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The Bank, the Bank-Run, and the Central Bank: The Impact of Early Deposit Withdrawals in a New Keynesian Framework

by Alexander Totzek

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Christian-Albrechts-Universität Kiel

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The Bank, the Bank-Run, and the Central Bank:
The Impact of Early Deposit Withdrawals in a New Keynesian Framework*

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Abstract

Currently, private trust in commercial banks declines as a consequence of today's financial crisis. As past crises, e.g. the Asian crisis, show, the loss of confidence in the financial sector typically causes private agents to withdraw their capital from financial institutions. Thus, the purpose of this paper is to implement the feature of early deposit withdrawal in a New Keynesian framework with commercial banks in order to analyze the implications of a loss of confidence. In addition, we present the optimal monetary policy to ensure a stabilized system.

JEL classification: E44, E50, G01

Keywords: banks, financial crises, deposit withdrawal, optimal monetary policy

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1 Introduction

Currently, private trust in commercial banks declines as a consequence of today's financial crisis. As past crises, e.g. the Asian crisis, show, the loss of confidence in the financial sector typically causes private agents to withdraw their capital from financial institutions. The corresponding extreme case scenario would be the bank-run. Fortunately, this scenario has not yet occurred in today's financial turmoil. But what happens, if it does?

Therefore, the purpose of this paper is to develop a New Keynesian model with explicit consideration of early deposit withdrawals in order to analyze the implications of households' loss of confidence in the financial system. Moreover, we will present the optimal monetary policy to ensure a stabilized system.

The main results are: (i) the extended withdrawal leads to temporary stagflation. (ii) also an impulse shock leads to persistent real effects. (iii) the resulting welfare losses decrease in bank's adjustment costs. (iv) the optimal central bank's response is to rise the interest rate in order to increase the private costs of withdrawals. (v) the optimal monetary policy response implies that the impact recession is amplified while inflation is stabilized.

This paper is related to recent literature as an implementation of early deposit withdrawal in a New Keynesian framework. Hence, like Henzel et al. (2007) or Hülsewig, Mayer and Wollmershäuser (2006), we explicitly model a third type of economic agent besides households and firms, namely the bank as a kind of profit maximizing firm. But in contrast to the latter studies that just implement commercial banks for the purpose of generating a cost channel, we allow the household to early withdraw deposits during the current period.

However, there are several studies which investigate the impact of early deposit withdrawal on the financial system [e.g. Gilkeson et al. (1999), Ringbom et al. (2004) or Stanhouse and Stock (2004)]. Other studies use such a framework for modelling financial problems [e.g. Carletti et al. (2007) who investigate the impact of bank mergers on liquidity needs or Diamond and Dybvig (1983) who investigate optimal bank contracts that can prevent bank-runs] but to our best knowledge, it has never been implemented in a New Keynesian framework, yet.

Moreover, the analysis shows that the shock of confidence causes both the marginal costs of firms and banks to increase. Hence, the current paper can also be seen as a new approach for implementing a microfounded cost push shock in a New Keynesian framework.

The remainder is structured as follows. Section 2 presents the basic idea of the interaction between the agents and the problems resulting from withdrawals. In section 3 the microfounded New Keynesian model for a closed economy with explicit consideration of the banking sector and the possibility for households of withdrawing deposits in a cash-in-advance framework is developed. The purpose of section 4 is to analyze the impulse responses to a shock in the withdrawal rate and the optimal monetary policy. In the last chapter, the main results are summarized.

2 Idea

Apart from consumption demand and labor supply decisions, the household can invest money in form of interest-bearing deposits with a duration of one period at a loan bank. Within the period, the household can decide to break the contract with the bank and to early withdraw deposits.

In the case that the household holds its deposits D till the end of the period, it obtains a next period return of $R_t^D D_t$. But the household only fulfills the contract with the probability $1 - \delta_t$. With the counter probability δ_t the household withdraws its capital from the bank within the period. In this case deposits are converted into liquid money. In punishment of breaking the contract the household does not get any interest payments. Its payoff is then simply given by D . Hence, it is implicitly assumed that deposits contain an embedded withdrawal option. In contrast to the withdrawal per se, the option is assumed to be costless [see e.g. Gilkeson et al. (2000) or Stanhouse and Ingram (2007)].

Due to the temporal sequence of cash flows, firms have to pre-finance households' wages at the loan bank by credits. Banks' business is therefore assumed to be given by pre-financing firms' working capital with the usage of private deposits. Thereby, the amount of credits is limited by the amount of private deposits and banks' reserve holdings. Reserves $\mathfrak{R}_t(i)$ are held to ensure the bank against liquidity shortages as a consequence of withdrawals.

If the demand for liquidity $\delta_t D_t(i)$ exceeds the reserve holdings, the loan bank has to refinance the resulting liquidity gap at a final creditor with $r_t^I > r_t^L > r_t$, where r_t^I , r_t^L and r_t denote the refinancing interest rate, the loan rate and the nominal interest rate (representing the central bank's instrument variable), respectively. The final creditor or lender of last resort substitutes the interbank market for short-run capital since in turbulent times/financial crises, interbank markets often fail [see e.g. Freixas et al. (2000) or Kahn and Santos (2005)]. Moreover, it is assumed that liquidity needs will not force the single banks into bankruptcy and that hence the lender of last resort must possess unlimited liquidity.

Figure 1 depicts the resulting cash flows between the differentiated types of agents. The interactions between banks and final creditor are put in parenthesis since they only occur if the amount of deposit withdrawals exceeds banks' reserve holdings. For sake of simplicity, dividend payments from banks and firms are neglected in figure 1.

Without any shock in confidence, the bank's balance of payments is shown in table 1. In period $t = 0$ the households makes its deposits $D_t(i)$ at bank i .

