Fig. 4. Response of the critical threshold value of $\Xi^{cb\prime}(0)$ for a corner solution, in the case of four different types of "purely financial" disturbances, each of which increases $\omega_t(\bar{L})$ by 4 percentage points. Interest-rate policy responds optimally in each case.

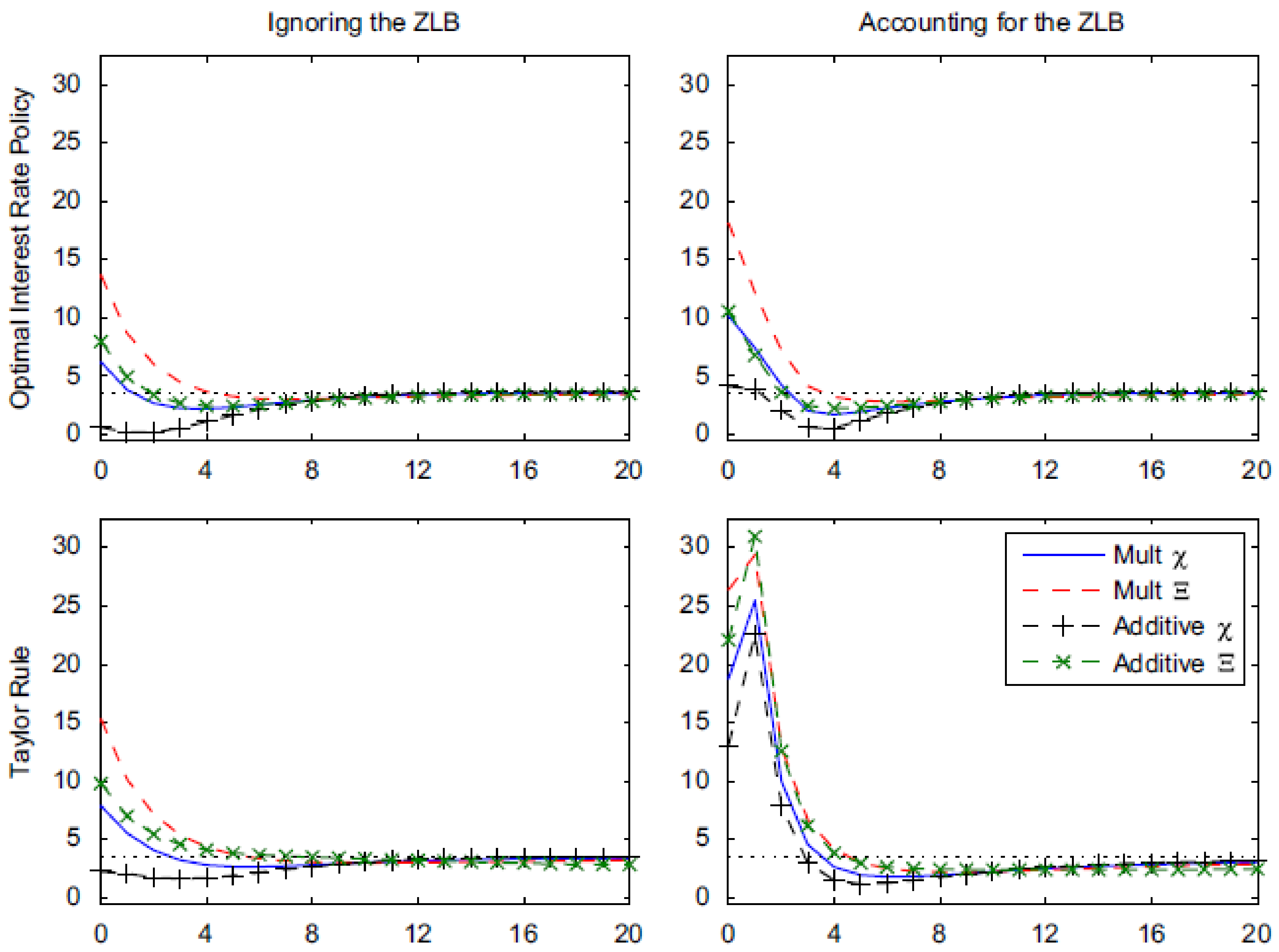

Fig. 5. Response of the critical threshold value of $\Xi^{cb\prime}(0)$ for a corner solution, in the case of financial disturbances that increase $\omega_t(\bar{L})$ by 12 percentage points. Interest-rate policy responds optimally in the panels of the top row, but follows a Taylor rule in the bottom panels. The zero lower bound is assumed not to constrain interest-rate policy in the panels of the left column, while the constraint is imposed in the corresponding panels of the right column.

