Central bankers and financial supervisors can have conflicting goals. While monetary policymakers work to ensure sufficient lending activities as a foundation for high and stable economic growth, supervisors may limit banks’ lending capacities in order to prevent excessive risk taking. We show that in theory, central bankers can avoid this potential conflict by adopting an interest rate strategy that takes account of capital adequacy requirements. Empirical evidence suggests that while policymakers at the Federal Reserve have adjusted their interest rate to neutralizing the procyclical impact of bank capital requirements, those in Germany and Japan have not. (JEL E52, E58, G21)

I. INTRODUCTION

Central bankers know that financial intermediation is important for achieving macroeconomic stability. Without a functioning banking system, an economy will grind to a halt. It is the job of regulators and supervisors to ensure that the financial system functions smoothly. But monetary policy and prudential supervisory policy can work at cross-purposes. An economic slowdown can cause deterioration in the balance sheets of financial institutions. Seeing the decline in the value of assets, supervisors will insist that banks should follow the regulation and ensure that they have sufficient capital given their risk exposures. The limit on bank lending set by capital adequacy requirements declines during recessions and increases during booms. And as intermediation falls, the level of economic activity goes down with it. It looks as if regulation deepens recessions. As the Basel Committee on Banking Supervision (2001) put, the capital regulation “has the potential to amplify business cycles.”

Blum and Hellwig (1995) provided the first theoretical demonstration that capital requirements can exacerbate business cycle fluctuations. In focusing entirely on the behavior of the banking system, the Blum and Hellwig model provides an important first step, but in the end, their analysis is incomplete. They do not consider the response of the central bank to economic fluctuations. This assumption is critical for their result but certainly unrealistic. What if central banks conduct monetary policy to explicitly account for the impact of capital requirements? Will the procyclical effect of capital requirements remain? Is this the optimal thing to do for central banks? To answer these questions, we derive an optimal monetary policy rule in both a static and
a dynamic model where the potential procyclicality of capital requirements is embedded.

Our conclusions are as follows: a country's monetary policymakers should react to the state of their banking system's balance sheet. And when they do, the procyclical effect of prudential capital regulation can be counteracted and completely neutralized. For a given level of economic activity and inflation, the optimal policy reaction dictates setting interest rates lower, the more financial stress there is in the banking system when the economic activity is in the downturn. We present simulation results to give a sense of the magnitude of the required reaction. But when taking this proposition to the data and estimating forward-looking monetary policy reaction functions for the United States, Germany (preunification), and Japan, we find that while monetary policymakers in the United States behave as the theory suggests, lowering interest rates by more in downturns in which the banking system is under stress, by contrast, central bankers in Germany and Japan do not.

We derive optimal interest rate rules with the static model and the dynamic model in Sections II and III, respectively. Section IV reports the simulation results, and Section V discusses the empirical estimation. Section VI concludes.

II. A STATIC MODEL

The Model

We begin with a static aggregate demand-aggregate supply model modified to include a banking sector. The purpose of this simple model is to highlight the impact of introducing bank capital requirements in their most stripped-down form in order to show the extent to which the banking industry can affect business cycles. The static model also sheds lights on the fruitful approach that solves the dynamic model.

The starting point is an aggregate demand curve that admits the possibility of banks having an impact on the level of economic activity. Following Bernanke and Blinder (1988), we distinguish between policy-controlled interest rate and lending rates and write aggregate demand as:

\[ y^d = y^d(i - \pi^e, \rho - \pi^e, \pi) + \eta, \]

where \( i \) is the short-term nominal interest rate, \( \rho \) is the nominal loan rate, \( \pi^e \) is expected inflation, \( \pi \) is the inflation rate, and \( \eta \) is a white noise random variable. We will refer to \( \eta \) as the aggregate demand shock, since in equilibrium it will tend to move output and inflation in the same direction. As we will see in a moment, while the lending rate (\( \rho \)) is determined by the equilibrium in the lending market, the short-term rate (\( i \)) is set by the monetary authority and so can be treated as a constant. For future reference, we note that we will make the standard assumption that aggregate demand falls when any of the three arguments in Equation (1) rises. That is, both higher inflation and higher real interest rates result in lower level of aggregate demand.

