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Optimal Monetary Policy in a Credit Economy

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Abstract

This paper investigates the performance of monetary policy rules in a credit economy. In particular, the paper considers whether or not performance depends upon financial market imperfection. For this purpose, the paper analyzes a credit economy model incorporating a financial friction into a new Keynesian macroeconomic model. The answer is *yes*. First, the central bank should respond to output rather than to inflation if the financial market is markedly imperfect. Second, under this market condition, the bank should not adopt policy smoothing. Third, the bank should not respond to inflation as aggressively under financial and wealth distribution shocks as under a common supply shock. The results are exactly the same even if the economy takes account of the stability of nominal interest rate or if the central bank responds to expected inflation rather than current inflation. The paper therefore does not support inflation targeting as the dominant strategy of monetary policy and suggests instead that, in practice, the Taylor rule might be more appropriate in fragile financial markets.

1 Introduction

Since the early 1970s, monetary macroeconomics has developed systematic monetary policies which exclude any discretion by monetary authorities. The trend began with Milton Friedman's *k % rule* and Robert E. Lucas's *Critique* which demonstrated the neutrality of expected monetary policy. In the 1980s, Finn E. Kydland and Edward C. Prescott clarified *the time inconsistency problem* which emphasized that a discretionary monetary policy involves a potential inflationary bias. Accordingly, common sense has established that the central bank should commit to some transparent monetary policy principle. A number of studies have been asking what kind of policy principle the central bank should adopt in rational expectation frameworks.

In the 1990s, Taylor[38] developed the analysis of monetary policy rules into the mainstream of monetary macroeconomics. He proposed a simple policy instrument rule, *the Taylor rule*, that the central bank manipulates the nominal interest rate as a linear function of current inflation rate and the current measure of output relative to potential. He presented strong evidence that the Taylor rule had been identified among recent central banks' principles and had contributed to the favorable performance of their monetary policies.

Taylor's work has subsequently stimulated a great number of studies of simple and effective instrument rules of monetary policy. For example, Rudebusch and Svensson[36] examine a number of policy rules on the basis of a variety of targets and conclude that inflation (forecast) targeting is optimal. King and Wolman[28] critically discuss monetary targeting, while McCallum[30] empirically supports a base money rule for developed countries. McCallum and Nelson[31] demonstrate that nominal income targeting is better than inflation targeting or the Taylor rule. Erceg et al.[21] support a wage rate targeting. Ball[2] and Clarida et al.[16] examine whether the central bank should consider the exchange rate in a small open economy. Amato and Laubach[1], Rotemberg and Woodford[35], and Woodford[42] evaluate the effectiveness of policy smoothing such that the central bank operates current policy instruments in response to lagged ones. Eggertsson and Woodford[19][20] and Reifschneider and Williams[33] discuss policy rules under the zero lower bound of nominal interest rate. Taylor[39] surveys existing studies and concludes that the Taylor rule has performed better, on average, in all studies.

Most authors, however, are little concerned with the relationship between the performance of the monetary policy rule and the condition of the financial market. The most clear-cut evidence is that their frameworks are fundamentally based on standard IS-LM or new Keynesian models, which do not incorporate any financial market imperfection or any financial shocks generated in that imperfect financial market. They merely focus on the performance of policy rules in response to simple supply and demand shocks. Consequently, the existing studies are unable to analyze what design of policy rules the central bank should adopt in an imperfect financial market and in response to financial shocks.

In fact, the analysis of monetary policy rules cannot be separated from financial market imperfection because, as several studies have shown, monetary policy itself depends critically upon the condition of the financial market. For example, Bernanke and Gertler[4] demonstrate *the financial accelerator mechanism*, showing that financial market imperfection can amplify and propagate the impact of structural shocks on the real economy. Bernanke et al.[7] and Carlstrom and Fuerst[13] clarify the characteristics of the impact of distributive or external finance shocks in credit economy models. Bernanke and Blinder[3] empirically confirm *the credit channel*, which stems from the financial market imperfection and is a significant transmission mechanism for monetary policy. It is, therefore, reasonable to consider the relationship between monetary policy rules and financial market imperfection.

The purpose of our paper is to investigate the performance of monetary policy rules in a credit economy. In particular, the paper focuses on: (1) Whether (or how) does the performance of a monetary policy rule depend upon the condition of the financial market? (2) What policy principle should the central bank adopt in response to financial shocks generated in the imperfect financial market, as well as to common supply and demand shocks? For this purpose, the paper specifies a credit economy model incorporating the financial market imperfection into a new Keynesian macroeconomic model, and examines the performance of a variety of monetary policy rules which the central bank operates in response to inflation rate, output gap, and the lagged policy instrument itself.

Our main results imply that the performance of a monetary policy rule depends significantly upon the condition of the financial market. First, the central bank should respond to output rather than inflation if the financial market is markedly imperfect, because structural shocks cause output to fluctuate via the financial accelerator mechanism rather than to cause inflation. Second, under the same market condition, the bank should not adopt policy smoothing which does not contribute to the stability of output but, instead, contributes to inflation. Third, the bank should not respond to inflation as aggressively under financial and wealth distribution shocks as it should to supply shock, because these financial shocks influence aggregate demand rather than aggregate supply through the impact on firms' financial availability. In summary, the central bank should not have too much confidence in either the inflation targeting or the policy smoothing when the financial market is imperfect or in the process of responding to financial and wealth distribution shocks.

These results have a number of significant implications for the analysis of monetary policy rules.

First, our paper is the first study to investigate the relationship between financial market imperfection and monetary policy rules, and in doing so, contributes to the set of studies considering the influence of financial market imperfection. For example, Bernanke and Gertler[5][6] and Gilchrist and Leahy[27] only examine asset price targeting in a credit economy model, but our paper additionally examines other policy rules in a similar framework. Devereux et al.[17] conclude that financial frictions have no impact on the ranking of alternative policy rules in an open economy, whereas our paper comes to the contrasting conclusion that frictions do affect policy rule ranking in a closed economy. Tuladhar[40] finds the relationship between the performance of policy rules and the condition of the financial market, but our paper makes detailed features of the relationship clearer.

Second, our paper provides a distinct caution to most recent literature. A number of economists have recently emphasized the effectiveness of inflation targeting as the optimal principle of monetary policy (e.g., Bernanke and Gertler[5]; Rudebusch and Svensson[36]). Others strongly recommend inflation targeting as a prescription for overcoming recent financial crises in developed and emerging economies. However, our results suggest that inflation targeting is not always a dominant strategy of monetary policy and is desirable only if the financial market is relatively frictionless. Our paper therefore shows how necessary it is to guard against overconfidence in inflation targeting.

Third, our paper provides a reason why recent central banks' principles have been empirically identified as the Taylor rule. Our results indicate that whether the bank should target inflation or output depends upon the condition of the financial market. We can conclude, therefore, that it might be reasonable that the Taylor rule, which responds equally to inflation and output, has been supported empirically under different actual financial market conditions. Our paper therefore supports the Taylor rule as a more appropriate practical rule in fragile financial markets.