Optimal credit policy under alternative financial disturbances

- Optimal state-contingent evolution of central-bank lending L_t^{cb}, only the constraint that it be non-negative is imposed, and resource costs of loan origination and central-bank monitoring are taken into account.
- Existence of a competitive loan market is still assumed : central-bank lends at the same (market-clearing) interest rate i_t^b as the private intermediaries, who continue to lend even when the central-bank lends as well.
- As previous results suggest, the degree to which active credit policy is optimal varies with the nature of the financial disturbance.
- See Fig. 6 to Fig. 12.

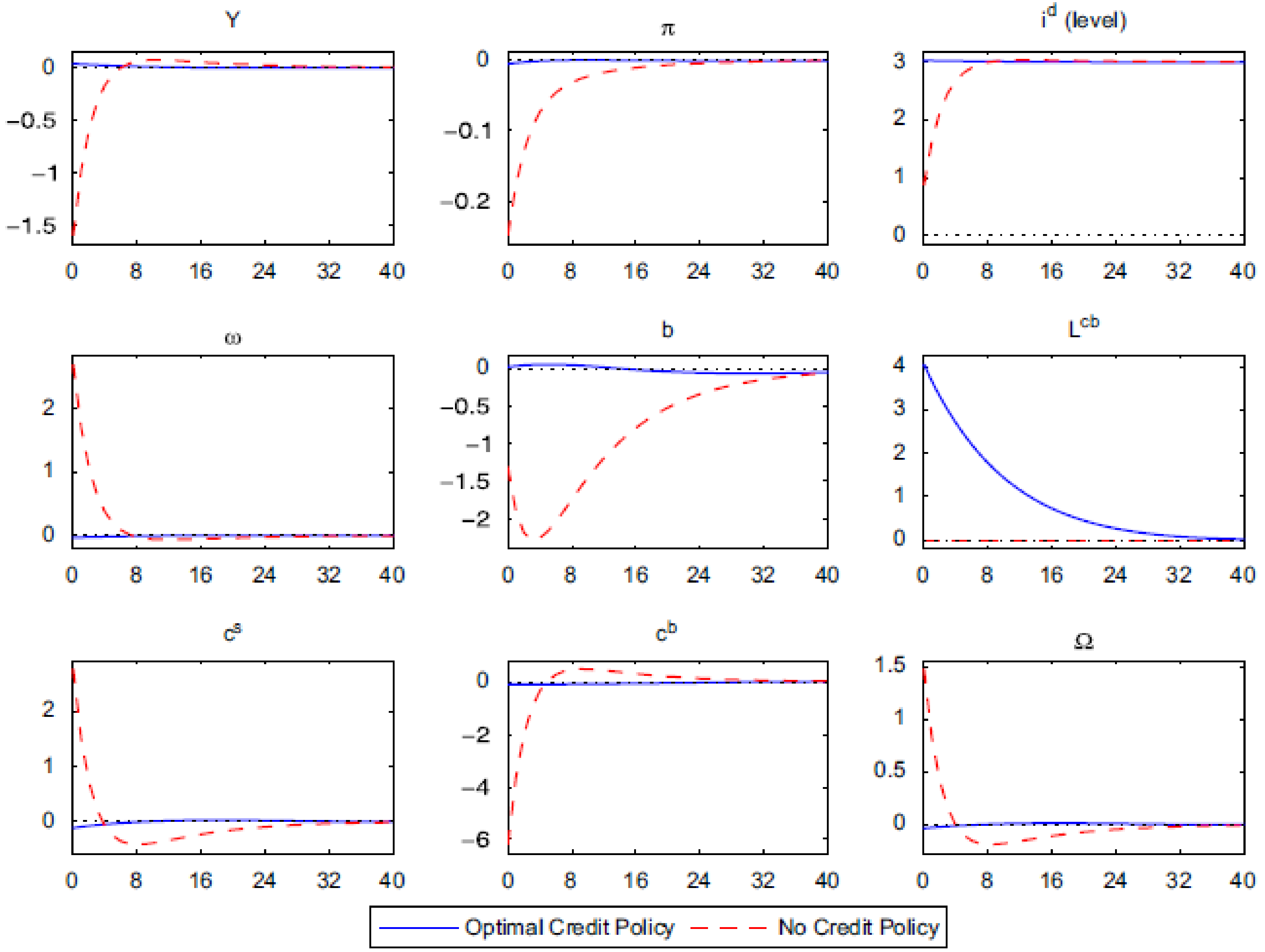

Fig. 6. Impulse responses under optimal credit policy compared to those under a policy of "Treasuries only," in the case of a "multiplicative Ξ" shock of the size considered in Fig. 4, if interest-rate policy follows a Taylor rule and $\bar{\Xi}^{cb}$ is exactly equal to the steady-state critical threshold.