Turning to the loan market, banks receive deposits and make loans. There are two cases. When the capital requirement is not binding, we write real loan supply when the bank has sufficient capital and is not constrained, \( L^s_u \), as

\[ L^s_u = B + (1 - 0)D, \]

where \( B \) is real bank capital, \( D \) is the level of real deposits, and \( 0 \) is reserve requirement.

When the capital requirement is binding, banks’ lending cannot reach the level indicated in Equation (2). Instead, loan supply is constrained to be a multiple of bank capital. That is,

\[ L^s_c = cB, \]

where \( c \) is banks’ statutory maximum leverage ratio and can be thought of as a measure of financial stress. In equilibrium, loan supply will be the minimum of \( L^s_u \) and \( L^s_c \).

Next, we need to model the relationship between bank deposits and bank capital on the one hand and macroeconomic variables like output, interest rates, and inflation on the other. We assume that the level of real bank deposits (\( D \)) depends on both the level of real output and the real short-term interest rate. We write this as:

\[ D = D(y, i - \pi^e), \]

where the function is increasing in the first argument and decreasing in the second argument. As for bank capital, it is assumed to rise and fall with aggregate economic activity.

2. We will refer to this in the paper as “banks are capital constrained” or “the capital constraint binds.”
That is, a rise in real output results in an increase in the value of bank assets. This could be because of an increase in the value of tradable securities or because borrowers are now more able to repay their debts. Using the established notation, this is

\[ B = B(y), \]

where the function is upward sloping.\(^3\)

To complete the story of banks and the loan market, we turn to the demand side. We assume that real loan demand depends on the real loan rate and the level of real economic activity, so

\[ L^d = L^d(\rho - \pi^e, y). \]

The higher the real loan rate (\(\rho\)), the lower loan demand, and the higher aggregate output (\(y\)), the higher the loan demand. We use a standard supply curve in which output depends positively on unanticipated inflation plus an additive white noise error. That is,

\[ y^s = y^s(\pi - \pi^e) + \varepsilon, \]

where a white noise random variable \(\varepsilon\) is mean zero and uncorrelated with the aggregate demand shock \(\eta\). The shock \(\varepsilon\) is a common aggregate supply shock, as it pushes output and inflation in opposite directions.

To determine the impact of capital requirements on aggregate fluctuations, we need to compute the impact of a shock on output both when banks are constrained by the capital requirement and when they are not. This requires solving two versions of a linearized version of the model, which we write as

\[
\begin{align*}
y^d &= -y^d_\rho(\rho - \pi^e) - y^d_\pi(i - \pi^e) - y^d_\eta + \eta, \quad y^d > 0, y^d_\pi > 0, y^d_\rho > 0, \\
D &= D_jy - D_j(i - \pi^e), \quad D_j > 0, D_i > 0, \quad (8a), (8b)
\end{align*}
\]

where \(X_h\) denotes partial derivative of \(X\) with respect to \(h\) evaluated at the equilibrium for the endogenous variables in the absence of shocks, which we normalize to be zero.

To solve this model, we first assume that agents have rational expectations but are unaware of the shocks \(\varepsilon\) and \(\eta\). This means that they expect inflation and output to be zero. That is, \(\pi^e = 0\). Next, using the loan and goods market equilibrium conditions, we solve for output and inflation in terms as functions of the two shocks and the nominal interest rate \(i\). We write the resulting two solutions in compact form as:

\[
\begin{align*}
\pi &= -a^d_\pi i - b^d_\eta \varepsilon + c^d_i \eta, \quad a^d_\pi \geq 0, \\
b^d_\eta \geq 0, c^d_i \geq 0, \quad (9a)
\end{align*}
\]

\[
\begin{align*}
y &= -a^d_j i + b^d_j \varepsilon + c^d_j \eta, \quad a^d_j \geq 0, \\
b^d_j \geq 0, c^d_j \geq 0, \quad (9b)
\end{align*}
\]

where the \(j\) superscript denotes whether the bank is constrained by the capital requirement, \(j = c\), or not, \(j = u\).

