Monetary Policy, Financial Stability and Interest Rate Rules

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Abstract

This paper investigates the empirical properties of simple interest rate rules that embed either “backward” or “forward” interest rate smoothing. Such interest rate rules can be rationalized as the operative reaction functions used by central banks pursuing monetary policy and financial stability targets. We explicitly consider the implications of banks’ risk management practices for monetary policy and we derive interest rate rules by modeling the desire of the central bank to stabilize different definitions of the “basis” risk as a contribution to financial stability.


Keywords: Central Banking, Interest Rate Rules, Monetary Policy, Financial Stability, Asset Prices, Futures Market, Hedging, Basis Risk, Federal Reserve.

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Monetary Policy, Financial Stability and Interest Rate Rules

1. Introduction

Financial stability is currently the focus of most Central banks around the world. The topic started to received increasing attention in policy debates well before the severe subprime mortgage crisis hit international financial markets in the Summer of 2007, leading to relevant bank failures and extraordinary financial and rescue interventions by the FED and other central banks and monetary authorities. Indeed, despite global progresses made in the fight against inflation, many episodes of financial and currency crises have continued to challenge the international financial system, in both emerging and industrial countries.

It is then somehow natural that central banks devote always more attention to how to prevent or reduce the risk of a financial crisis and of contagion waves. Recently, this has also been considered a rationale in support of the stylized fact that interest rates seem to move gradually in response to changes in macroeconomic conditions (notably output gap and inflation). It has been argued that by making interest rate changes smaller and more predictable, Central Banks reduce the volatility of commercial banks’ profits and lower the risk of bank insolvencies.

In this paper, we evaluate the empirical properties of interest rate rules that explicitly take into consideration the target of financial stability and its interaction with the canonical mandate of central banks to pursue and maintain price stability.

Numerous theoretical and empirical studies of different kinds of central banks’ reaction functions have been presented in the literature. A recent strand of research focused on central banks’ practice of smoothing interest rate movements by showing the optimality of such behaviour. In particular, Woodford (1999) showed that interest rate smoothing is an essential ingredient of optimal monetary policy under commitment, and Woodford (2003b) showed that it is optimal to delegate (under discretion) monetary policy to a central bank with an interest rate smoothing term in the objective function. Moreover, Woodford (2003a) and Bullard and Mitra (2007) showed that monetary inertia can help alleviate problems of indeterminacy (and learning) of stationary rational expectations’ equilibria. And in general, interest rate rules which embed backward interest rate smoothing seem to perform empirically well in a variety of countries and in different data samples (see for instance Clarida, Gali and Gertler, 1998).

However, in the literature, interest rate smoothing is usually simply assumed, without any formal link to interest rate risk management by banks. Given the hedging practices related to interest rate risk followed by banks and other financial institutions, it is by no means obvious why central banks should smooth interest rates. In this paper, we justify such behaviour by assuming that central banks
will try to stabilize “basis” risk, i.e. the residual risk that remains after all imperfect hedging opportunities have been exploited (see Hull, 2000), as a contribution to financial stability (see Di Giorgio and Rotondi, 2007). We show that the desire of central banks to stabilize basis risk leads to interest rate rules characterized by either “backward” or “forward” interest rate smoothing, depending on the definition of the “basis” risk adopted and we estimate a set of interest rate rules for the Fed coherent with such modelling. Our empirical investigation confirms the practice of backward interest rate smoothing; it also provides some support to the importance of the future expected interest rate as an additional argument in the reaction function of the Federal Reserve.

The paper is organized as follows. Section 2 discusses risk management practices used by banks and argues that these lower (although do not eliminate) the necessity for the central banks to smooth interest rates as a contribution to financial stability. Section 3 presents a simple New Keynesian theoretical model that in equilibrium lead to different specifications of central banks interest rate rules embedding either backward or forward interest rate smoothing. In section 4 we evaluate the empirical performance of such interest rate rules for the US economy. Section 5 summarizes and concludes.