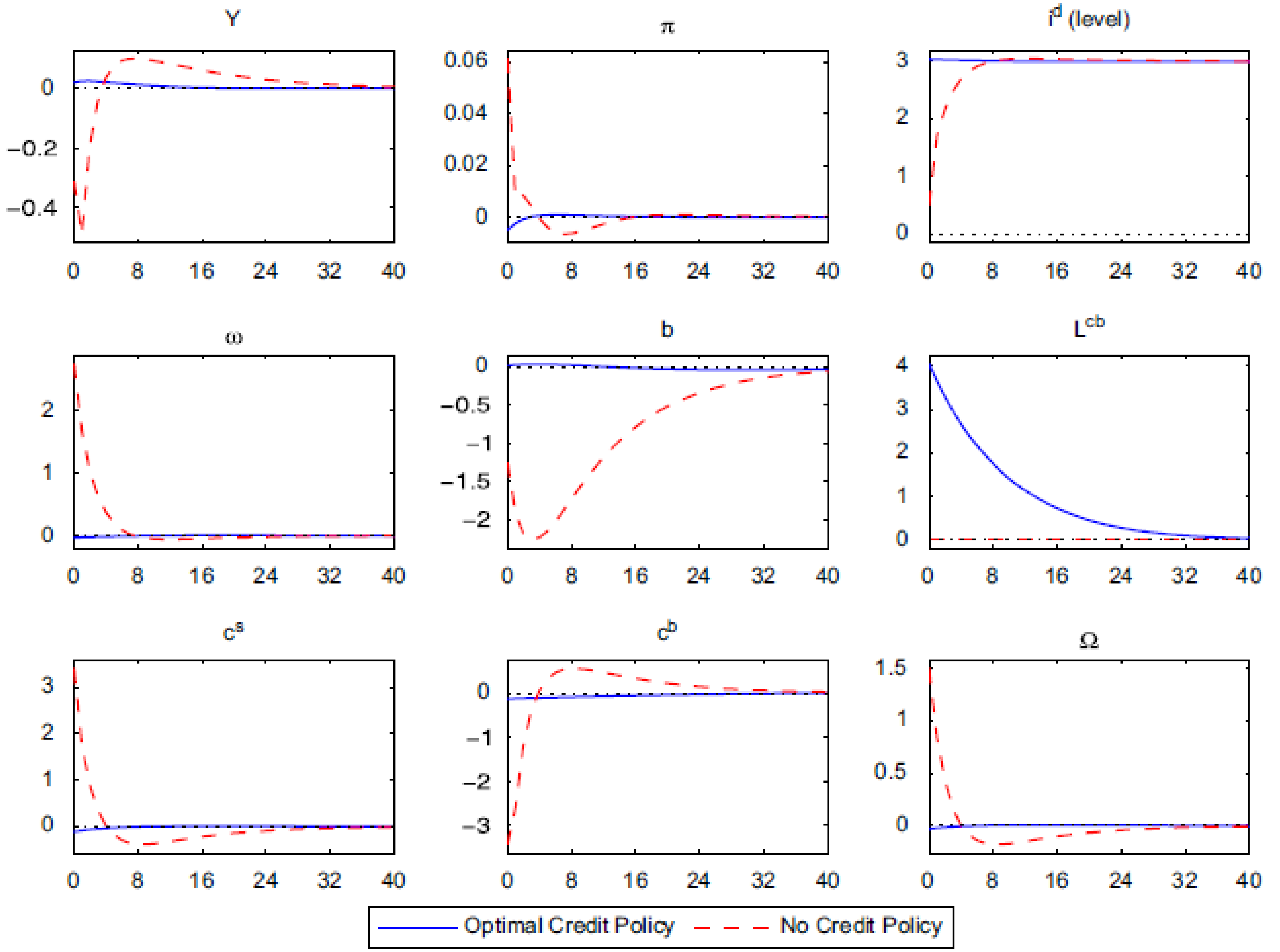

Fig. 7. Impulse responses under optimal credit policy compared to those under a policy of "Treasuries only," with the same disturbance as in Fig. 6, but under optimal interest-rate policy. Again $\bar{\Xi}^{cb}$ is exactly equal to the steady-state critical threshold.