Fourth, our paper contributes not only to the analysis of *the instrument rule* of monetary policy examined here but also to *the targeting rule* [1] . A targeting rule is the policy principle that the central bank is assigned to achieve an explicitly determined policy objective using *all available information*, not only inflation or output. For practical reasons recent literature often focuses on the targeting rule (e.g., Mishkin[32]; Svensson[37]). But the literature gives little guidance as to how the central bank should operate its instruments to achieve a certain policy objective. Hence, our paper clarifies the optimal instrument rules under a variety of policy objectives.

Finally, our paper also provides a unique implication for monetary policy in emerging countries because those countries usually have immature financial markets and face a variety of financial frictions. We note that, in contrast, other studies often analyze this from the viewpoint of economic openness or the credibility of the central bank and then are unable to make any suggestions about our issue (e.g., Ball[2]; Clarida et al.[16]).

The remainder of our paper is organized as follows. Section 2 provides a credit economy model which incorporates financial market imperfection in a new Keynesian macroeconomic model. Section 3 sets the value of structural parameters and, using calibration, confirms that our model depicts real credit economies well. Section 4 considers the performance of a variety of monetary policy rules by executing stochastic simulations. Section 5 checks the robustness of the previous results in different conditions. Section 6 offers several concluding remarks.

2 The Model

We formulate a credit economy model based on a new Keynesian macroeconomic model. Our model specification is closely related to those of Bernanke et al.[7], Carlstrom and Fuerst[13], Gali and Gertler[23], and Kiyotaki and Moore[29]. The model economy consists of four types of agent: households, banks, firms, and retailers. We assume that banks, firms, and retailers are risk neutral and owned by households. Further, we normalize the numbers of

[1] Recent literature often uses "inflation targeting" to express not only an instrument rule but also a targeting rule. Note that we use this phrase to express the instrument rule.

each agent to unity. We will first describe their optimization problems, then move to the analysis of equilibrium. Hereafter, we will express the steady state values of variables with capital letters without time subscript, and the percent deviation of the variables from their steady state with small letters with time subscript.

2.1 Households

The household lives forever, with a utility function given by

$$E_t \left[\sum_{k=0}^{\infty} \beta^{t+k} \left(\ln C_{t+k} + \gamma \ln \left(1 - L_{t+k}\right) + \chi \ln \left(M_{t+k}/P_{t+k}\right)\right) \right]. \tag{1}$$

$C_t \in [0, +\infty)$ is consumption in period t, $L_t \in [0, 1]$ is labor supply, $M_t \in [0, +\infty)$ is nominal money holding, $P_t \in (0, +\infty)$ is price level, $\beta \in (0, 1)$ is the discount factor, and $\gamma \in [0, +\infty)$ and $\chi \in [0, +\infty)$ are the relative importance of leisure $1 - L_t$ and real money holding $\frac{M_t}{P_t}$ compared to consumption. E_t is the conditional expectation operator in period t.

In period t, the household has money M_{t-1} and deposit $I_{t-1} \in [0, +\infty)$ in banks, and supplies labor L_t to firms. The household also receives interest $R_{t-1}I_{t-1}$ and labor income W_tL_t, where $R_{t-1} \in [1, +\infty)$ and $W_t \in [0, +\infty)$ are the gross real interest rate and the real wage rate, respectively. Then, the household decides to consume C_t and hold M_t in money and a deposit I_t. The household's budget is consequently given by

$$I_t = W_tL_t + R_{t-1}I_{t-1} - C_t - \frac{M_t - M_{t-1}}{P_t} + \textit{exogenous variables}, \tag{2}$$

where *exogenous variables* include any variables exogenous to household decisions: lump sum profits from other agents and government tax (or transfer) explained later.

Here we introduce the *financial market imperfection*, that the household is unable to lend directly to firms because the household is unable to enforce firms to commit loan contracts between themselves and firms. The household therefore has no choice but to deposit funds in banks.

After all, the household maximizes the expected utility Eq. (1) under the budget Eq. (2). The first-order conditions are as follows:

$$\frac{E_tC_{t+1}}{C_t} = \beta R_t, \tag{3}$$

$$\begin{aligned} \gamma C_t &= W_t \left(1 - L_t\right), & (4) \\ \chi \frac{P_t}{M_t} &= \frac{1}{C_t} \left(1 - \frac{P_t}{R_t E_t P_{t+1}}\right). & (5) \end{aligned}$$

Eq. (3), Eq. (4), and Eq. (5) are an Euler equation, a labor supply function, and a money demand function, respectively.

2.2 Banks

The bank has the financial skill to set up financial contracts between households and firms even in the imperfect financial market. Then, the bank accepts deposit I_t from households, makes loans to firms, receives repayments $R_t I_t$ in the next period, and repays households.

Here we specify the bank's skill by assuming *the enforcement problem* according to Kiyotaki and Moore[29]: *The bank can verify firms' realized revenue only up to a ratio* $\Delta_t \in (0, 1]$ *of their expected revenue in period* $t + 1$. Under the circumstance, the bank sets on firms the credit constraint that it lends no more than the size of the verification ratio Δ_t of firms' expected revenue:

$$\Delta_t E_t X_{t+1} = R_t I_t, \tag{6}$$

where $X_{t+1} \in [0, +\infty)$ is the firm's realized revenue in period $t+1$, explained later. In short, the ratio Δ_t represents the credit constraint imposed by the bank or the condition of the financial market.

Additionally, we assume that the verification ratio Δ_t increases with the firm's revenue, because firm's revenue could be more verifiable during larger production due to, for example, the increase of the price of firm's capital [2] . Then, we assume a function of the ratio Δ_t which increases with the firm's expected revenue $E_t X_{t+1}$:

$$\Delta_t \equiv \Theta_t \left(\frac{E_t X_{t+1}}{X}\right)^{\tau}. \tag{7}$$

[2]See, for example, Bernanke et al.[7] or Carlstrom and Fuerst[13] as for the detailed relationship between the price of capital and the credit constraint. Of course, It is possible to specify the above mechanism so explicitly as existing studies, but here we concentrate on describing their fundamental implicaitons by assuming this simplest form. Consequently, we can describe the financial accelerator mechanism in the later log-linearized model with ease.

Instead of the ratio Δ_t, $\Theta_t \in (0,1)$ and $\tau \in (0,+\infty)$ represent the condition of the financial market, and have a driving force behind *the financial accelerator mechanism.* In particular, the parameter τ represents financial market imperfection in the later log-linearized model.