2. Risk management, “basis” risk and monetary policy.

Mostly everywhere, safeguarding the stability of the financial system has been considered a key function of the central bank. In different institutional arrangements this responsibility has been assigned only to the central bank or also to the central bank2, via some sharing mechanism with other financial regulatory and supervisory agencies or government bodies. Safeguarding financial stability requires controls over financial exchanges, clearing houses, payment and securities settlement systems that are usually assigned to the central bank. While performing this task, however, central banks should carefully consider its interaction with traditional monetary policy targets. In this perspective, many authors have interpreted the observed practice of smoothing interest rates undertaken by central banks as directed to preserve the stability of financial markets.3

By responding slowly over a period of several months to changes in macroeconomic conditions, the central bank reduces the size of unanticipated changes in short-term interest rates that banks and other participants in financial markets have to face. The main reason why sharp changes in short-term policy rates may damage banks’ profits is that banks tend to borrow short and lend long. Although financial institutions have increasingly used interest-rate related derivatives as part of

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2 See Di Noia and Di Giorgio (1999).
3 See the empirical evidence reviewed in Clarida et al. (1998, 2000).
their strategy for managing exposure to interest rate risk, such contracts may not remove all the risk arising from maturity mismatch. These hedging instruments do not allow banks to insure against fluctuations in the rate of interest they pay on short-term deposits and reserves, which is closely related but not identical to the overnight rate. Banks remain exposed to the risk of fluctuation in the cost of their deposits with respect to the overnight rate, a residual risk which is known as “basis” risk (Hull, 2000). Although in theory the risks to banking and financial stability posed by movements in short-term interest rates should have only a limited influence on monetary policy decisions, in practice the residual basis risk may still induce some caution on the part of the central bank, as banks cannot insure against it. In any case, it is somehow peculiar that considerations about the risk management of interest rate risk by banks – and in particular the concern for basis risk as an important source of interest rate risk exposure - are totally absent in the literature that analyses the nexus between monetary policy and financial stability.

In the following, we analyze how monetary policy may be conducted by central banks that care about financial stability but are also aware of the instruments that banks may use to hedge against the risk of sharper policy decisions. We will focus on interest rate rules that embed a particular type of financial stability objective in the central bank reaction function.

3. Interest rate rules

In this section, we will present a simple version of a pretty standard theoretical model of the business cycle. In order to derive or rationalize (instead of simply assuming) interest rate smoothing, we introduce in the central bank’s rule a reaction to the “basis” risk, which takes into account that banks hedge risks of interest rates changes by actively using futures contracts. As discussed above, this hedging behavior is relevant for financial institutions, but may still justify some limited financial stability concerns from the point of view of monetary authorities. In our framework, “backward” or “forward” interest rate smoothing is showed to be induced by different but plausible modeling of a financial stability concern for the central bank.5

The baseline model.

We follow the literature on New Keynesian microfounded dynamic general equilibrium models and assume:

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4 Also, overdraft facilities or lines of credit are often made at variable interest rates, while fixed term loans are generally made at rates that allow for default risk and account only for a relatively small fraction of banks’ portfolios.

5 In a companion paper, we derive and discuss the implications for equilibrium determinacy of the interest rate rules obtained by augmenting the policy reaction function with “basis” risk stabilization. See Di Giorgio and Rotondi (2007).
- a New Keynesian Phillips curve relating inflation positively to the output gap and to future expected inflation:
\[ \pi_t = ky_t + \beta E_t \pi_{t+1}, \]
with \(0 < \beta < 1\) and \(k > 0\);

- a IS curve relating the output gap positively to its future expected value and negatively to the current real interest rate:
\[ y_t = E_t y_{t+1} - \sigma (r_t - r^n_t - E_t \pi_{t+1}), \]
with \(\sigma > 0\).

The model represents a log-linear approximation of the equilibrium conditions under the assumption of a deterministic steady state. Hence, all variables are expressed in log-deviation from their long run level. The nominal short-term interest rate \(r_t\) is the instantaneous interest rate or continuously compounded interest rate and empirically could be approximated by the overnight interest rate (in the US, the Fed funds rate). Thus, if \(R_t\) is the gross nominal interest rate on a risk-free one-period bond, then \(r_t = \log R_t\), given the assumption of no arbitrage opportunities and complete financial markets.