Our interest is in whether the reaction of output to a shock changes as the bank goes from being unconstrained to being constrained by the capital requirement. Specifically, we need to figure out whether \(b^c_j > b^u_j\) and whether \(c^c_j > c^u_j\).

Taking derivatives with respect to the shocks, we get two results. First, given a realization of shocks, real output responds to
shocks more when the banking system is constrained by the capital requirement. Computation shows that the following is true:

\[ b_y^c = [\partial y/\partial \epsilon]^c > b_y^u = [\partial y/\partial \epsilon]^u, \]

if and only if \( B_y > (1 - 0)D_y/(c - 1) \).

\[ c_y^c = [\partial y/\partial \eta]^c > c_y^u = [\partial y/\partial \eta]^u, \]

if and only if \( B_y > (1 - 0)D_y/(c - 1) \).

That is, the capital requirement increases the amplitude of business cycles if and only if bank capital is sufficiently responsive to the level of real output. Or put another way, given loan demand, the output sensitivity of the equilibrium loan rate (through loan supply side, so it is negative) is larger in absolute value when the bank is capital constrained than when the bank is not.

Second, when the banking system is constrained, the response of output to a shock is bigger, the higher the ratio of bank lending to bank capital. That is to say, \( b_y^c \) and \( c_y^c \) are both increasing in \( c \), or,

\[ \frac{\partial b_y^c}{\partial c} = [\partial^2 y/\partial \epsilon \partial c]^c > 0, \]

\[ \frac{\partial c_y^c}{\partial c} = [\partial^2 y/\partial \eta \partial c]^c > 0. \]

This is all really by way of introduction, as we have done thus far to establish that Blum and Hellwig’s (1995) result follows through to our setup. In the next step, we add optimal monetary policy to see what happens when interest rates are set with the knowledge that bank behavior is constrained by the capital requirement.

**Optimal Monetary Policy**

We assume that the central bank is engaged in stabilization policy. Monetary policymakers adjust the short-term interest rate (\( i \)) in an effort to reduce the variability of inflation and output. Formally, we take this to mean that the central bank solves a static optimization problem in which it seeks to mini-

\[ \lambda \pi^2 + (1 - \lambda)y^2, \quad 0 < \lambda \leq 1, \]

subject to the structure of the economy specified above.\(^5\) Central banks assign both weights \( \lambda \) on inflation stabilization and \( 1 - \lambda \) on output stabilization, where output and inflation are both expressed as deviations from their no-shock equilibrium levels (which are normalized to zero).

We assume that policymakers are able to set their instrument with full knowledge of the shocks that have hit the economy.\(^6\) This means that they can adjust the current interest rate (\( i \)) knowing the aggregate demand and aggregate supply shocks \( \eta \) and \( \epsilon \). Since they understand what is happening in the banking system, they will respond differently depending on whether the banking system is constrained by the capital requirement or not. That is,

\[ i_c^* = A_1^c \eta + A_2^c \epsilon, \]

\[ i_u^* = A_1^u \eta + A_2^u \epsilon, \]

where again \( c \) refers to the case in which banks are constrained by the capital requirement and \( u \) refers to the case in which they are not.\(^7\) The coefficients are given by

\[ A_j^c = \frac{[1 - \lambda]bc_j^c + \lambda c_j^c]/\left[ (1 - \lambda)bc_j^u + \lambda a_j^u \right], \quad j = c \text{ or } u, \]

\[ 5. \quad \text{The objective functions of central banks do not traditionally include terms representing financial stability. This suggests that the central banks care about the stability of banking system only insofar as it influences outcomes of inflation and output. This policy framework is called the inflation-targeting regime.} \]

\[ 6. \quad \text{Another way to say this is that all agents get information about the shocks but with noises. Central banks can extract signals (the true shocks) perfectly from these information, while private agents cannot.} \]