2.3 Firms

In period t, the firm has borrowed I_{t-1} at the real rate R_{t-1} from banks and invested in capital $K_{t-1} \in [0,+\infty)$. The firm then hires labor L_t from households and produces *a wholesale good* $Y_t \in [0,+\infty)$ with a technology:

$$Y_t = A_t K_{t-1}^{\alpha} L_t^{1-\alpha}.$$

$A_t \in [0,+\infty)$ is productivity in period t. $\alpha \in (0,1)$ is the capital share. Then, the firm competitively sells off output Y_t and residual capital to retailers at the real price $\frac{1}{Q_t}$. $\frac{1}{Q_t}$ is the relative price measured with aggregate final goods because $Q_t \in (0,+\infty)$ is the retailer's markup introduced later. After the sale, the firm pays wage $W_t L_t$ and debt $R_{t-1} I_{t-1}$, and transfers its profit as a lump sum to households. Finally, the firm again borrows and invests I_t for future production.

In order to preclude a corner solution $I_t = 0$ under the credit constraint Eq. (6), we assume that *a proportion* $\eta \in (0,1)$ *of capital* K_t *is transformed into, for example, technological knowledge which is inalienable to other agents.* That is, the firm still holds the inalienable part of residual capital $(1-\delta)\eta K_t$ after the production, where $\delta \in [0,1]$ is the depreciation rate of capital. Consequently, this capital plays the role of *internal capital* that enables the firm to borrow from banks by collaterizing the expected revenue derived from this internal capital [3] . In this case, the parameter η will influences financial market imperfection together with the condition of the financial market Δ_t.

The firm's revenue X_{t+1} in Eq. (6) is therefore given by

$$X_{t+1} = \frac{Y_{t+1} + (1-\delta)(1-\eta)K_t}{Q_{t+1}} - W_{t+1}L_{t+1}.$$

[3] Bernanke et al.[7] and Carlstrom and Fuerst[13] add a peculiar entrepreneur to their models in order to define a productive agent which has internal capital. As a result, their models are very complicated and need a number of arbitrary parameters. On the other hand, we add peculiar capital for the purpose of tractability.

For the purpose of tractability, the wage $W_{t+1}L_{t+1}$ is supposed to be paid prior to the repayment to banks, but this setting has no influence on later analysis.

Further, we introduce a disturbance term $K(D_t - 1)$ that influences wealth distribution between the (productive) firm and the (unproductive) household. The transition of capital is given by

$$K_t = (1-\delta)\eta K_{t-1} + I_t + K(D_t - 1), \tag{8}$$

where $D_t \in (-\infty, +\infty)$ is *a wealth redistribution* in period t which equals unity in the steady state ($D = 1$). For example, if $D_t > 1$, then part of households' wealth $K(D_t - 1)$ spills over to firms, which can borrow and invest more than before [4]. The expression for the term is prepared for later log-linearization. By this assumption, we will examine the impact of wealth redistribution between productive sectors and unproductive ones in the credit economy.

The firm maximizes expected profit

$$\max_{I_t, L_{t+1}} E_t \left[\frac{Y_{t+1} + (1-\delta)(1-\eta)K_t}{Q_{t+1}} - W_{t+1}L_{t+1} - R_t I_t \right],$$

given the credit constraint Eq. (6) and the transition of capital stock Eq. (8) [5]. The first-order conditions are:

$$(1 + (1+\tau)\Lambda_t \Delta_t)\, E_t \left[\frac{\alpha Y_{t+1} + (1-\delta)(1-\eta)K_t}{Q_{t+1}K_t} \right] = (1+\Lambda_t)R_t, \tag{9}$$

$$\frac{(1-\alpha)Y_t}{Q_t L_t} = W_t, \tag{10}$$

$$\Delta_t E_t \left[\frac{Y_{t+1} + (1-\delta)(1-\eta)K_t}{Q_{t+1}} - W_{t+1}L_{t+1} \right] = R_t I_t, \tag{11}$$

where Λ_t is the Lagrangian multiplier with respect to the credit constraint Eq. (6). Eq. (9), Eq. (10), and Eq. (11) are, respectively, the capital and labor demand functions, and the credit constraint.

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[4] In reality, when productive sectors happen to buy ex post unworthy wealth from unproductive sectors ($D_t < 1$), it is frequently the case that the former's wealth spills over to the latter's. A similar case was often seen in Japan in the late 1980s, the bubble period. Firms had scooped up vast amount of land at abnormal prices, but they recognized that the land had no value after the bubble.

[5] Note that inalienable capital $\eta(1-\delta)K_t$ is excluded from the profit because the capital is not transferable. Further, we do not introduce dynamic maximization because it provides no different results from instantaneous maximization.

2.4 Retailers

In period t, the retailer competitively purchases wholesale goods from firms at the real price $\frac{1}{Q_t}$, produces a differentiated final good at no cost, sets its price rationally, and supplies to households in the monopolistically competitive market. Finally, the retailer's profit is returned as a lump sum to households.

Here we introduce staggered price setting as proposed by Calvo[11]: *The retailer has to maintain its own price with probability* $\mu \in [0, 1)$ *in each period, irrespective of how long the price has been fixed since the retailer last changed its price.* By the law of large numbers, the fraction $1 - \mu$ of retailers change their prices in each period, while the others keep their prices unchanged. After the demand for final goods is specified according to Dixit and Stiglitz[18], a log-linearized relationship between inflation $\Pi_t \equiv \frac{P_t}{P_{t-1}}$ and markup Q_t are given by:

$$\pi_t = -\kappa q_t + \beta E_t \pi_{t+1}, \tag{12}$$

where $\kappa \equiv \frac{(1-\mu)(1-\beta\mu)}{\mu}$. Eq. (12) expresses the *new Keynesian Phillips curve* reflecting retailers' forward-looking price setting [6] .

2.5 The Monetary Policy Rule

Finally, we define a standard monetary policy rule, that the central bank manipulates gross nominal interest rate $R^n_t \in [1, +\infty)$ $(= R_t E_t \Pi_{t+1})$ as the unique policy instrument of monetary policy. Actual monetary policies are often recognized as not only responding to inflation Π_t and output Y_t, but also to have the characteristic of *policy smoothing.* Then, we specify a generalized monetary policy rule that is log-linearized as follows:

$$r^n_t = \rho r^n_{t-1} + (1 - \rho)(\nu \pi_t + \sigma y_t) + \epsilon^r_t. \tag{13}$$

$\nu \in [0, +\infty)$ and $\sigma \in [0, +\infty)$ are, respectively, response coefficients to π_t and y_t. $\rho \in [0, 1)$ is a nominal interest rate smoothing coefficient. ϵ^r_t is the *monetary shock* in period t. In Section 4, we will examine the performance of monetary policy rules responding to structural shocks by changing the values of policy parameters (ρ, ν, σ).

[6] We also tried a revised Calvo model proposed by Gali and Gertler[23], who introduced backward-looking price setting into Eq. (12) because the original Calvo model was not consistent with several stylized facts. However, the revised version did not change our results.

2.6 Equilibrium and Structural Shocks

We summarize several characteristics of the equilibrium of the credit economy and define several structural shocks. Here we will focus on the unique bounded stable equilibrium where state variables follow paths which are close to the equilibrium.