$t = 0$	$0 < t < 1$	$t = 1$
$D_t(i)$	$-\delta_t D_t(i)$	$-(1 - \delta_t) R_t^D D_t(i)$
$-L_t(i)$	$\mathfrak{R}_t(i) = \delta_t D_t(i)$	$R_t^L L_t(i)$
$-\mathfrak{R}(i) = \delta_t D_t(i)$		
0	0	> 0

Table 1: The Bank's balance of payments without confidence shock

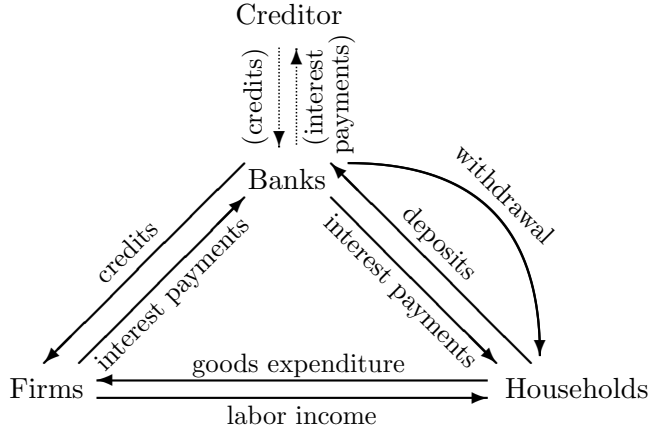


Figure 1: cash flows

The contributed capital the bank deals in credits $L_t(i)$ for firms and in reserves $\mathfrak{R}_t(i)$. The bank chooses the amount of reserves as $\mathfrak{R}_t(i) = \delta_t D_t(i)$ to ensure itself against the *expected* withdrawal during the period. In $0 < t < 1$ some constant fraction of households $\delta_t = \delta$ now withdraws its capital. Since the bank has considered that in its reserve holding decision, the balance of payments is even within the period. At the beginning of $t = 1$ (or at the end of $t = 0$) the fraction $1 - \delta_t$ of households that has not withdrawn its deposits gets its interest payments $R_t^D D_t(i)$. In addition, firms have to clear their debt with an amount of $R_t^L L_t(i)$ in $t = 1$. Since the bank is assumed to be a monopolistic competitor, the resulting profit should be positive.

The analysis gets more complicated if we assume δ_t to have an unobservable stochastic component, i.e. $\delta_t = \delta + \nu_t$ where δ and ν_t represent the constant and the stochastic part of δ_t , respectively. In this case the fraction δ_t is not constant anymore.

In the following we assume that the bank makes its reserve decision *before* the shock has occurred. Hence, $\delta_t \neq E_t[\delta_t | \Omega_t^{Bank}]$ if $\nu_t \neq 0$ where E_t and Ω_t^{Bank} denote the rational expectations operator and the bank's information set in t . In this case, the bank is no longer able to ensure the balance of payments to be even within the period. In fact, it just can ensure itself against the expected withdrawal $E_t[\delta_t | \Omega_t^{Bank}] D_t$. Thus, if a positive unanticipated shock occurs, i.e. $\delta_t > E_t[\delta_t | \Omega_t^{Bank}] \Leftrightarrow \nu_t > 0$, the bank does not hold enough reserves to remain liquid. The resulting liquidity gap has to be shortly refinanced with an interest rate $r_t^I [> r_t^L > r_t^D]$ at the lender of last resort.

Correspondingly, if a contractionary shock occurs, i.e. $\delta_t < E_t[\delta_t | \Omega_t^{Bank}]$, the bank has a surplus of capital during the period. For sake of simplicity, we assume that the bank cannot invest the capital surplus in any kind of interest bearing asset in the current period.

3 Microfoundation

In this section the microfounded model for a closed-economy with early deposit withdrawal in a cash-in-advance (CIA) framework is developed. We will distinguish between *three* types of economic agents, namely households, firms and banks. Thereby and in contrast to Henzel et al. (2007), firms and banks are assumed to be faced with Rotemberg adjustment costs.

3.1 Households

The household maximizes its utility given by

$$U = \sum_{t=0}^{\infty} \beta^t \left(\frac{1}{1-\sigma} C_t^{1-\sigma} - \frac{1}{1+\eta} N_t^{1+\eta} \right) \quad (1)$$

under consideration of the budget constraint

$$P_t C_t + D_t + M_t = W_t N_t + M_{t-1} + \delta_{t-1} D_{t-1} + (1 - \delta_{t-1}) R_{t-1}^D D_{t-1} + \Pi_t + T_t \quad (2)$$

where $P_t C_t$, $W_t N_t$, M_t , D_t , Π_t and T_t represent household's nominal consumption expenditure, nominal labor income, money holdings, deposit holdings, profit income and transfers in period t , respectively. The probability of withdrawing is denoted by δ_t . Note that R_t^D represents the gross deposit rate, i.e. $(1 + r_t^D)$ where r_t^D denotes the (quarterly) net deposit rate. The profit income results from the ownership of firms *and* banks.

In addition, the household has to consider the CIA condition

$$P_t C_t \leq M_{t-1} + \delta_{t-1} D_{t-1} \quad (3)$$

The assignment of a CIA approach is needed to avoid early withdrawals just for the purpose of consumption. Without consideration of (3), a positive effect on consumption occurs from a rise in the withdrawal rate. See footnote 2 for further details.