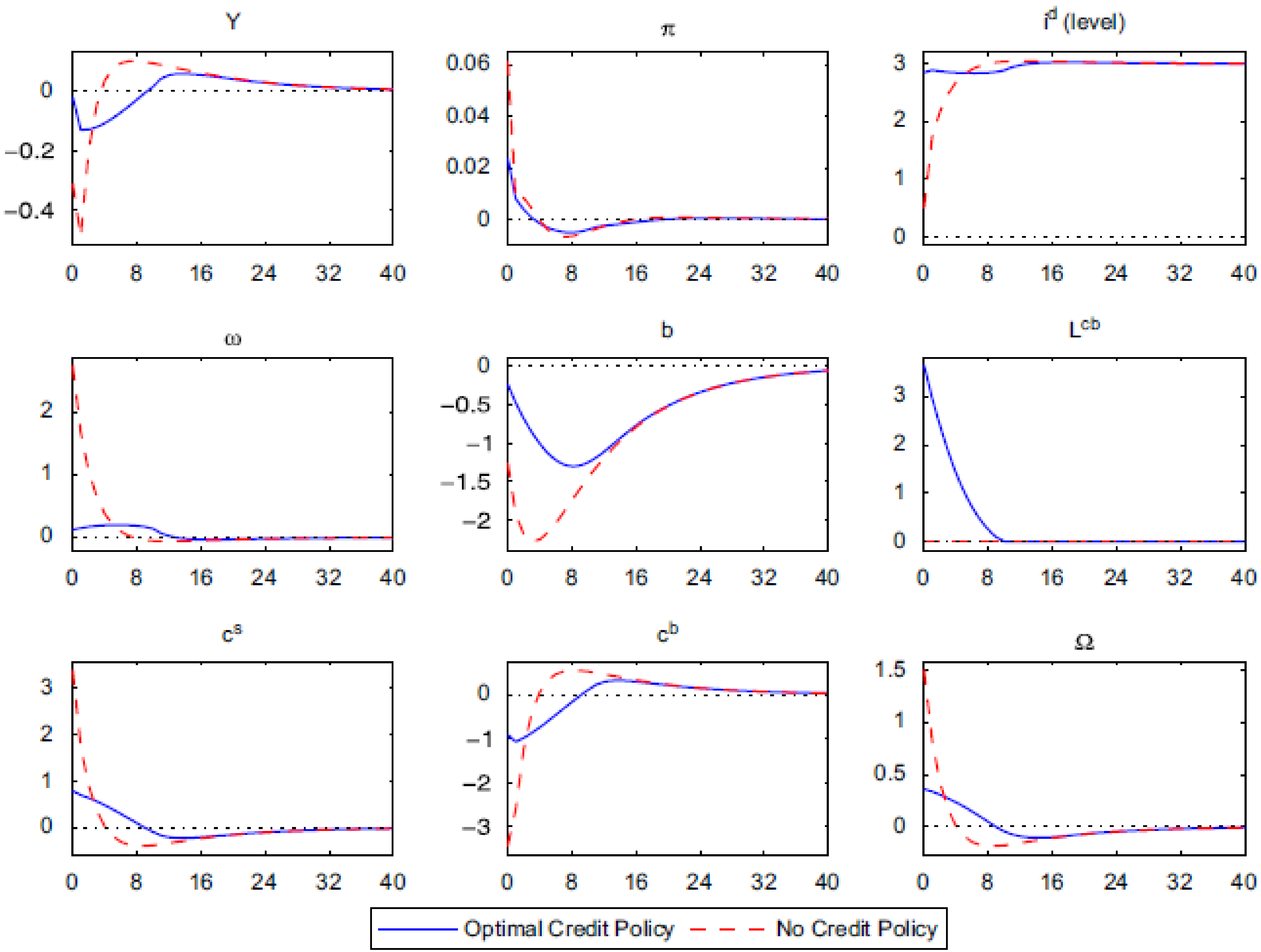

Fig. 8. Impulse responses under optimal credit policy and under "Treasuries only," for the same disturbance and interest-rate policy as in Fig. 7, but when $\bar{\Xi}^{cb}$ is 10 bp higher than the steady-state critical threshold.