The equilibrium of the aggregate final goods is derived from the household's budget Eq. (2):

$$Y_t + (1-\delta)(1-\eta)K_{t-1} = C_t + I_t + G_t + K(D_t - 1),$$

where $G_t \equiv \frac{M_t - M_{t-1}}{P_t} + T_t$. $G_t \in (-\infty, +\infty)$ and $T_t \in (-\infty, +\infty)$ are, respectively, fiscal expenditure and tax. $K(D_t - 1)$ is the wealth redistribution introduced in Eq. (8).

We introduce several structural shocks such that productivity A_t, fiscal policy G_t, the condition of the financial market Θ_t, and wealth redistribution D_t, follow log-linear AR(1) stochastic processes. They have AR(1) coefficients $(\rho_y, \rho_g, \rho_\theta, \rho_k)$ and exogenous shocks $(\epsilon_t^y, \epsilon_t^g, \epsilon_t^\theta, \epsilon_t^k)$, the expectations of which are equal to zero, respectively.

The condition under which the steady state equilibrium of the credit economy is *stable* is that the marginal collateral of investment is less than the marginal debt in Eq. (6) in the steady state, $\frac{\partial (l.h.s)}{\partial I} < R$, which is transformed to

$$\tau < \frac{\eta(1-\delta)}{1-\eta(1-\delta)}. \tag{14}$$

Eq. (14) means that the verification ratio Δ_t does not increase extremely with the firm's revenue $E_t X_{t+1}$ in Eq. (7).

Another condition under which the credit constraint Eq. (6) binds in the steady state equilibrium is $\Lambda > 0$ in Eq. (9) , which is transformed to

$$\Theta + \eta(1-\delta) < 1. \tag{15}$$

Eq. (15) means that the credit constraint can appear if the financial market is severely imperfect or if the firm's capital is much inalienable.

In the next section, we will log-linearize our model around the unique steady state because our model is not solvable in a closed form solution; then we will transform the structural system into a reduced one according to the popular technique of Blanchard and Kahn[9]. In Section 4, we will analyze the performance of a variety of monetary policy rules in response to structural shocks in different financial market conditions.

3 Calibration

Here we confirm that our model depicts real credit economies so well as to obtain some realistic implications for actual monetary policy in Section 4. First, we set the values of parameters introduced in our model. Next, we test the potential of our model by examining the steady state and impulse response to structural shocks. We will also identify the financial accelerator mechanism by comparing the response in different financial market conditions as well.

To begin, we set the values of parameters on the quarterly basis as in Table 1 according to existing studies. Note that the parameters associated with the financial market condition (Θ, τ) are respectively set so as to satisfy Eq. (14) and Eq. (15). In addition, we set the steady state fiscal policy G and the target rate of inflation Π to equal to $0.2Y$ and 1.005, which equals 2% on an annual basis, respectively.

Then, we will test our model by examining steady states and impulse responses to structural shocks. First, Table 2 shows the unique steady states in the imperfect financial market and the average U.S. and Japanese economies. We easily find that our credit economies are almost consistent with the real economies.

Next, Figure 1 shows the impulse responses to the five structural shocks in the perfect and imperfect financial markets. Here the parameters of the monetary policy rule (ρ, ν, σ) are set at $(0.7, 2.0, 0)$ according to Clarida et al.[14], who find that the Fed adopted a rule $(0.66, 1.96, 0.07)$ during the Volcker–Greenspan era (1979–1996). Each graph shows the responses of output and inflation to an unexpected positive structural shock. The dashed and solid lines depict the results under the perfect and imperfect financial market, respectively.

We immediately find that the standard supply and demand shocks $(\epsilon^y, \epsilon^g, \epsilon^r)$ have popular impacts consistent with the existing literature (e.g., Bernanke et al.[7]). Output responds to the productivity and fiscal shocks positively and responds to monetary shock negatively. Inflation responds to the fiscal shock positively and to the productivity and monetary shocks negatively. Further, the financial accelerator amplifies and propagates the impact of shocks in the imperfect financial market.

We also make sure that the financial and wealth distribution shocks $(\epsilon^\theta, \epsilon^k)$ also have several impacts consistent with existing literature. The economy, naturally, has no response to the shocks in the perfect financial market. Meanwhile, in the imperfect market, output and inflation respond to the shocks positively because both shocks enlarge firms' financial availability and stimulate their investment. The responses imply that the economy would plunge into recession and deflation in response to a negative financial shock (e.g., financial crisis) or a negative distribution shock (e.g., the bubble which stimulates the abnormal transfer from productive sectors to unproductive ones).

In summary, we can conclude that our model successfully depicts real economies. Most important is that our model demonstrates well the financial accelerator mechanism.

4 Simulations

We will consider the performance of a variety of monetary policy rules by executing stochastic simulations. Then we will investigate whether the condition of the financial market could affect the performance of policy rules and, if so, what rules are desirable in the credit economy.

4.1 Setup

We introduce, first, a welfare loss function for the economy which evaluates the performance of monetary policy rules, second, three financial market conditions, and third, the values of the policy parameters in Eq. (13) examined here.

First, we introduce a common loss function targeting the stability of output and inflation as follows [7] :

$$Loss = Var[y_t] + \phi Var[\pi_t]. \tag{16}$$

$Var[.]$ is the expectation operator of unconditional variance. The coefficient ϕ is the relative weight of inflation stability. We adopt several realistic weights $\{0.1, 0.5, 1.0, 2.0\}$ in order to consider how the performance of policy rules depends upon the weight of the loss function [8] .

[7] Svensson[37] and Woodford[43] show the foundation for the function Eq. (16) in detail. Clarida et al.[14] and Rotemberg and Woodford[34] explain how the loss function analysis is better than other welfare analysis.

[8] We also examine a number of other weights but their key results are exactly the same as the ones reported in this paper.

Next, we consider three different financial market conditions in order to investigate how the performance of policy rules depends upon such condition: (1) *No* imperfection (or perfection), (2) *Low* imperfection ($\tau = 0.05$), and (3) *High* imperfection ($\tau = 0.1$). Remember that the parameter τ represents the financial market imperfection in the log-linearized model.

Finally, there are three policy parameters (ρ, ν, σ) in the monetary policy rule Eq. (13). We consider 10 values of the smoothing parameter ρ and 16 sets of values of the other parameters (ν, σ) as in Table 3. To make this clear, we label a set (ν, σ) with a number and order in a way that a rule which is more inflation responding (or less output responding) has a larger number. In total, we examine 160 policy rules.

4.2 Results

Table 4 shows the results of stochastic simulations. The table consists of four panels corresponding to the alternative weights of inflation stability ϕ. The row in the panel represents the structural shock and the financial market condition, and the column represents the value of the smoothing parameter ρ. The value in the cell expresses the number of a *locally* optimal rule (ν, σ) in Table 3 under a financial market condition (row), in response to a shock (row), and under a smoothing parameter ρ (column). The bold type value represents the number of the *globally* optimal rule (ρ, ν, σ) under a financial market condition and in response to a shock.