Following Bullard and Mitra (2002), we assume that the natural rate of interest \(r^n_t\) is an exogenous stochastic term that follows an AR(1) process given by
\[ r^n_t = \omega r^n_{t-1} + \varepsilon_t, \]
where \(0 < \omega < 1\) and \(\varepsilon_t\) is an iid disturbance with variance \(\sigma^2\) and mean zero.

**“Backward” interest rate smoothing**

We close the model by assuming that monetary policy is formulated in terms of a feedback rule for setting the nominal short-term interest rate:
\[ r_t = \phi_2 \pi_t + \phi_3 y_t + \phi_4 [\log P_{t,\text{euro}}^A - \log F_t] - [\log P_{t+1,\text{euro}}^A - \log F_t], \]
where the last term captures the intention of the central bank to stabilize “basis” risk because of the contribution that this policy might give to banking and financial stability. In the equation above, we assume that banks and other financial institutions manage risk by using futures: \(F_t\) is the price of a one-period eurodollar future contract and \(P_{t,\text{euro}}^A\) is the price of the asset underlying such future, i.e. a one-period eurodollar deposit. Again, these variables are expressed in log-deviation from their long
run level. In order to simplify the analysis, without affecting the results, we assume that the central bank smooths the ratio of $P_{t}^{A}$ over $F_{t}$, instead of the spread.$^{6}$

In the interbank market, banks have the possibility of switching between a one-period Eurodollar deposit - i.e. lending to another bank for a one-period horizon - and a strategy of rolling over loans in the overnight market. When banks take a long position in the interbank market they might decide whether to hedge or not their investment. If we consider a hedge put in place at time $t-1$, the hedging risk is the uncertainty associated with the spread realized at time $t$ and is termed as basis risk. When the price of the asset increases by more (less) than the futures price, the basis increases (decreases). This is referred to as a strengthening (weakening) of the basis. Moreover the Libor rate is strongly influenced by the (average) overnight rate expected to prevail over one-period ahead.$^{7}$

According to the policy rule (4), the central bank is concerned about the deviation of the spread between the price ratio of the future and of the underlying asset from its past level. This concern reflects the idea that, for banks being locked in hedging positions, failure to adjust reserves in response to unexpected rate changes would have direct impact on their balance sheet and profitability. It is important to observe that the spread considered above is an ex-post measure related to basis risk in a hedging situation. Hence, equation (4) explicitly assumes a central bank concern with stabilizing basis risk as a contribution to financial stability. By considering a one period future contract, it is possible to show that the central bank by setting the short-term interest rate according to (4) affects the basis risk by smoothing the basis over time. In order to see this we introduce the (quite common) assumption that futures and forward prices are perfect substitute.$^{8}$

This implies that

$$F_{t} = P_{t}^{A} e^{\log R_{t}}.$$  \hspace{2cm} (5)

From (5), it also follows that

$$\log P_{t}^{A} - \log F_{t} = -\log R_{t};$$
$$\log P_{t-1}^{A} - \log F_{t-1} = -\log R_{t-1}. $$  \hspace{2cm} (6)

$^{6}$ Notice that we model the concern of central banks for stabilizing basis risk by adding a response to an asset price in the policy reaction function. Bullard and Schaling (2002) and Driffill et al. (2006) already showed that introducing asset prices in the central bank’s interest rate rule may weaken the requirement for determinacy of the rational expectations equilibrium and potentially lead to macroeconomic instability. In an open economy model, this has been confirmed by Di Giorgio and Nisticò (2007), who show how reacting more intensively to stock price misalignments may ask for central banks’ stronger response to inflation in order to avoid indeterminacy of the rational expectations equilibria.

$^{7}$ Notice that the relationship between the Libor rate and the overnight rate is not exact and the differences that might arise reflect another type of basis risk, that we analyze below (see Section 3.4).