The resulting timing of trades according to (3) is depicted in figure 2. Thus,

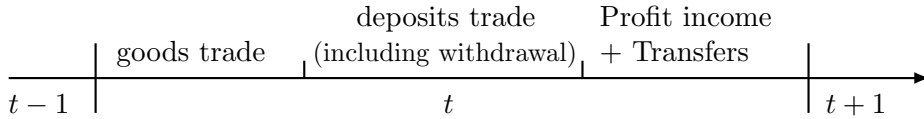


Figure 2: Trade timing

goods are assumed to be traded at the beginning of each period while deposits trades are made after that within the period. Finally, the household obtains its profit income and transfers at the end of each period.

However, maximizing (1) subject to (2) and (3) yields the following first-

order conditions

$$\frac{\partial L}{\partial M_t} = \beta^t \lambda_t - \beta^{t+1} \lambda_{t+1} - \beta^{t+1} \mu_{t+1} = 0 \quad (4)$$

$$\frac{\partial L}{\partial D_t} = \beta^t \lambda_t - \beta^{t+1} \lambda_{t+1} (\delta_t + (1 - \delta_t) R_t^D) - \beta^{t+1} \mu_{t+1} \delta_t = 0 \quad (5)$$

$$\frac{\partial L}{\partial C_t} = \beta^t C_t^{-\sigma} + \beta^t \lambda_t P_t + \beta^t \mu_t P_t = 0 \quad (6)$$

$$\frac{\partial L}{\partial N_t} = -\beta^t N_t^\eta - \beta^t W_t \lambda_t = 0 \quad (7)$$

where L , λ_t and μ_t represent the Lagrangian, the Langrange multipliers corresponding to equation (2) and (3), respectively. The Euler equation and the optimal labor supply is then given by²

$$R_t^D = \frac{C_{t+1}^{-\sigma} P_{t+2}}{C_{t+2}^{-\sigma} P_{t+1}} \frac{1}{\beta} \quad (8)$$

$$N_t^\eta = \beta \frac{W_t}{P_{t+1}} C_{t+1}^{-\sigma} \quad (9)$$

Finally, log-linearizing (8) and (9) yields the log-linearized Euler equation which is standard for CIA and the log-linearized labor supply

$$c_{t+1} = c_{t+2} - \frac{1}{\sigma} (r_t^D - \pi_{t+2}) \quad (10)$$

$$w_t - p_{t+1} = \sigma c_{t+1} + \eta n_t \quad (11)$$

3.2 Firms

In the following we turn to the production side. Thereby, we will distinguish final and intermediate good producers. Since per assumption wages are paid at the beginning of the period and profits are generated at the end, firms have to pre-finance their working capital $W_t N_t$ at the loan bank.

²Without the CIA constraint the Euler equation would follow

$$R_t^D = \frac{1}{1 - \delta_t} \frac{C_t^{-\sigma} P_{t+1}}{C_{t+1}^{-\sigma} P_t} \frac{1}{\beta} - \frac{\delta_t}{1 - \delta_t}$$

or in log-linear form

$$c_t = c_{t+1} - \frac{1}{\sigma} \left[(1 - \bar{\delta}) r_t^D - \pi_{t+1} \right] + \underbrace{\frac{1 - \beta}{\sigma(1 - \bar{\delta})(1 - \bar{\delta}\beta)}}_{>0} d\delta_t$$

The latter equation shows that a positive effect on today's consumption would arise from an increase in δ_t . Although, this effect is supported by Gilkeson and Ruff (1996) who show that the reinvestment incentive has a significant positive impact on the early withdrawal, we use the CIA approach in order to avoid withdrawal effects just for the purpose of consumption. To assign a reason, recall that the purpose of the current paper is to analyze a loss of confidence in financial institutions that is expressed as an increase in the withdrawal rate.

3.2.1 Final Good Producers

The final good producer acts under perfect competition. For production he bundles a continuum of differentiated intermediate goods. The corresponding CES technology is assumed to follow

$$Y_t = \left(\int_0^1 Y_t(f)^{\frac{\xi-1}{\xi}} df \right)^{\frac{\xi}{\xi-1}} \quad (12)$$

where $Y_t(f)$ represents the differentiated intermediate good and ξ denotes the elasticity of substitution between intermediate goods. By cost minimization, good demand is then given by

$$Y_t(f) = \left(\frac{P_t(f)}{P_t} \right)^{-\xi} Y_t \quad (13)$$

with the price index P_t

$$P_t = \left(\int_0^1 P_t(f)^{1-\xi} df \right)^{\frac{1}{1-\xi}} \quad (14)$$

3.2.2 Intermediate Good Producers

The production function of the monopolistic intermediate good producer is assumed to be of Cobb-Douglas-type with decreasing returns on labor

$$Y_t(f) = A_t N_t(f)^{1-\alpha} \quad (15)$$

where A_t represents a productivity shock.

As already mentioned, firms have to pre-finance wages due to the temporal sequence of cash flows. Thus, their cost minimization problem includes the nominal producers wage $R_t^L W_t$. The nominal marginal costs are then given by

$$MC_t^n = \frac{1}{1-\alpha} R_t^L W_t A_t^{\frac{1}{\alpha-1}} Y_t^{\frac{\alpha}{1-\alpha}} \quad (16)$$

In real terms it follows that

$$MC_t = \frac{MC_t^n}{P_t} = \frac{1}{1-\alpha} \frac{R_t^L W_t}{P_t} A_t^{\frac{1}{\alpha-1}} Y_t^{\frac{\alpha}{1-\alpha}} \quad (17)$$

where MC_t represents the real marginal costs of the domestic intermediate good producer.

Since monopolistic competition is assumed on the intermediate good market, the optimal price $P_t(f)^{opt.}$ in absence of any nominal rigidities can be represented as a constant mark-up over the nominal marginal costs

$$P_t(f)^{opt.} = \frac{\xi}{\xi-1} MC_t^n \quad (18)$$

with MC_t^n defined in (16).