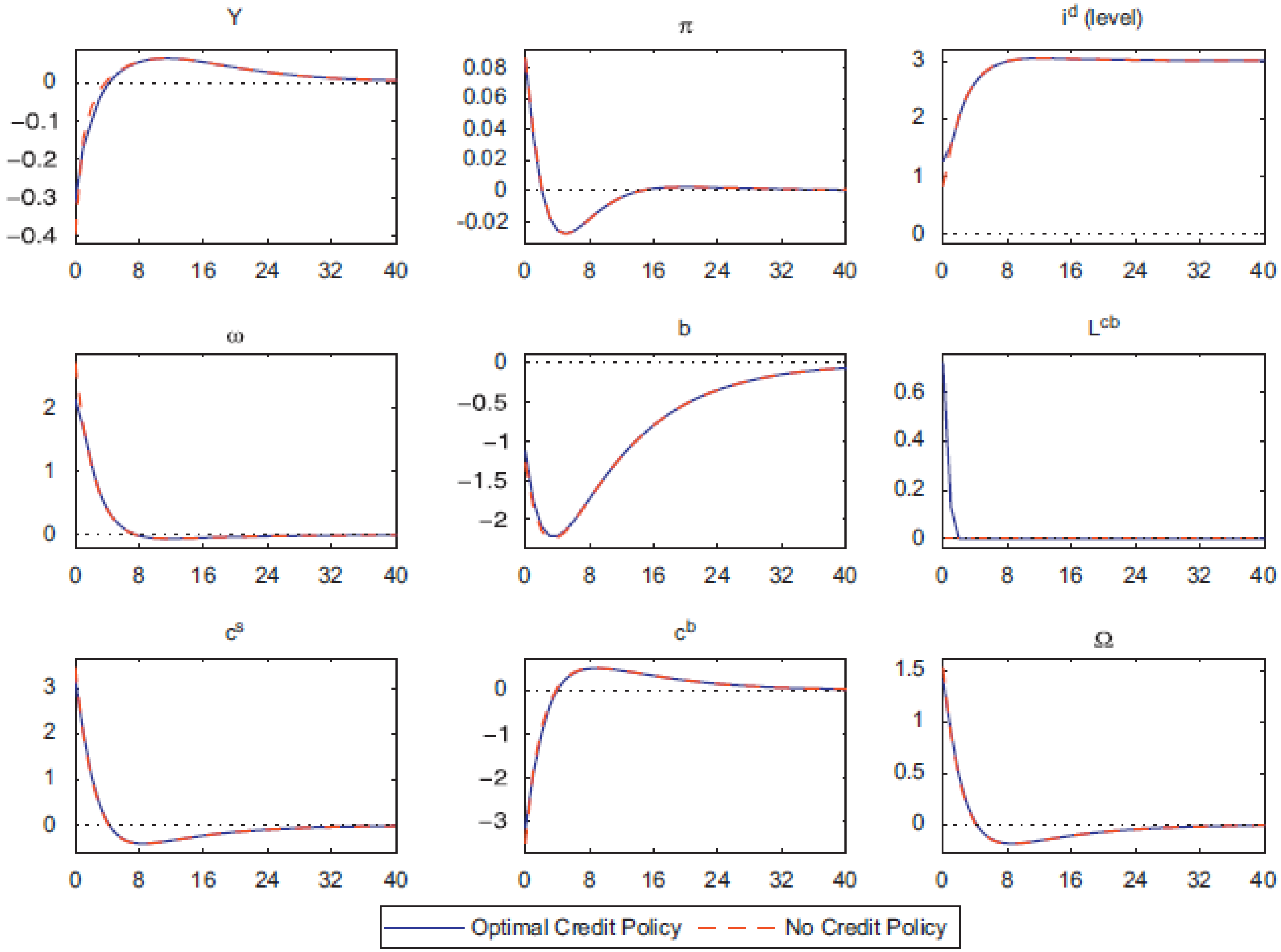

Fig. 9. Impulse responses under optimal credit policy and under "Treasuries only," in the case of a "multiplicative χ" shock of the size considered in Fig. 4. As in Fig. 8, interest-rate policy is optimal and $\hat{\Xi}^{cb}$ is 10 bp higher than the steady-state critical threshold.