We immediately find three common results which are independent of the financial market condition. First, the values of locally optimal rules increase with the increase in the weight ϕ independent of parameter ρ and type of shock. This means that, if the economy focuses on the stability of inflation, the central bank should respond mainly to inflation. Second, the parameter ρ of globally optimal rules also increases with the increase in the weight ϕ, independent of type of shock. This result means that the bank should adopt policy smoothing under a large weight of inflation stability, because smoothing makes it easier to stabilize not only the future nominal interest rate but also retailers' price setting [9] . Third, the values of locally optimal rules (ν, σ) and the values of globally optimal parameters ρ are no smaller in

[9] Woodford[41] derives the same result. Further, Giannoni and Woodford[25] show that the presence of forward-looking terms in the model's structural equations necessarily makes history-dependent policy desirable. Our model introduces a forward-looking term in retailers' price setting and then derives the same result.

response to the productivity shock ϵ^y than to the fiscal shock ϵ^g. This result is also understandable, as the central bank should respond relatively more to inflation and adopt smoothing in response to a supply shock than it should to a demand shock.

More importantly, we observe other three significant results with respect to the financial market condition. The results emphasize that the optimal rule of monetary policy depends strongly upon the financial market condition.

First, the values of optimal rules decrease in order of *No, Low*, and *High* imperfection, independent of weight ϕ, type of shock, and parameter ρ. This means that the central bank should respond to output rather than inflation if the financial market is imperfect. This is because there exists not only price inertia but also the financial accelerator in the imperfect financial market. The accelerator enables a shock to have additional impact on firms' real investment through the credit constraint. As a result, the central bank should concentrate on the stability of output rather than on inflation in a highly imperfect market [10].

The effect of the financial accelerator can be understood with *the efficient policy frontier* (the so-called *Taylor curve*) as well. For example, Figure 2 shows two frontiers in response to the productivity shock ϵ^y with *No* and *High* imperfection of financial market, respectively. The efficient policy frontier expresses a set of optimal rules that realize the most effective performance under various weights of loss functions. A loss function is plotted with straight lines in the figure. Here the financial accelerator makes the frontier *flatter* in the imperfect financial market. As a result, the optimal rule in the imperfect financial market (point B) is less inflation stabilizing (or more output stabilizing) than that in the perfect market (point A) under the same loss function.

Second, in any panel, the values of globally optimal smoothing rules decrease in order of *No, Low*, and *High* imperfection, independent of weight ϕ and type of shock. This means that the central bank should not adopt smoothing aggressively in an imperfect financial market. This is because

[10] We also find in the first panel that the 5th rule $(\nu, \sigma) = (0.8, 2.2)$ is supported in several situations. This rule does not satisfy the Taylor principle that the central bank must increase the nominal interest rate more than the increase in inflation rate in order to guarantee the existence of a unique equilibrium (e.g., Taylor[39]; Woodford[42]). Gali et al.[24] indicate that there exists a condition under which a unique equilibrium is not guaranteed by the principle. Meanwhile, our results show the adverse possibility that a unique equilibrium can be guaranteed even without the principle. This is our future work.

smoothing stabilizes inflation via the stabilization of the nominal interest rate, but destabilize output for the same reason as the first result (e.g., Amato and Laubach[1]).

Third, in any panel, the values of optimal rules in response to financial and distribution shocks $(\epsilon^{\theta}, \epsilon^{k})$ are no larger than those to the productivity shock ϵ^{y}, independent of the parameter ρ and the financial market condition. This means that the central bank should not respond to inflation as strongly in response to shocks associated with the credit economy as to a supply shock. This is because those shocks are a type of demand shock similar to fiscal shock ϵ^{g}.

In summary, we can conclude that the performance of monetary policy rules depends deeply upon the financial market condition. Specifically, if the financial market is severely imperfect, the central bank should not adopt inflation targeting or smoothing strictly. In addition, the bank should not adopt inflation targeting as aggressively in response to shocks associated with the credit economy as to a supply shock. In short, our results do not support inflation targeting as the optimal strategy of monetary policy in real imperfect financial markets.

5 Other analysis

We will check the robustness of the previous results by repeating the same analysis on the basis of another loss function and under another type of monetary policy rule.

5.1 Another Loss Function

First, following Giannoni and Woodford[25][26], we will check the robustness under another style of loss function which also includes the variance of nominal interest rate $Var\left[r_t^n\right]$:

$$Loss = Var[y_t] + \phi Var[\pi_t] + \psi Var[r_t^n]. \quad (17)$$

This function represents the welfare loss generated by the volatility of nominal interest rate. The parameter ψ is the relative weight of nominal interest rate stability and is assumed to equal to 0.5 [11] .

[11]Giannoni and Woodford[26] assume the weight of nominal interest rate stability to be 0.077 in a similar loss function, but we assume the larger value in order to clarify the

Table 5 shows the results based on the loss function Eq. (17). These are almost the same as the results presented in Table 4. In short, we can conclude that the central bank should not adopt aggressive inflation targeting and smoothing if the financial market is very imperfect or if the bank faces shocks associated with the credit economy.

Note that the values in Table 5 are no smaller than the corresponding values in Table 4. This means that if stability of the nominal interest rate is considered further, then the central bank should respond to inflation rather than output and adopt smoothing. This result is not unexpected, because both inflation targeting and smoothing lead to stability of the nominal interest rate.

5.2 Inflation Forecast Targeting Rules

Next, we examine the performance of inflation *forecast* targeting. Rudebusch and Svensson[36] argue that the central bank should respond to *expected* inflation rather than *current* inflation. Then we specify another style of monetary policy rules which respond to expected inflation $E_t\pi_{t+1}$ instead of to current inflation π_t:

$$r_t^n = \rho r_{t-1}^n + (1-\rho)\left(\nu E_t\pi_{t+1} + \sigma y_t\right) + \epsilon_t^r. \tag{18}$$

Table 6 shows the result on the basis of the loss function Eq. (16) [12] . This also reinforces the conclusion in Table 4 that aggressive inflation targeting and smoothing are inappropriate with the imperfect financial market or in response to shocks associated with the credit economy. We can therefore conclude that our previous results do not change when the central bank responds to expected inflation.

There are several additional results in Table 6. First, the values of locally optimal rules are no smaller than those in Table 4. This means that the central bank should respond to inflation more aggressively when targeting expected inflation than when targeting current inflation. This follows because, under Eq. (18), the bank *indirectly* stabilizes current inflation by

influence of the inclusion of that stability. Note that our result does not change if we assume other values for the parameter ψ.