$^{8}$ See for instance Hull (2000) for a discussion on the validity of this assumption.
Substituting (6) back into expression (4) and using the definition of the instantaneous rate we get

\[ r_t = \phi_x \pi_t + \phi_y y_t - \phi_{BR} (r_t - r_{t-1}) \]  

(7)

From (7) we obtain the following policy rule

\[ r_t = \rho r_{t-1} + \Phi_x \pi_t + \Phi_y y_t \]  

(8)

with

\[
\rho = \frac{\phi_{BR}}{1 + \phi_{BR}}; \\
\Phi_x = \frac{\phi_x}{1 + \phi_{BR}}; \\
\Phi_y = \frac{\phi_y}{1 + \phi_{BR}};
\]

(9)

where the coefficient \( \rho \), with \( 0 \leq \rho < 1 \), measures the degree of inertia in the central bank’s response to macroeconomic shocks. Notice that the rule (8) can be also rewritten as

\[ r_t = \rho r_{t-1} + (1 - \rho) (\phi_x \pi_t + \phi_y y_t) \]

where we have a partial adjustment mechanism with a convex combination between the operating target, which specifies the reaction of monetary policy to changes in macroeconomic conditions, and the lagged interest rate. This formalization represents the standard specification used in the empirical literature on inertial interest rate rules. It also makes explicit the existence of a trade off between the objective of financial stability and the one of macroeconomic stabilization. In most empirical specification, and coherently with a fully developed micro based model, expected inflation replaces current inflation in the interest rate rule to estimate.

Summing up, our analytical framework derives the partial adjustment mechanism implied by “backward” interest-rate smoothing from a Taylor-type rule augmented with a reaction to the change of the basis. From (8)-(9) it is possible to see that as \( \phi_{BR} \to +\infty \) the current interest rate tends to the previous period level, and the change of the basis tends to zero.\(^9\) Accordingly, rational

\(^9\) Recall that all variables are expressed as log-deviations from their trend level and constants are omitted for simplicity.
agents expecting this behaviour from the central bank will find the basis risk reduced to zero. Clearly, $\phi_{BR} \to +\infty$ implies monetary policy following a super-inertial interest rate rule, with no reaction to deviations of inflation or output from their trend level.

*An alternative definition of basis risk*

Thus far, we have assumed that the interest rate rule is augmented with a term that captures the intention of the central bank to stabilize one possible source of basis risk, namely the differences that might occur between the price of the underlying asset to be hedged – e.g. the eurodollar deposit - and the price of the future contract used – i.e. a eurodollar future contract. Here we consider a second type of basis risk, which is related to the differences that might arise between the Libor rate and the average overnight rate in a hedging situation.

The one-period eurodollar future rate, $R_{t}^{EF}$, can be expressed as the sum of the expected future level of the underlying interest rate, i.e. the one-period eurodollar Libor rate $R_{t+1}^{E}$, and a risk premium as follows

$$R_{t}^{EF} = E_{t}R_{t+1}^{E} + \theta_{t},$$

where $\theta_{t}$ is the risk premium. As shown in Sack (2004) definition (10) can be modified to express the expectations in terms of the federal funds rate rather than the Libor rate as follows

$$R_{t}^{EF} = E_{t}\bar{r}_{t,t+1} + E_{t}(R_{t+1}^{E} - \bar{r}_{t,t+1}) + \theta_{t},$$

where $\bar{r}_{t,t+1}$ is the average of the daily Fed funds rates from $t$ to $t+1$, when the futures contract is expiring.\(^{10}\) As the relationship between the Libor rate and the overnight rate is not exact, the term $E_{t}(R_{t+1}^{E} - \bar{r}_{t,t+1})$ reflects another type of basis risk. The excess expected return of the Libor rate over the average overnight rate will typically be positive, reflecting that for a bank lending to another bank for a one-period horizon (1 month or 3 months) implies a greater credit risk than lending on an