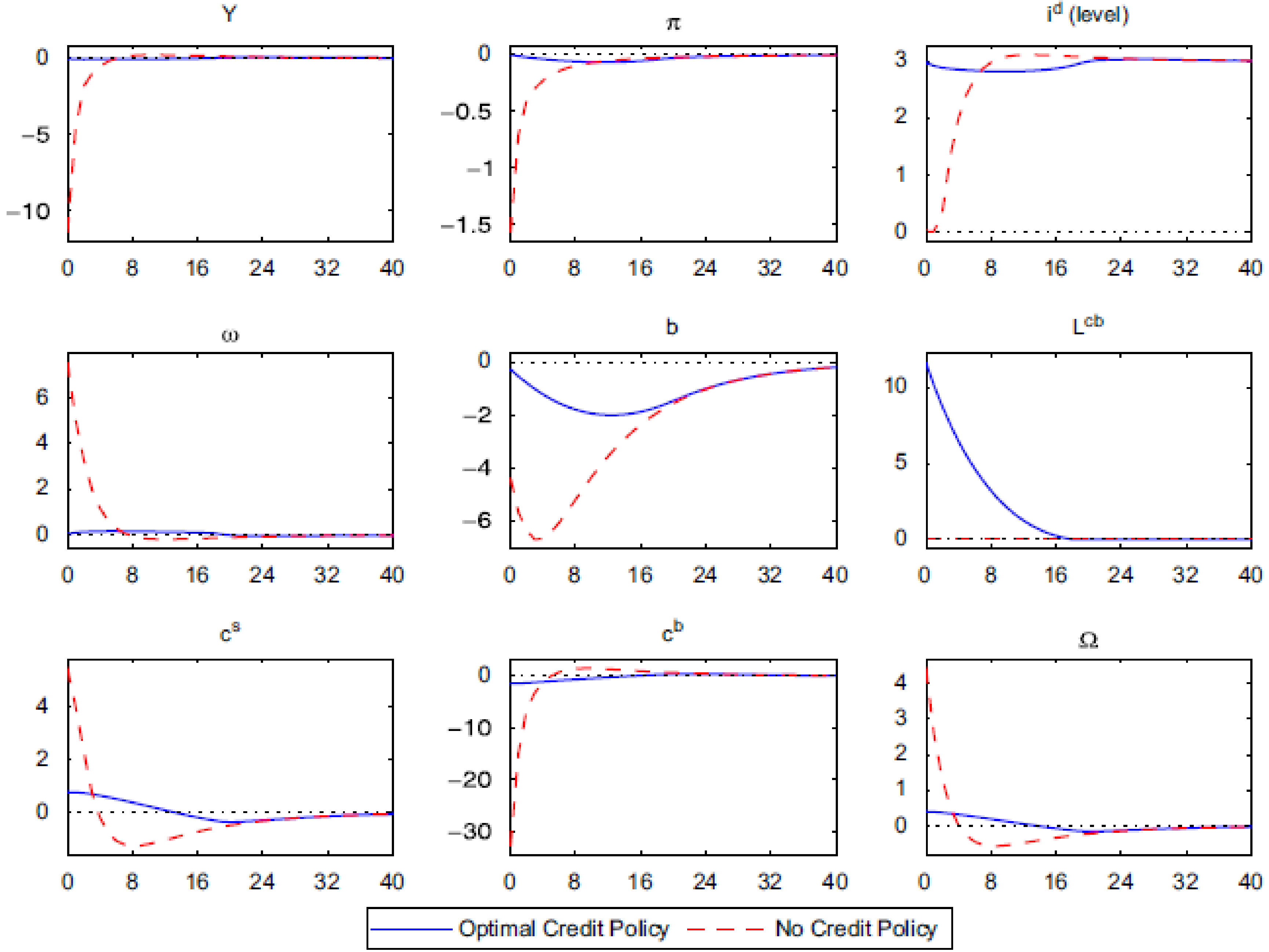

Fig. 10. Impulse responses under optimal credit policy and under "Treasuries only," in the case of a "multiplicative Ξ" shock of the size considered in Fig. 5. Interest-rate policy follows a Taylor rule and $\bar{\Xi}^{cb}$ is 10bp higher than the steady-state critical threshold.