\[ 7. \quad \text{Some of the results in Kopecky and VanHoose (2004a, b) are related to our analysis here. For instance, they examined how the capital standard changes basic loan market outcomes relative to the outcomes in the absence of such requirements. Unfortunately, we cannot use their framework for our purpose. While they focused on the impact of adjustment costs and capital requirements on loan market outcomes, our paper emphasizes that the monetary authority can assert control over the procyclical effect of the capital requirements.} \]
While the sign of $A_2^j$ is always positive, the sign of $A_4^j$ can be either positive or negative, depending on the “slope” of the first-order condition of Equation (12) (i.e., the ratio of inflation and output, $-(1 - \lambda)\beta/\lambda$) and the slope of the aggregate demand of Equation (8a) (while the loan rate is replaced with the solution from Equation (8h) and the interest rate is kept constant, i.e., $-b_k'/b_l'$).

As is the standard case, monetary policy is capable of neutralizing aggregate demand shocks, but supply shocks create a trade-off between output and inflation variability. The important thing here is that the interest rate rule depends on whether the banking system is constrained by the capital requirement or not. And, as we would expect, when the banking system is constrained, the interest rate reaction is larger. For an aggregate demand shock, the result is unambiguous:

$$\partial i_c^c/\partial \eta \geq \partial i_u^u/\partial \eta.$$

In response to a supply shock, whether the interest rate response is larger depends on whether bank capital amplifies the impact of the shock on output. That is,

$$\partial i_c^c/\partial e \geq \partial i_u^u/\partial e$$

if $B_y > (1 - \theta)D_y/(c - 1)$.

Next, we show that when the banking system is constrained, an increase in the ratio of bank lending and bank capital implies a larger response of the interest rate to an aggregate supply shock. Using the established notation, we write this as:

$$\partial^2 i_c^c/\partial e \partial e \geq 0.$$

Finally, we substitute the optimal monetary policy rule into the solution for output and inflation. That is, we substitute Equations (13a) and (13b) into Equations (9a) and (9b). After simplification, we write the result as:

$$\partial^2 y_t/\partial e \partial e \geq 0.$$

III. A DYNAMIC MODEL

The results in the static context are important, as they establish the fragility of the earlier Blum and Hellwig result. That is, by simply adding an optimal monetary policy to their framework, we are able to show that capital constraints need not exacerbate business cycle fluctuations. The next natural question is to see if these conclusions carry over to a dynamic framework, one in which output and inflation deviations are persistent, and policymakers cannot affect the economy immediately. To do this, we add a banking system to the model originally examined by Svensson (1997, 1999). The result is a dynamic form of the model written in Equation (8) of the previous section:

$$y_{t+1} = \alpha_y y_t - \alpha_t (i_t - \pi_{t+1}) - \alpha_p (\rho_t - \pi_{t+1}) + \eta_{t+1}$$

$1 > \alpha_y > 0, \alpha_p > 0, \gamma_t > 0,$
\[ (21b) \quad D_t = D_y y_t - D_y (i_t - \pi_{t+1}|t), \]
\[ D_y > 0, D_I > 0, \]
\[ (21c) \quad B_t = B_y y_t, \quad B_y > 0, \]
\[ (21d) \quad L_t^s = \min[L_{t,u}^s, L_{t,c}^s], \]
where \( L_{t,u}^s = B_t + (1 - \theta)D_t \)
and \( L_{t,c}^s = cB_t, \)
\[ (21e) \quad L_t^d = -L_p (\rho_t - \pi_{t+1}|t) \]
\[ + L_y y_t, \quad L_p > 0, L_y > 0, \]
\[ (21f) \quad \pi_{t+1} = \pi_t + \beta_y y_t + \epsilon_{t+1}, \quad \beta_y > 0, \]
\[ (21g) \quad L_t^s = L_t^d, \]
where all variables are defined as before, except that now we write expected inflation
as \( \pi_{t+1}|t, \) that is, the expectation based on information available at time \( t. \)
Note two additional important adjustments to the model (we have omitted the equilibrium condition
for the goods market). First, the output gap in the aggregate demand equation \((21a), \)
depends on the lagged output gap, the real loan rate, and the policy-controlled interest
rate. And second, we write the aggregate supply equation \((21f)\) with inflation on the left
hand side, and it is a function of previous inflation. As before, the loan rate \( (\rho_t) \) is determined
in the loan market depending on whether the banking system is constrained, and the central
bank controls the short-term interest rate \( (i_t). \)
Demand shocks and supply shocks are assumed to be uncorrelated with each other
and across time. Finally, when \( \sigma_p \) equates zero and so lending is unimportant, the system
collapses into the Svensson model.