The monopolistic firm is now assumed to be faced with quadratic adjustment costs [Rotemberg (1982)]. Thus, the firm has to minimize

$$\min_{p_t} E_0 \sum_{s=0}^{\infty} \beta^s \left[(p_{t+s} - p_{t+s}^{opt.})^2 + \vartheta (p_{t+s} - p_{t+s-1})^2 \right] \quad (19)$$

where p_t and $p_t^{opt.}$ represent the log-linear price level and the optimal log-linear price level in absence of any nominal rigidities of the representative monopolistic firm, respectively. ϑ denotes the costs resulting from price adjustments.

Minimizing (19) yields the inflation rate in log-linear form

$$\pi_t = \beta \pi_{t+1} + \frac{1}{\vartheta} (p_t^{opt.} - p_t) \quad (20)$$

where $p_t^{opt.}$ can be derived by log-linearizing (18) with (16)

$$p_t^{opt.} = r_t^L + w_t + \frac{1 + \alpha}{1 - \alpha} a_t + \frac{\alpha}{1 - \alpha} y_t \quad (21)$$

Finally, inserting (21) in (20) yields the modified Phillips-curve

$$\pi_t = \beta \pi_{t+1} + \omega_w (r_t^L + w_t - p_t) + \omega_a a_t + \omega_y y_t \quad (22)$$

with

$$\omega_w = \frac{1}{\vartheta}, \quad \omega_y = \frac{\alpha}{\vartheta(1 - \alpha)}, \quad \omega_a = \frac{1}{\vartheta(\alpha - 1)}$$

Equation (22) deviates from the baseline case since producers' and consumers' real wages ($r_t^L + w_t - p_t$ and $w_t - p_t$) must be distinct in the present approach. Hence, like Henzel et al. (2007) and in contrast to e.g. Bernanke and Gertler (1995) we obtain an *endogenous* cost channel.

However, due to profit maximization the optimal labor demand is given by

$$(1 - \alpha) A_t N_t^{-\alpha} = \frac{R_t^L W_t}{P_t} \quad (23)$$

or in log-linear form

$$a_t - \alpha n_t = r_t^L + w_t - p_t \quad (24)$$

3.3 Banks

As already mentioned in section 2, a bank's business is assumed to be given by pre-financing firms wages and holding reserves with the usage of households' deposits. Thereby, the bank maximizes the following profit maximization approach

$$\begin{aligned} \Pi_t^B(i) = & R_t^{L,opt.}(i) L_t(i) - (1 - \delta_t) R_t^D D_t(i) - \delta_t D_t(i) \\ & - R_t^I (\delta_t D_t(i) - \mathfrak{R}_t(i)) \Phi(\delta_t) \end{aligned} \quad (25)$$

where $L_t(i)$, $\mathfrak{R}_t(i)$ and $R_t^{L,opt.}$ represent the loan supply, bank's reserve holdings and the optimal loan rate in absence of any nominal rigidities for the bank, respectively. $\Phi(\delta_t)$ denotes the probability that the bank must be shortly refinanced with R_t^I at the final creditor. More precisely, $\Phi(\delta_t)$ is given by

$$\begin{aligned}\Phi(\delta_t) &= \text{Prob}\{\delta_t D_t(i) - \mathfrak{R}_t(i) > 0\} \\ &= \text{Prob}\{(\delta + \nu_t)D_t(i) - \delta D_t(i) > 0\} \\ &= \text{Prob}\{\nu_t > 0\}\end{aligned}\tag{26}$$

with $\delta_t = \delta + \nu_t$ and $\mathfrak{R}_t(i) = E_t[\delta_t | \Omega_t^{Bank}] = \delta D_t(i)$. For all distributions of δ_t that are not skewed, equation (26) is equal to 0.5. By assumption, ν_t is white noise and therefore a balanced distribution.

The optimal loan demand $L_t(i)$ follows from the firm's cost minimization with respect to

$$L_t = \left(\int_0^1 L_t(i)^{\frac{\zeta-1}{\zeta}} di \right)^{\frac{\zeta}{\zeta-1}}\tag{27}$$

and is given by

$$L_t(i) = \left(\frac{R_t^L(i)}{R_t^L} \right)^{-\zeta} L_t\tag{28}$$

where ζ represents the interest rate elasticity of loan demand. According to (28) we assume that banks provide differentiated loans and act under monopolistic competition.³ Like Carletti, Hartmann and Spagnolo (2007) and Henzel et al. (2007) we argue that the differentiation of loans can be caused by different specifications of commercial banks in types of lending or in geographical space.

However, inserting the bank's budget constraint $D_t(i) = L_t(i) + \mathfrak{R}_t(i)$ in (25) and differentiating the resulting approach subject to (28) yields the optimal loan rate in absence of any nominal rigidities

$$R_t^{L,opt.}(i) = \frac{\zeta}{\zeta-1} [(1 - \delta_t)R_t^D + \delta_t + \delta_t \Phi(\delta_t)R_t^I]\tag{29}$$

where $R_t^I = \Upsilon R_t^D$ with $\Upsilon > 1$. In this case the refinancing rate is simply given by a constant mark-up Υ over the deposit rate R_t^D . As Stanhouse and Stock (2004) claim, the optimal loan rate is proportional to the withdrawal rate.

Note that equation (29) coincides with the baseline model case without withdrawal $R_t^{L,opt.}(i) = \frac{\zeta}{\zeta-1} R_t^D$ if $\delta_t = 0$, i.e. the optimal loan rate is then given by a constant mark-up over the deposit rate as e.g. in Dressler and Li (2009).