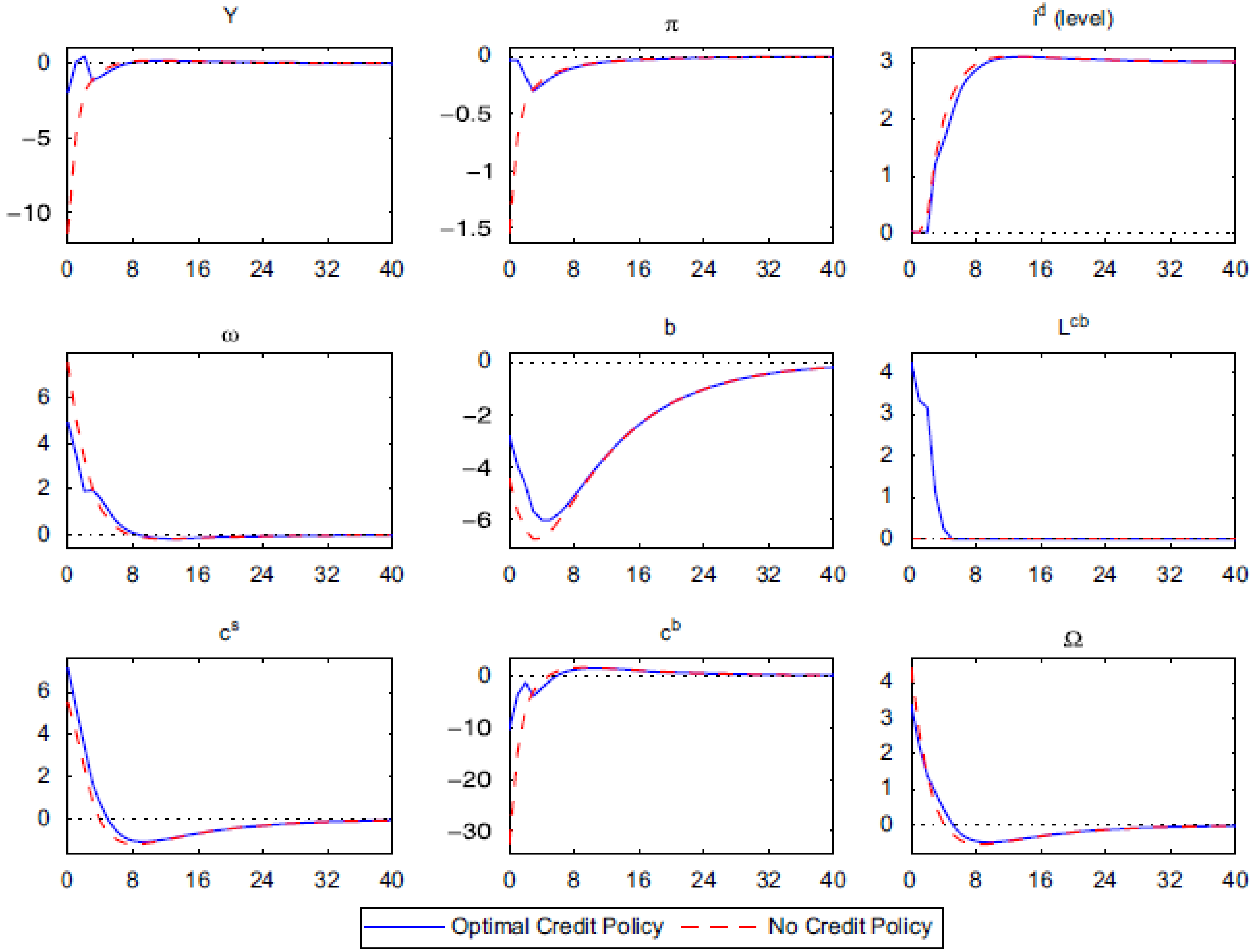

Fig. 11. Impulse responses in the case of a "multiplicative χ" shock of the size considered in Fig. 5, under the same assumptions as in Fig. 10.