[12]As Bernanke and Woodford[8] and Giannoni and Woodford[26] mention, if the central bank responds to expected inflation strongly, the economy would have indeterminate steady state equilibria. Here, we focus on policy rules in Table 3 which have a unique equilibrium.

targeting expected inflation. Second, the smoothing parameters of globally optimal rules are no larger than those in Table 4. This means that the central bank should not adopt smoothing as aggressively as when targeting current inflation. This is because inflation forecast targeting and smoothing are mutually complementary at the point that both rules stabilize private sector expectations.

Table 7 shows the result based on the loss function Eq. (17). The result has the same characteristic as in Table 5. That is, the values in Table 7 are no smaller than the corresponding values in Table 6. This means that if stability of the nominal interest rate is considered more important, then the central bank should adopt inflation targeting and smoothing aggressively.

In summary, we can conclude that the central bank should not adopt aggressive inflation targeting and smoothing if the financial market is severely imperfect or if the bank faces shocks associated with the credit economy. This conclusion remains the same even if the economy responds to stability of the nominal interest rate or if the central bank targets expected inflation rather than current inflation.

6 Concluding Remarks

Recent studies have energetically researched some simple and effective monetary policy rules. Most of them, however, are little concerned with the relationship between the performance of monetary policy rules and financial market condition. Meanwhile, several studies have shown that monetary policy itself depends crucially upon the state of the financial market. This paper specifies a credit economy model which incorporates financial market imperfection into a new Keynesian macroeconomic model and examines the performance of monetary policy rules in a credit economy.

The main conclusion is that *the performance of a monetary policy rule depends significantly upon the financial market condition* as follows: First, the central bank should respond to output rather than inflation if the financial market is markedly imperfect, because structural shocks cause output to fluctuate rather than inflation via the financial accelerator mechanism. Second, for the same reason, the bank should not adopt policy smoothing under the same market condition. Third, the bank should not respond to inflation as aggressively under financial and wealth distribution shocks as it would to a supply shock, because financial and wealth distribution shocks influence aggregate demand rather than aggregate supply through the impact on firms' financial availability. In summary, the central bank should not be overconfident about inflation targeting and smoothing in the credit economy or in response to several shocks associated with the credit economy.

This paper has a variety of significant implications for the analysis of monetary policy rules. The paper indicates that inflation targeting, as the optimal principle of monetary policy or as the prescription to overcome recent financial crises, is not always appropriate. We also provide a reason why the Taylor rule has been identified and supported empirically in most literature. Further, the paper contributes to the analysis of emerging countries' monetary policy, given the incidence of market imperfection in those countries' financial markets.

Finally, we suggest some future research. First, the results of our paper need to be tested empirically by comparing monetary policies in several countries with different financial market conditions. Second, the paper specifies a traditional style of monetary policy rule responding to inflation rate, output gap, and lagged policy instruments. However, it is also necessary to consider other styles, such as those responding to asset prices or the price level, as analyzed in recent studies. Further, we have considered only a closed economy, but the same analysis needs to be done for an open economy because monetary policy could also be transmitted through the foreign exchange rate. In addition, we have seen, in passing, that it may be possible that a unique equilibrium can be guaranteed even without the Taylor principle. This result, suggested only in a footnote, has to be investigated in more detail. These are some of the issues on which we will focus our future work.

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Table 1 Values of Structural Parameters on the Quarterly Basis

β	γ	χ	A	α	δ	η	μ	Θ	τ	ρ_y	ρ_g	ρ_θ	ρ_k
0.99	2.5	0.05	100	0.33	0.05	0.1	0.75	0.9	0.1	0.9	0.9	0.9	0.9

Notes: This table shows the values of structural parameters on the quarterly basis. The values are set according to Bernanke et al.[7], Carlstrom and Fuerst[12], Clarida et al.[15], Gali and Gertler[23], and Rotemberg and Woodford[34],[35]. δ and η are according to Brynjolfsson and Yang[10] and Foray[22,p.22], respectively.

Table 2 Steady State Values

	U.S.	Japan	Model
C/Y	0.71	0.63	0.74
I/Y	0.11	0.18	0.057
G/Y	0.19	0.17	0.2
M/PY	2.7	4.5	2.51
Q	1.1	1.2	1.12
L	0.25	0.26	0.242

Note: This table shows our unique steady state in the imperfect financial market and the U.S. and Japanese economies during the 1990s on the quarterly basis. U.S. economy is calculated with data from U.S. Department of Commerce, U.S. Department of Labor, and FRB. Japanese economy is from the Nikkei Needs data base.

Table 3 Policy Parameters

$\rho = \{0, 0.1, \ldots, 0.9\}$

	No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ν		0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
σ		3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2	0.0

Table 4　Optimal Rules (1)

Loss Function: Eq.(16); Policy Rule: Eq.(13)

(1) $\phi = 0.1$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	7	7	7	7	7	7	7	8	9	12
	Low	6	6	7	7	7	7	7	7	8	11
	High	6	6	6	7	7	7	7	7	8	10
ϵ^g	No	6	6	6	6	6	6	6	6	7	9
	Low	5	5	5	5	6	6	6	6	7	9
	High	5	5	5	5	5	5	5	6	6	8
ϵ^θ	No										
	Low	5	5	5	6	6	6	6	6	7	8
	High	5	5	5	5	6	6	6	6	7	8
ϵ^k	No										
	Low	5	5	5	6	6	6	6	6	7	8
	High	5	5	5	5	6	6	6	6	7	8

(2) $\phi = 0.5$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	8	9	9	9	9	9	9	9	10	12
	Low	8	8	8	8	8	8	9	9	10	12
	High	8	8	8	8	8	8	8	8	9	11
ϵ^g	No	8	8	8	8	8	8	8	8	9	10
	Low	7	7	7	7	7	7	7	8	8	10
	High	6	6	6	7	7	7	7	7	7	9
ϵ^θ	No										
	Low	7	7	7	7	7	7	8	8	8	9
	High	7	7	7	7	7	7	7	7	8	9
ϵ^k	No										
	Low	7	7	7	7	7	7	8	8	8	9
	High	7	7	7	7	7	7	7	7	8	9

(3) $\phi = 1.0$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	10	10	10	10	10	10	10	11	11	13
	Low	9	9	10	10	10	10	10	10	11	12
	High	9	9	9	9	9	9	9	9	10	12
ϵ^g	No	9	9	9	9	9	9	9	10	10	11
	Low	9	9	9	9	9	9	9	9	9	10
	High	8	8	8	8	8	8	8	8	9	10
ϵ^θ	No										
	Low	9	9	9	9	9	9	9	9	9	10
	High	8	8	8	8	8	8	8	8	9	10
ϵ^k	No										
	Low	9	9	9	9	9	9	9	9	9	10
	High	8	8	8	8	8	8	8	8	9	10

(4) $\phi = 2.0$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	12	12	12	12	12	12	12	12	13	13
	Low	11	11	11	11	11	11	11	12	12	13
	High	10	10	10	10	10	11	11	11	11	13
ϵ^g	No	11	11	11	11	11	11	11	11	11	12
	Low	10	10	10	10	10	10	10	11	11	11
	High	9	9	9	9	9	9	10	10	10	11
ϵ^θ	No										
	Low	10	10	10	10	10	10	11	11	11	11
	High	10	10	10	10	10	10	10	10	10	11
ϵ^k	No										
	Low	10	10	10	10	10	10	11	11	11	11
	High	10	10	10	10	10	10	10	10	10	11

Notes: This table shows the results of stochastic simulations. The table consists of four panels corresponding to the alternative weights of inflation stability ϕ. The row in the panel represents the structural shock and the financial market condition, and the column represents the value of the smoothing ρ. The value in the cell expresses the number of a *locally* optimal rule (ν,σ) in Table 3 under the above conditions. The *bold type* value represents the number of the *globally* optimal rule (ρ,ν,σ).