Now, we also assume the loan bank to be faced with quadratic Rotemberg adjustment costs that must be minimized

$$\min_{r_t^L} E_t \sum_{s=0}^{\infty} \beta^s \left[\left(r_{t+s}^L - r_{t+s}^{L,opt.} \right)^2 + \gamma \left(r_{t+s}^L - r_{t+s-1}^L \right)^2 \right]\tag{30}$$

³In contrast, Goodfriend and McCallum (2007) assume for the sake of simplicity that banks act under perfectly competitive markets.

The optimization yields the relation

$$\left(1 + \beta + \frac{1}{\gamma}\right) r_t^L = \beta r_{t+1}^L + r_{t-1}^L + \frac{1}{\gamma} r_t^{L,opt} \quad (31)$$

where $r_t^{L,opt.}$ is given by log-linearizing (29)

$$r_t^{L,opt.} = \varrho_D r_t^D + \varrho_i r_t^I + \varrho_\delta \nu_t \quad (32)$$

with

$$\begin{aligned} \varrho_d &= \frac{(1 - \bar{\delta})\beta^2}{1 + \bar{\delta}(\beta + \Phi\Upsilon - 1)} \\ \varrho_i &= \frac{\bar{\delta}\Phi\beta^2}{\Upsilon[1 + \bar{\delta}(\beta + \Phi\Upsilon - 1)]} \\ \varrho_\delta &= \frac{\beta + \Phi\Upsilon - 1}{1 + \bar{\delta}(\beta + \Phi\Upsilon - 1)} \end{aligned}$$

Eventually, inserting (32) in (31) yields the final conditional equation for the loan rate

$$r_t^L = \beta\omega_l r_{t+1}^L + \omega_l r_{t-1}^L + \omega_d r_t^D + \omega_i r_t^I + \omega_\delta \nu_t \quad (33)$$

with

$$\begin{aligned} \omega_l &= \frac{\gamma}{1 + \gamma(1 + \beta)}, & \omega_d &= \frac{\varrho_d}{1 + \gamma(1 + \beta)}, \\ \omega_i &= \frac{\varrho_i}{1 + \gamma(1 + \beta)}, & \omega_\delta &= \frac{\varrho_\delta}{1 + \gamma(1 + \beta)} \end{aligned}$$

3.4 The Model

The presented model for a closed-economy framework with explicit consideration of a banking sector and the possibility of early deposit withdrawal consists of equations (10), (11), (22), (33) and the log-linear version of the production function (36) as well as the market clearing condition $y_t = c_t$. Moreover, we set $r_t = r_t^D$. The latter condition implies that money market credits and deposits are assumed to be perfect substitutes [at least in log-linear form] and is supported by Freixas and Rochet (1997). Finally, monetary policy is assumed to be of Taylor-type. The whole model in log-linear form is then given by⁴

$$c_t = c_{t+1} - \frac{1}{\sigma} (r_{t-1}^D - \pi_{t+1}) \quad (34)$$

$$c_t = y_t \quad (35)$$

$$y_t = (1 - \alpha)n_t \quad (36)$$

$$w_t - p_{t+1} = \sigma c_{t+1} + \eta n_t \quad (37)$$

$$r_t^L = \beta\omega_l r_{t+1}^L + \omega_l r_{t-1}^L + \omega_d r_t^D + \omega_i r_t^I + \omega_\delta \nu_t \quad (38)$$

$$\pi_t = \beta\pi_{t+1} + \omega_w (r_t^L + w_t - p_t) + \omega_a a_t + \omega_y y_t \quad (39)$$

$$r_t = r_t^D \quad (40)$$

$$r_t = (1 - \phi)(\lambda_\pi \pi_t + \lambda_y y_t) + \phi r_{t-1} \quad (41)$$

⁴Note that we represent (37) for the simulations as $w_t - p_t + \pi_t = \sigma c_{t+1} + \eta n_t$.

The associated parameterizations can be found in table 2. The calibration is rather standard but $\bar{\delta}$, γ and Υ . We set $\bar{\delta}$ equal to the minimum reserve requirement of the European Central Bank since this amount of reserves is designed to satisfy average withdrawal demands.⁵

γ is chosen to obtain $\omega_b = 0.3515$ as in the empirically estimated model of Henzel et al. (2007). Moreover, we set ϑ equal to 23.79 to obtain a slope of the Phillips curve equal to the baseline Calvo model of Galí (2008)⁶ with an average price duration of three quarters ($\theta = 2/3$). Finally, the mark-up over the interest rate Υ is assumed to be equal to 1.05.

Parameter	β	σ	η	α	ξ	$\bar{\delta}$	γ	ϑ	Υ	λ_π	λ_y	ϕ
Value	0.99	2	2	0.8	6	0.02	1.17	23.79	1.05	1.5	0.5	0.9

Table 2: Baseline parameterizations

In order to analyze optimal monetary policy, a welfare function is needed. As Galí (2008) or Woodford (2003) show in a Calvo framework, the second-order Taylor approximation of the utility function yields the following loss function

$$\mathbb{L} = -\frac{1}{2}E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \left[\frac{\xi}{\tau} \right] \pi_t^2 + \left[\sigma + \frac{\eta + \alpha}{1 - \alpha} \right] y_t^2 \right\} \quad (42)$$

where $\tau = 1/\vartheta$ represents the slope of the Phillips curve in a π_t/mc_t -space. Ravenna and Walsh (2006) show that in absence of fiscal shocks the form of (42) is not altered by considering a cost channel.⁷ However, we are according to (42) in a flexible inflation targeting regime [Svensson (1999)] whose weight on output is rather small.

4 Simulations

In this section, the impulse responses to a one-off shock in households withdrawal rate are discussed. In addition, we will present the optimal monetary policy.