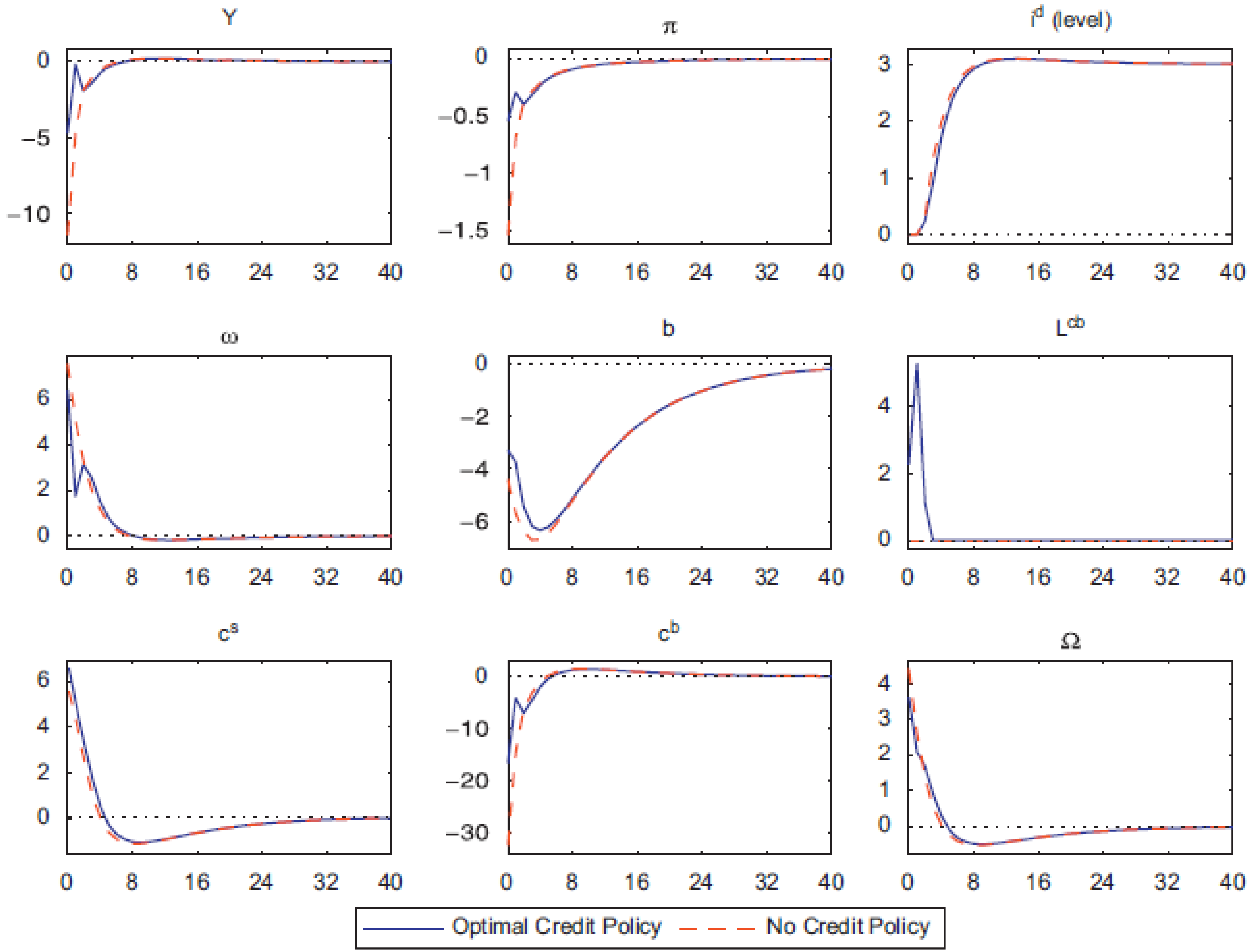

Fig. 12. Impulse responses in the case of an "additive χ" shock of the size considered in Fig. 5, under the same assumptions as in Fig. 10.

Segmented credit markets

- In reality, there are many distinct credit markets, and many different parties to which the central-bank might consider lending.
- For each of the segmented credit markets, we have Eq. 25 and Eq. 26.
- Lending might be justified in one or two specific markets while the corner solution remained optimal in the other markets.
- Aggregate conditions will be one factor that affects the shadow value of marginal reductions in the size of credit spreads : market-specific multiplier $\varphi_{\omega,t}$.

Conclusion (1)

- Analysis of additional dimensions of central-bank policy.
- Explicitly modeling the role of the central-bank balance sheet don't imply any role for quantitative easing as an additional tool of stabilization policy, even when ZLB is reached.
- Maybe a role for central-bank credit policy (or for targeted asset purchases) when private financial markets are **sufficiently impaired**.
- It is only at times of unusual financial distress (i.e. when financial markets fail to fulfill that function) that active credit policy will have substantial benefits.
- Even when financial markets are seriously disrupted, as indicated by significant increases in interest-rate spreads, one must be cautious in drawing conclusions about the welfare consequences of credit policy.

Conclusion (2)

- ZLB does not necessarily involve welfare-improving active credit policy.
- Interest-rate policy decisions are not constrained in any direct way by decisions about either the size or composition of the central bank's balance sheet, as long as the central bank is willing to adjust the interest rate paid on reserves appropriately.
- Fed "exit" strategy and nominal interest rate increase are not necessarily linked.