\(^{10}\) Here for convenience we assume that the average is over the entire horizon of the futures contract. However, more correctly, the average should be referred only over the delivery period of the futures contract (i.e. near the expiration: for example for a three-month eurodollar futures contract we should take the average of the daily Fed funds rates over the delivery month).
overnight basis. Using the Expectations Hypothesis we can rewrite the expression for the basis risk as

$$E_t \left( R^E_{t+1} - R^E_t \right).$$

(12)

Now again we can think of a central bank trying to stabilise this type of basis risk and insert the term (12) in the interest rate rule as follows

$$r_t = \phi_\pi \pi_t + \phi_y y_t + \phi_{BR} E_t (\log R^E_{t+1} - \log R^E_t)$$

(13)

Again, these variables are expressed in log-deviation from their long run level and. We continue to assume that the central bank stabilises the ratio of $R^E_{t+1}$ over $R^E_t$, instead of the spread. It is important to observe that the spread considered above is an ex ante measure related to basis risk in a hedging situation. After substituting with the Fed fund rate and collecting terms we get

$$r_t = \rho E_t r_{t+1} + \Phi_\pi \pi_t + \Phi_y y_t,$$

(14)

with expressions (9) holding also in this case.

In equilibrium, the interest rate rule implies “forward” interest rate smoothing.\(^{11}\) Again, a similar specification could be obtained by replacing current with expected inflation in the original policy function of the central bank.

In this section we have provided a financial stability – or more exactly a basis risk stabilization – motivation for including “backward” or “forward” interest-rate smoothing terms in the central bank’s interest rate rule. Notice that, under some restrictive assumptions, it is also possible to show that an interest rate rule with both “backward” and “forward” smoothing can be optimally derived in the framework used by Woodford (2003b) for examining monetary policy under a discretionary regime when the central bank has a (backward) interest-rate smoothing objective (see Di Giorgio and Rotondi, 2007).

\(^{11}\) Di Giorgio and Rotondi (2007) have showed that in this case, a new trade-off between macroeconomic stability and financial stability can emerge as the conditions for equilibrium determinacy are no longer satisfied for $\phi_{BR} \to +\infty$. 

9
4. Estimation

In this section, we evaluate the empirical performance of different specifications of interest rate rules coherent with the theoretical representation offered above. Our main contribution is to assess the relevance of the expected future rate in the policy rule of the Federal Reserve.

We start by estimating standard interest rate rules with inertia (backward smoothing) for the period from 1987-Q4 to 2005-Q3. In particular, we estimate the following baseline interest rate rules:

\[ r_t = \rho_1 r_{t-1} + (1 - \rho_1 - \rho_2)\bar{y}_t + \rho_2 r_{t-2} + \theta_t, \]

(15)

And

\[ \bar{r}_t = \phi + \phi_x E_t \pi_t + \phi_y E_t y_t, \]

(16)

Or

\[ \bar{r}_t = \phi + \phi_x E_t \pi_{t-1} + \phi_y E_t y_t. \]

(17)

Where \( \bar{r}_t \) is an operational target. The estimation approach used is based on the Generalized Method of Moments (GMM) and is the same as that of Clarida, Gali and Gertler (2000) for the case of the Federal Reserve. The second-order partial adjustment mechanism modeled in the specification is intended to capture the degree of monetary inertia by the Fed.

The data used are the Federal funds interest rate, defined as the average effective Federal funds rate over the quarter, the output gap, defined as percent deviation of actual real GDP from the potential output estimated by the Congressional Budget Office, and inflation, measured as four-quarter change in the GDP deflator. We have used a correction for heteroskedasticity and autocorrelation of unknown form with a Newey-West fixed bandwidth, and chosen Bartlett weights to ensure positive definiteness of the estimated variance-covariance matrix. The instrument set includes the constant and 1-4 lagged values of output gap, inflation and the federal funds rate.

In columns 1 and 2 of Table 1 we report the estimates obtained respectively for the backward-looking specification (15)-(16) and the forward looking specification (15)-(17).