To solve the model, we compute the equilibrium loan rate using Equations \((21b)-(21e),\)
holding the policy-controlled interest rate fixed. As before, there are two solutions
that depend on whether the capital constraint binds. Substituting these results into the aggregate
demand equation \((21a)\) and using the aggregate supply equation \((21f)\) to compute inflation expectations, we obtain the following solution for the dynamics of the output gap:
\[ (22) \quad y_{t+1} = -\phi'_y (i_t - \pi_t) + \phi'_y y_t \]
\[ + \eta_{t+1}, \quad \phi'_y > 0, \quad \phi'_y > 0, \]
where, as before, the superscript \( j \) equals either \( c \) when the capital constraint binds or \( u \) when it does not. The coefficients \( \phi'_y \) and \( \phi'_y \) are complex functions of the model parameters as defined in the Appendix. When the short-term interest rate is constant, this economy can display the same behavior as the static model. As in Blum and Hellwig (1995), the impact of shocks upon output can be amplified by a capital-constrained banking system if bank capital is sufficiently responsive to the level of real output.\(^9\)

The next step is to introduce a central bank engaged in a stabilization policy. Following
the derivation in the static model, we introduce a policymaker’s objective function and
then derive an optimal monetary policy rule. In the dynamic context, this means that the
central bank chooses a path for the interest rate \( \{i_t\}_t^{\infty} = 0 \) in order to minimize a forward-looking version of the objective function (Equation \(12). \) That is,
\[ (23) \quad \min_{\{i_t\}_t^{\infty}} E_t \sum_{k=0}^{\infty} \delta^k [\lambda \pi_{t+k}^2 + (1 - \lambda) y_{t+k}^2], \]
\[ 0 < \lambda < 1 < \delta < 1, \]

subject to the structure of the economy specified from Equation \((21a)\) to Equation \((21g);\)
where \( \delta \) is a discount factor and, following our previous convention, output and inflation are written as deviations from their no-shock equilibrium values. Since the inflation and the output gap at \( t \) are both known when policymakers choose \( i_t, \) the objective function in Equation \((23)\) includes squared losses starting from time \( t + 1.\)

To facilitate analytical derivations, we assume \( D_I = 0 \) so that the capital constraint
binds (does not bind) if and only if the output gap is negative (positive). This assumption is
not costly in terms of alleviating the impact of the capital constraint.

Solving the resulting stochastic dynamic optimization problem, we can derive optimal

\(^9\) Details of the derivation are available in the appendix to Cecchetti and Li (2005).
interest rate rule as a linear function of inflation and the output gap:

\[ i_{t, t}^* = A_t \pi_t + A_y y_t, \]  
\[ i_{u, t}^* = A_t \pi_t + A_u y_t, \]

where the As are complex functions of the parameters of the model as defined in the Appendix. We note that the stability condition that \( A_r \geq 1 \) always holds whenever the structural parameters of the model meet the conditions we have imposed.

Using these, we can derive the impact multipliers for the dynamic model. The conclusions are analogous to those in the static model. Following a shock, the interest rate reaction depends on whether the banking system is constrained. If it is, monetary policy becomes more aggressive. That is, central banks lower interest rates by more in downturns in which the banking system is capital constrained:

\[ \partial i_{t, t}^*/\partial y_t > \partial i_{u, t}^*/\partial y_t \]  
if \( B_y > (1 - \theta)D_y/(c - 1) \).