The impulse responses for different values of banks' adjustment costs (γ) under the ad-hoc Taylor rule (41) are shown in figure 3.⁸ For our simulation we uniquely set the standard deviation of the shock ν_t equal to unity in the first period. However, let's initially have a look at the blue (solid lines with circles) curves only, i.e. $\gamma = 1.17$.

As already mentioned in section 2, an expansionary shock in deposit withdrawal rate δ_t causes banks to underestimate the amount of households' withdrawal. In that case, banks do not hold enough reserves and must therefore refinance the resulting liquidity gap at the lender of last resort. Thus, banks' costs

⁵Note that in our framework the average and expected withdrawal coincides.

⁶The estimated model of Henzel et al. (2007) is a hybrid framework. We thus cannot use their calibration for the current forward-looking Phillips curve.

⁷In the current calibration, the loss is then given by $\mathbb{L} = -\frac{1}{2}E_0 \sum_{t=0}^{\infty} \beta^t \{141.18\pi_t^2 + 16y_t^2\}$.

⁸Note that all variables in figure 3 and 4 are expressed in percentage deviations from their respective steady state values.

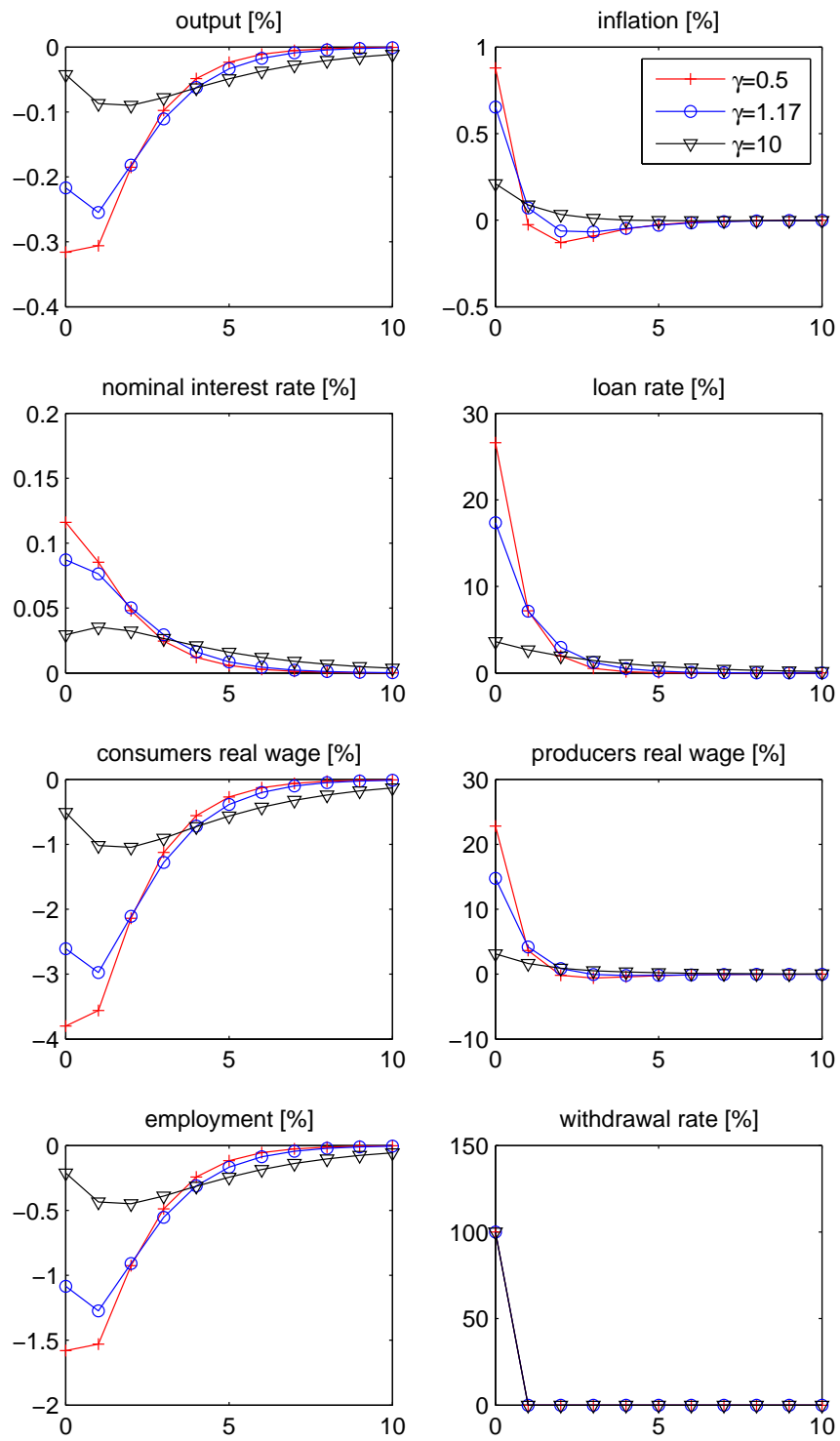


Figure 3: Time paths under varied bank's adjustment costs under an ad hoc Taylor rule with smoothing

for pre-financing firms' working capital and hence also the loan rate increase. On the production side, this leads to higher marginal costs for the intermediate good producers. It is thus worth noting that the shock in the withdrawal rate increases both the marginal costs of firms and banks. Hence, the current paper can also be seen as a new approach for implementing a microfounded cost push shock in a New Keynesian model.

However, the increase in marginal costs of firms leads on the one hand to an increase in inflation and on the other hand to a decrease in labor demand and thus to lower output according to the assumed production function. Furthermore, as will be shown later in more detail, the monetary authority aims to amplify this output recession under optimal monetary policy.

Taking the responses of output and inflation together, the current shock leads, on impact, to *stagflation*. These results are in line with the observed economic developments, e.g. in the European Union at the beginning of the financial crises in 2008.