Table 5 Optimal Rules (2)

Loss Function: Eq.(17); Policy Rule: Eq.(13)

(1) $\phi = 0.1$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	9	9	9	9	9	9	9	9	10	12
	Low	8	8	8	8	8	8	9	9	9	11
	High	8	8	8	8	8	8	8	8	9	11
ϵ^g	No	8	8	8	8	8	8	8	8	8	10
	Low	7	7	7	7	7	7	7	7	8	9
	High	6	6	6	6	7	7	7	7	7	9
ϵ^θ	No										
	Low	7	7	7	7	7	7	7	7	8	9
	High	6	6	6	7	7	7	7	7	8	9
ϵ^k	No										
	Low	7	7	7	7	7	7	7	7	8	9
	High	6	6	6	7	7	7	7	7	8	9

(2) $\phi = 0.5$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	10	10	10	10	10	10	10	10	11	12
	Low	9	9	9	9	9	10	10	10	10	12
	High	9	9	9	9	9	9	9	9	10	11
ϵ^g	No	9	9	9	9	9	9	9	9	9	10
	Low	8	8	8	8	8	8	8	8	9	10
	High	7	7	7	7	7	8	8	8	8	9
ϵ^θ	No										
	Low	8	8	8	8	8	8	8	9	9	10
	High	7	7	8	8	8	8	8	8	8	10
ϵ^k	No										
	Low	8	8	8	8	8	8	8	9	9	10
	High	7	7	8	8	8	8	8	8	8	10

(3) $\phi = 1.0$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	11	11	11	11	11	11	11	11	12	13
	Low	10	10	10	10	10	11	11	11	11	12
	High	10	10	10	10	10	10	10	10	11	12
ϵ^g	No	10	10	10	10	10	10	10	10	10	11
	Low	9	9	9	9	9	9	9	9	10	10
	High	8	8	8	8	8	8	9	9	9	10
ϵ^θ	No										
	Low	9	9	9	9	9	9	9	10	10	10
	High	8	8	9	9	9	9	9	9	9	10
ϵ^k	No										
	Low	9	9	9	9	9	9	9	10	10	10
	High	8	8	9	9	9	9	9	9	9	10

(4) $\phi = 2.0$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	12	12	12	12	12	12	12	12	13	13
	Low	12	12	12	12	12	12	12	12	12	13
	High	11	11	11	11	11	11	11	11	12	13
ϵ^g	No	11	11	11	11	11	11	11	11	11	12
	Low	11	11	11	11	11	11	11	11	11	11
	High	10	10	10	10	10	10	10	10	10	11
ϵ^θ	No										
	Low	11	11	11	11	11	11	11	11	11	11
	High	10	10	10	10	10	10	10	10	11	11
ϵ^k	No										
	Low	11	11	11	11	11	11	11	11	11	11
	High	10	10	10	10	10	10	10	10	11	11

Notes: See Table 4.

Table 6 Optimal Rules (3)

Loss Function: Eq.(16); Policy Rule: Eq.(18)

(1) $\phi = 0.1$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	7	7	7	7	7	8	8	8	9	13
	Low	7	7	7	7	7	7	8	8	9	12
	High	7	7	7	7	7	7	7	8	8	11
ϵ^g	No	6	6	6	6	6	6	7	7	8	10
	Low	6	6	6	6	6	6	6	6	7	10
	High	6	6	6	6	6	6	6	6	6	9
ϵ^θ	No										
	Low	6	6	6	6	6	6	6	7	7	9
	High	6	6	6	6	6	6	6	7	7	9
ϵ^k	No										
	Low	6	6	6	6	6	6	6	7	7	9
	High	6	6	6	6	6	6	6	7	7	9

(2) $\phi = 0.5$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	9	9	9	9	9	9	10	10	11	14
	Low	9	9	9	9	9	9	9	10	10	13
	High	8	8	8	8	8	9	9	9	10	12
ϵ^g	No	8	8	8	8	8	8	9	9	10	11
	Low	8	8	8	8	8	8	8	8	9	10
	High	7	7	7	7	7	7	7	8	8	10
ϵ^θ	No										
	Low	7	7	7	8	8	8	8	8	9	10
	High	7	7	7	7	7	7	7	8	8	10
ϵ^k	No										
	Low	7	7	7	8	8	8	8	8	9	10
	High	7	7	7	7	7	7	7	8	8	10

(3) $\phi = 1.0$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	11	11	11	11	11	11	11	11	12	14
	Low	10	10	10	10	10	10	11	11	12	13
	High	9	9	9	10	10	10	10	10	11	13
ϵ^g	No	10	10	10	10	10	10	10	10	11	12
	Low	9	9	9	9	9	9	9	10	10	11
	High	8	8	8	8	8	9	9	9	9	11
ϵ^θ	No										
	Low	9	9	9	9	9	9	9	9	10	11
	High	8	8	8	8	8	8	9	9	9	11
ϵ^k	No										
	Low	9	9	9	9	9	9	9	9	10	11
	High	8	8	8	8	8	8	9	9	9	11

(4) $\phi = 2.0$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	12	12	12	12	12	12	12	13	13	14
	Low	12	12	12	12	12	12	12	12	13	14
	High	11	11	11	11	11	11	11	12	12	14
ϵ^g	No	11	11	11	11	11	11	12	12	12	12
	Low	11	11	11	11	11	11	11	11	11	12
	High	10	10	10	10	10	10	10	10	11	11
ϵ^θ	No										
	Low	10	10	10	10	10	10	11	11	11	12
	High	10	10	10	10	10	10	10	10	11	11
ϵ^k	No										
	Low	10	10	10	10	10	10	11	11	11	12
	High	10	10	10	10	10	10	10	10	11	11

Notes: See Table 4.