Furthermore, the higher the ratio of bank lending to bank capital, the bigger the interest rate response:

\[ \partial^2 i_{t, t}^*/\partial y_t \partial c > 0. \]

Finally, by substituting the optimal interest rate into Equation (22) and using Equation (21f), we can write the output gap as a function of previous shocks,

\[ y_t = \eta_t - [1 - \varphi(\beta_y, \delta, \lambda)](\beta_y \eta_{t-1} + \varepsilon_{t-1})/\delta \]
\[ + \beta_y(1 - \varphi(\beta_y, \delta, \lambda) L), \]

where \( L \) is a lag operator and \( \varphi(\beta_y, \delta, \lambda) = (1 - \lambda)/(1 - \lambda + \beta_y^2 \delta) < 1 \). The current output gap is the sum of all previous shocks weighted by a constant factor less than unity. The output process becomes stable and mean reverting. More importantly, when monetary policymakers behave optimally, the output gap depends on shocks in a manner that is independent of the capital requirements.

IV. SIMULATION

The theoretical exercise yields an important analytical result: optimal monetary policy will move interest rates by more when the banking system is capital constrained, making the output gap invariant to the level at which the capital requirement is set. To help understand if this analytical result is quantitatively important, we now turn to a simple simulation exercise. Specifically, we compare two policy regimes. The first, labeled Regime I, assumes that the policymaker behaves optimally following the rule \( i_{t, t}^* \) in Equation (24a) when banks are capital constrained at period \( t \) and policy rule \( i_{u, t}^* \) in Equation (24b) when banks are not. We compare this to a policy regime, labeled Regime II, in which the policymaker ignores the fact that the banking system occasionally becomes constrained. This naive policymaker simply uses the rule \( i_{u, t}^* \) all the time.

**Parameter Values**

In order to simulate the model, we need to make a number of decisions, which are summarized in Table 1. First, we interpret the model as applying roughly to economic activity at an annual frequency. With this in mind, we choose our parameter values (except those parameter values related to the loan market) based on Jensen (2002). That is, the output persistence \( \sigma_y \) is 0.5, the real interest rate sensitivity of demand \( \alpha_y \) is 0.75, the sensitivity of inflation to the output gap \( \beta_y \) is 0.1, and the weight on inflation stabilization \( \lambda \) is 0.8. We set the discount factor \( \delta \) to be 0.96 rather than 0.99 in Jensen (2002).\(^1^0\)

The difference between our benchmark (Policy Regime I) and alternative Policy Regime II mainly is a result of the fact that bank capital and deposits are both output sensitive. That is, the difference between the behaviors of output, inflation, and the optimal interest rate in the two cases depends largely on \( B_y \) and \( D_y \).\(^1^1\) In an attempt to get the rough

---

10. Jensen wants to use a value close to unity so that the deviation from natural rate hypothesis is negligible, while in our model this concern does not exist. For this reason, we use a more conventional value.

11. We have tried to find empirical evidence for \( B_y \) and \( D_y \). The outcome is disappointing. We run a few simulations for different values of \( B_y \) and \( D_y \) (results are not shown). As the ratio of \( B_y \) and \( D_y \) falls, the difference between the optimal policy (Regime I) and the suboptimal policy (Policy Regime II) becomes smaller.
scaling correct, we set $B_t$ and $D_t$ to be 0.15 and 0.2, respectively. The rest of the parameters are set primarily for illustration.

They are as follows: the leverage ratio $(c)$ is set to 10,\(^1\(^2\) the reserve requirement ratio for bank deposits $(\theta)$ is set equal to 0.1, the output sensitivity of loan demand $(L_y)$ is set to zero (for simplification), the real loan rate sensitivity of aggregate demand $(\sigma_q)$ equals 0.75 (the conventional value for $\sigma_q$),\(^1\(^3\) the real loan rate sensitivity of loan demand $(L_y)$ is normalized to be unity, and the real policy-controlled rate sensitivity of bank deposit $(D_t)$ is set to zero. Finally, the standard deviations of two random shocks $(\sigma_{\eta}$ and $\sigma_{e})$ are each normalized to 1. We note that we are careful to set the parameters so that the condition needed for the Blum and Hellwig result holds.