In addition, due to decreasing labor demand the consumers real wage $w_t - p_t$ declines while on the other hand that effect is dominated on the production side by an increasing loan rate. As a result, producers' real wage increases while consumers' real wage declines.

Needless to say that in the current framework all real variables return to their initial values during the adjustment process. The hump-shaped adjustment path in output results from the time-lagged CIA-type of the Euler equation and the hybrid representation of loan rate adjustments. Also the undershooting in inflation is a result of consumption's adjustment path.

Now, let's also have a look on the remaining impulse responses that are shown for varied bank's adjustment costs in figure 3 under the ad hoc Taylor rule (41). It is obvious that under higher adjustment costs the shock leads to more persistent effects of all variables. This result is quite reasonable since the shock enters the system via the loan rate. Thus, if banks are less able to adjust their prices for credits, the resulting effects for the whole economy will occur more persistently.

A less obvious result is that the social loss according to (42) declines in increasing banks' adjustment costs γ . To depict that relationship without distortionary effects from the ad hoc Taylor rule, the losses under different values of γ are shown in table 3 for the regime of the optimal unrestricted monetary policy under commitment. The social loss is thereby affected by two opposing effects, (i) the lower impact of the shock ν_t since according to (38) ω_δ decreases in γ and (ii) the higher persistence of the adjustment paths.

The numerical simulations in table 3 show unambiguously the positive relation between γ and L as well as the negative relation between γ and the shock coefficient ω_γ . Thus, the first effect must exceed the second one. This result is quite robust to different model calibrations. Hence, social loss declines in increasing banks' adjustment costs.⁹

In what follows, we finally present the optimal monetary policy. We will analyze ad hoc and optimal Taylor rules with and without interest rate smooth-

⁹This result also holds for increasing firms' adjustment costs.

γ	ω_δ	$ \mathbb{L} \cdot 10^{-4}$	$\mathbb{L}[\%]$
10.0	0.0244	0.8931	8.06
5.00	0.0466	2.1515	19.41
4.50	0.0512	2.4481	22.08
4.00	0.0569	2.8238	25.47
3.50	0.0640	3.3131	29.89
3.00	0.0731	3.9723	35.83
2.50	0.0853	4.9019	44.22
2.00	0.1024	6.2966	56.80
1.50	0.1279	8.5874	77.46
1.17	0.1531	11.0852	100.00
1.00	0.1705	12.9391	116.72
0.50	0.2556	23.8293	214.96

Table 3: Welfare losses for varied adjustment costs γ

ing,¹⁰ the interest rate peg rule (IPEG)¹¹ and the optimal unrestricted monetary policy rule under commitment (COM). The welfare losses according to (42) under the different kinds of monetary policy rules are shown in table 4 for the baseline parameterizations. In addition, figure 4 shows the impulse responses under the regime of an ad hoc Taylor rule with smoothing (TRS) and the optimal unrestricted monetary policy under commitment (COM).

Policy rule	$\pi_t^2 \cdot 10^{-5}$	$y_t^2 \cdot 10^{-5}$	$ \mathbb{L} \cdot 10^{-4}$	$\mathbb{L}[\%]$
COM	0.4753	9.6627	11.0852	100.00
TR	5.1804	3.3095	39.2163	353.77
TRS	4.7291	1.7327	34.7681	313.64
IPEG	3.6573	2.1191	27.5120	248.19
OTR	0.4736	9.6841	11.0905	100.05
OTRS	0.4736	9.6840	11.0905	100.05

Table 4: Social losses under different policy rules [COM: optimal unrestricted policy under commitment, TR: ad-hoc Taylor rule, TRS: ad-hoc Taylor rule with smoothing, IPEG: interest rate peg, OTR: optimal Taylor rule, OTRS: optimal Taylor rule with smoothing]

Inflation is assumed to be the most important objective for the central bank according to (42). Moreover, the output change is smaller than the effect on inflation. Hence, the central bank will rise the interest rate independently from the monetary policy regime. Hence, the central bank's reaction leads to higher opportunity costs of cash holdings in order to increase the punishment costs for early withdrawal. But, as already mentioned the increase in the interest rate

¹⁰In the following, we will denote the ad hoc Taylor rule with "TR", the ad hoc Taylor rule with smoothing with "TRS", and the respective optimal rules with "OTR" and "OTRS". Recall that in case of $\phi \neq 0$, the interest rate rule (41) includes interest rate smoothing.

¹¹In our simulations, we follow Collard and Dellas (2005) and set $\phi = 0.999$, $\lambda_\pi = 1.01$ and $\lambda_y = 0$ in order to avoid indeterminacy problems.

amplifies the recession. In fact, as shown in figure 4, this result is intensified by optimal policy since for the sake of welfare maximization the rise in interest rate reaction has to be enforced in order to stabilize inflation.¹²

The increase in the interest rate stands in sharp contrast to the observable policy reaction to financial turmoils. But notice that the purpose of the current paper is not to determine the optimal policy to financial crises but to a decline in private trust in the financial system. Note that the current problem setting only represents a small part of the entire financial problem. However, a decrease in the interest rate may lead to deflationary forces.

Taking the optimal policy under unrestricted commitment as a reference, table 4 shows that the ad hoc Taylor rule without smoothing yields the worst outcome. On the one hand inflation volatility clearly exceeds those under unrestricted commitment while on the other hand the output volatility is lower than under COM. Since the central bank's weight on output in (42) is rather small, the social loss under TRS is clearly lower than in the reference regime.