Table 7 Optimal Rules (4)

Loss Function: Eq.(17); Policy Rule: Eq.(18)

(1) $\phi = 0.1$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	9	9	9	9	9	10	10	10	11	13
	Low	9	9	9	9	9	9	9	10	10	13
	High	9	9	9	9	9	9	9	9	10	12
ϵ^g	No	8	8	8	8	8	8	8	8	9	11
	Low	8	8	8	8	8	8	8	8	8	10
	High	7	7	7	7	7	7	7	7	8	9
ϵ^θ	No										
	Low	7	7	7	7	7	7	8	8	8	10
	High	7	7	7	7	7	7	7	7	8	10
ϵ^k	No										
	Low	7	7	7	7	7	7	8	8	8	10
	High	7	7	7	7	7	7	7	7	8	10

(2) $\phi = 0.5$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	10	10	10	11	11	11	11	11	12	14
	Low	10	10	10	10	10	10	10	11	11	13
	High	9	9	9	9	10	10	10	10	11	13
ϵ^g	No	9	9	9	9	9	9	10	10	10	11
	Low	9	9	9	9	9	9	9	9	9	11
	High	8	8	8	8	8	8	8	8	9	10
ϵ^θ	No										
	Low	8	8	8	8	8	9	9	9	9	10
	High	8	8	8	8	8	8	8	8	9	10
ϵ^k	No										
	Low	8	8	8	8	8	9	9	9	9	10
	High	8	8	8	8	8	8	8	8	9	10

(3) $\phi = 1.0$

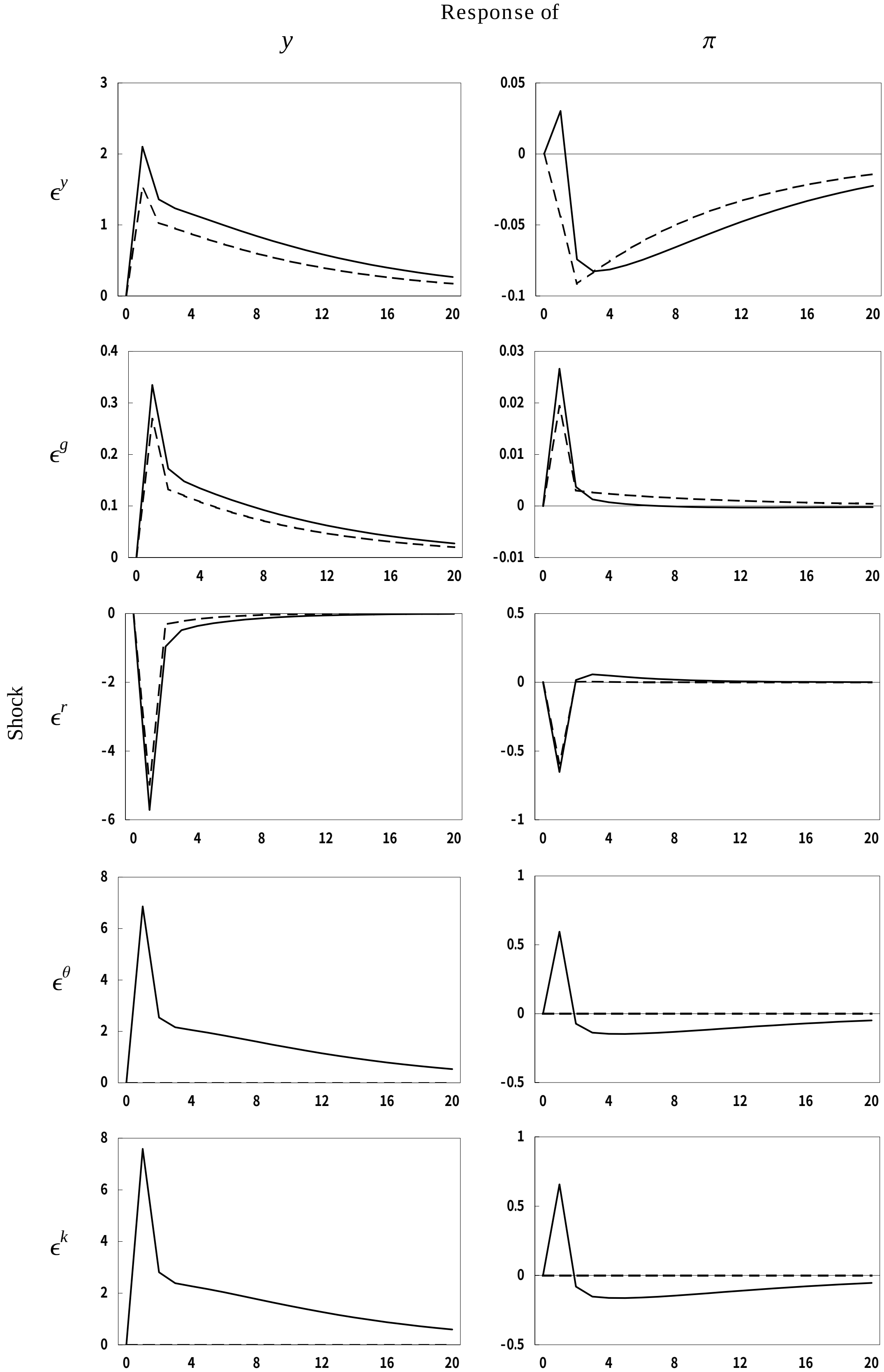
	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	11	11	11	11	12	12	12	12	13	14
	Low	11	11	11	11	11	11	11	12	12	14
	High	10	10	10	10	10	10	11	11	11	13
ϵ^g	No	10	10	10	10	10	10	11	11	11	12
	Low	10	10	10	10	10	10	10	10	10	11
	High	9	9	9	9	9	9	9	9	10	11
ϵ^θ	No										
	Low	9	9	9	9	9	10	10	10	10	11
	High	9	9	9	9	9	9	9	9	10	11
ϵ^k	No										
	Low	9	9	9	9	9	10	10	10	10	11
	High	9	9	9	9	9	9	9	9	10	11

(4) $\phi = 2.0$

	$\rho=$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ϵ^y	No	12	12	12	13	13	13	13	13	13	14
	Low	12	12	12	12	12	12	12	13	13	14
	High	11	11	11	11	11	12	12	12	12	14
ϵ^g	No	12	12	12	12	12	12	12	12	12	12
	Low	11	11	11	11	11	11	11	11	12	12
	High	10	10	10	10	10	10	11	11	11	12
ϵ^θ	No										
	Low	11	11	11	11	11	11	11	11	11	12
	High	10	10	10	10	10	10	10	10	11	12
ϵ^k	No										
	Low	11	11	11	11	11	11	11	11	11	12
	High	10	10	10	10	10	10	10	10	11	12

Notes: See Table 4.

Figure 1 Output and Inflation Responses to Structural Shocks



Note: This figure shows the impulse responses of output (y) and inflation (π) to one percent unexpected structural shocks (ϵ^y, ϵ^g, ϵ^r, ϵ^θ, ϵ^k). Dashed and solid lines describe the responses in the perfect and imperfect financial markets, respectively.

Figure 2: Efficient Policy Frontiers