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12 The econometric approach used relies on the assumption that, within our short sample, short term interest rates, inflation and output gap are I(0). However, standard Dickey-Fuller test of the null that the above series are I(1) is not rejected for the US. Nevertheless, as argued for instance by Clarida, Gali and Gertler (1998), standard Dickey-Fuller test has lower power against the alternative of stationarity for short samples. For this reason the assumption of stationary series is standard in the empirical literature of interest rate rules, as this literature is in general based on short samples with a stable monetary regime like in our case.

13 Data on the Fed funds rate, output gap and inflation are taken from FRED, of the Federal Reserve Bank of St. Louis.

14 The optimal weighting matrix is obtained from first-step Two-Stage Least Squares (2SLS) parameter estimates.

15 The J-test reported in the tables is the test for the validity of the instruments used. The associated statistic is distributed as a \( \chi^2 \).
Next, consistently with the analysis developed in section 3, we include the expected future rate in the interest rate rules considered (backward and forward interest rate smoothing). We then estimate:

\[ r_t = \rho_1 r_{t-1} + (1 - \rho_1 - \rho_2) \bar{r}_t + \rho_2 r_{t-2} + \mu E_r r_{t+1} + \theta_t, \]  

(18)

where either (16) or (17) holds. In the present analysis we have considered the expected future interest rate two quarters ahead.\(^{16}\) Rudd and Whelan (2005) show that in tests of the new-Keynesian Phillips curve GMM implies biased estimates when the instruments used belong to the true model of inflation.\(^{17}\) Thus, similarly to the case of the New Keynesian Phillips curve, we need to provide additional instruments not previously included in the interest rate specification.\(^{18}\) We choose as instruments for the expected future interest rate 1-4 lagged values of the rate on a eurodollar future contract that settles three months ahead, taken as the average rate over the quarter.

As it is possible to see from the estimations reported in Table 1, the introduction of the expected future interest rate improves substantially the goodness of fit of the estimated policy rules. The coefficient of the expected future interest rate is statistically significant (at the 1 percent level) and positive, as expected. As it is possible to observe, the introduction of the expected future interest rate reduces the response to inflation and output.

Overall, our empirical evidence supports the presence of the expected future interest rate as an additional argument of the Fed’s interest rate rule.

5. Conclusions and future research

This paper tries to link banks’ risk management practices and interest rate policy decisions by central banks who care about monetary and financial stability. We assume that the central bank is aware that financial institutions may hedge against the risk of sharp interest rate movements by using derivatives. However, part of this risk, namely “basis” risk, cannot be hedged and hence provides a limited motivation for central banks to stabilize it as a contribution to financial stability. We show that the desire to stabilize basis risk leads central banks to smooth interest rates, either

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\(^{16}\) We have considered also other forecasting horizons for the future interest rate, but for simplicity we have reported only the case with the best fitting and diagnostic outcomes. In particular, if we include the expected future interest rate one quarter ahead (not reported in the table) the goodness of fit improves compared to the baseline case without the future interest rate, but the response to inflation and output becomes not significant. While with forecasting horizons greater than two quarters ahead the goodness of fit worsens. Such estimations are available on request.

\(^{17}\) See also the debate on the remedies proposed for solving this problem: Lindé (2005) and Rudd and Whelan (2007).

\(^{18}\) As discussed by Rudd and Whelan (2005) the chosen instruments should also not be correlated with erroneously omitted variables in the interest rate specification.
backward or forward. Our estimates of different interest rate rules suggest that embedding backward and forward interest rate smoothing allows to improve the econometric specification and provides a better explanation of the conduct of the Federal Reserve in our sample.
References


Basle Committee on Banking Supervision, 1997. *Principles for the management of interest rate risk*.


### Table 1 - Estimation of the Federal Reserve’s interest rate rule

<table>
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<tr>
<th></th>
<th>Backward-looking specification</th>
<th>Forward-looking specification</th>
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<td></td>
<td>Standard inertial rule</td>
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<tr>
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<td>(3)</td>
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<td>(4)</td>
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<td>0.26</td>
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*Notes*: GMM estimation for the period 1987Q4 - 2005Q3. Adjusted R squared, regression standard error and the p-value of the J-statistic for overidentifying restrictions are reported at the bottom of the table. Robust T-statistic in italics.