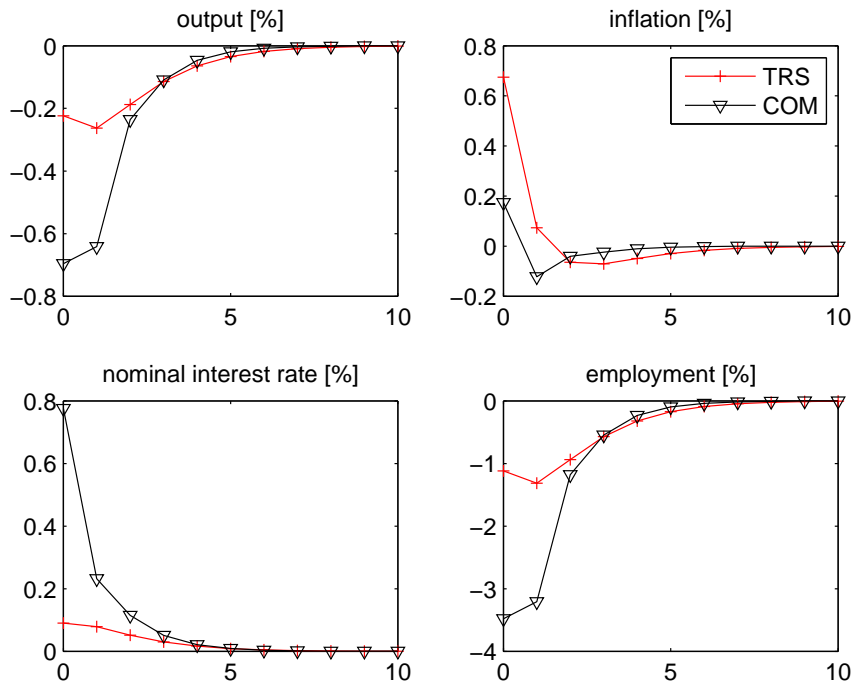


Figure 4: Time paths under ad hoc Taylor rule with smoothing (TRS) vs. optimal unrestricted monetary policy under commitment (COM)

By introducing interest rate smoothing in the ad hoc Taylor rule (TRS), both output and inflation volatility decline in comparison to the case without

¹²This result is quite robust to changes in the welfare function. If we assume the central bank to be also concerned about changes of its instrument variable r_t in absolute or relative terms, the ad hoc loss function would then follow $L = -\frac{1}{2}E_0 \sum_{t=0}^{\infty} \beta^t \{\pi_t^2 + \lambda_y y_t^2 + \lambda_r r_t^2\}$ or $L = -\frac{1}{2}E_0 \sum_{t=0}^{\infty} \beta^t \{\pi_t^2 + \lambda_y y_t^2 + \lambda_r (r_t - r_{t-1})^2\}$ [see e.g. Svensson (1999) or (2007)] with $1 > \lambda_y > \lambda_r > 0$. Also in these cases this result is not altered. Hence, it is not a consequence of the rather high weight on inflation.

smoothing. Hence, we obtain a welfare gain. Another welfare enhancement can be achieved by holding the nominal interest rate totally constant (IPEG). But the best results are obtained by an optimal simple Taylor rule with or without smoothing (OTR or OTRS). The welfare gain by introducing a smoothing parameter in the optimized rule is negligible small since the value of social loss under OTR is already really close to the optimum. Under OTRS the welfare reaches the value of the optimal monetary policy under commitment just with marginal deviations. This result also holds, if we ad hoc set a higher weight on output in the loss function. But in this case the welfare gain by introducing history dependence [Woodford (2000)], in the sense of interest rate smoothing, is significantly positive in both the ad hoc and the optimized Taylor rule.

It is worth noting that, as shown in figure 4, the impact reaction of the interest rate is about nine times higher than under the ad hoc Taylor rule.¹³ Moreover, figure 4 shows that apart from inflation the impact reaction of all variables are larger under the optimal policy reaction than under the ad hoc one.¹⁴ Thus, the central bank's optimal reaction leads to more volatile reactions in all variables but inflation. Hence, it is welfare-optimal to increase the initial output recession and therefore simultaneously to decrease employment in the current framework as a response to the analyzed shock in confidence.

5 Conclusion

By explicitly modelling a third kind of economic agent – the bank as a profit maximizing firm – we are able to implement the feature of early deposit withdrawal in a New Keynesian framework.

We show that a one-off shock in the withdrawal rate as a consequence of a decline in private trust in commercial banks leads to stagflation and to persistent real effects. Due to the expansionary shock in the withdrawal rate both the marginal costs of firms and banks increases. Hence, the current paper can also be seen as a new approach for implementing a microfounded cost push shock in a New Keynesian model.

In the current framework, the optimal central bank reaction is to rise the interest rate in order to increase the opportunity costs of cash holdings and thus the costs of withdrawals. More precisely, it is welfare-optimal in the current framework to enforce the initial output recession by explicitly increasing the interest rate for the sake of inflation stabilization. This stands in sharp contrast to the observable central bank reaction in past and current financial turmoils. But the analyzed problem setting only represents a small part of the nowadays financial problems. Thus, it should not be taken as a policy advice for the monetary authority.

The purpose of further research could be the extension of the presented

¹³In fact, the amount of the difference between the interest rates is a result of the rather strict inflation targeting of the central bank. Of course, if the central bank also considers the additional term $\lambda_{\Delta r}(r_t - r_{t-1})^2$ [see e.g. Svensson (1999) or (2007)] that measures relative changes in the interest rate in its loss function, this result naturally does not hold any more for a sufficiently large value of $\lambda_{\Delta r}$.

¹⁴Unless it is not depicted in figure 4, this result also holds for the loan rate and the real wage.

model to an open economy in order to depict exchange rate implications and international cash flows as well as to investigate international policy coordination. Maybe, it could also be helpful to implement the interbank sector.

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