### Simulation Results

We start with a baseline experiment in which the central bank does not react to shocks at all, instead keeping the policy-controlled rate constant. To give some sense of what these parameter settings mean, we compute that a one–standard deviation, purely transitory negative shock to either aggregate demand or aggregate supply drives output down by five times as much after four periods in the economy that is capital unconstrained.

#### Transitory Supply Shocks

Turning to the experiment, we first examine the impact of a one–standard deviation purely transitory aggregate supply shock. That is, we set $\varepsilon_t = 1$ for $t = 1$, and 0 otherwise. Furthermore, we set the initial conditions so that the economy is capital constrained at the outset. Under Regime II, the central bank sets interest rates ignoring the capital constraint, using Equation (24b). Under Regime I, the central bank takes account of the capital constraint and uses the interest rate rule given by Equation (24a), switching to Equation (24b) whenever the capital constraint no longer binds. The resulting paths for output, inflation, and the interest rate are shown in Figure 1. As we would expect, the output and inflation fluctuations are much larger under Regime II when the policymakers ignore the banking system. But under Regime I, since interest rates are moved aggressively in response to the negative output gap at the outset, they are less variable over the entire horizon of the simulation. The

### Table 1

<table>
<thead>
<tr>
<th>Equation</th>
<th>Left Hand–Side Variable</th>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>21a</td>
<td>Aggregate demand $(y_{t+1})$</td>
<td>Output persistence $(\sigma_y)$</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elasticity with respect to real policy-controlled rate $(\sigma_r)$</td>
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<tr>
<td></td>
<td></td>
<td>Elasticity with respect to real loan rate $(\sigma_L)$</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Standard deviation of demand shock $(\sigma_d)$</td>
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</tr>
<tr>
<td>21b</td>
<td>Real bank deposit $(D_t)$</td>
<td>Elasticity with respect to output gap $(\delta_D)$</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elasticity with respect to real policy-controlled rate $(\delta_r)$</td>
<td>0.00</td>
</tr>
<tr>
<td>21c</td>
<td>Bank capital $(B_t)$</td>
<td>Elasticity with respect to output gap $(\delta_B)$</td>
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</tr>
<tr>
<td>21d</td>
<td>Unconstrained loan supply $(L^u)$</td>
<td>Reserve deposit ratio $(\theta)$</td>
<td>0.10</td>
</tr>
<tr>
<td>21e</td>
<td>Constrained loan supply $(L^c)$</td>
<td>Leverage ratio $(c)$</td>
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<tr>
<td>21f</td>
<td>Loan demand $(L^d)$</td>
<td>Elasticity with respect to real loan rate $(\delta_L)$</td>
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<tr>
<td></td>
<td></td>
<td>Elasticity with respect to output gap $(\delta_d)$</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Aggregate supply $(\pi_{t+1})$</td>
<td>Elasticity with respect to output gap $(\delta_d)$</td>
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<tr>
<td></td>
<td></td>
<td>Standard deviation of supply shock $(\sigma_s)$</td>
<td>1.00</td>
</tr>
</tbody>
</table>
standard deviations of interest rates under Regimes I and II are 0.36 and 0.82 over 100 periods, respectively.

More specifically, to offset a transitory positive supply shock, the policy-controlled interest rate has to rise in the initial period. Over the following period, the fully optimal policy (Regime I) moves the interest rate low (aggressive) enough to counteract the procyclical effect of the binding capital constraint so that the inflation gap and the output gap are set on the optimal path.

The suboptimal policy (Regime II) is conducted with the same objective as the Policy Regime I but fails to account for the procyclical effect of the capital constraint. As a result, the Regime II policy sets the interest rate too high in Period 2 and does not dampen the recession. In Figure 1, from Period 1 to Period 9, the banking system is constrained by capital and policymakers keep conducting the suboptimal policy (Regime II). However, starting from Period 10, bank capital constraints are not binding under Policy Regime II, while the constraint always binds under Policy Regime I. From Period 10, the inflation gap and the output gap are set on the optimal path. The suboptimal policy (Regime II) generates significantly larger loss over the entire horizon. Computing the loss over a horizon of 100 periods—that is, we truncate the infinite-horizon objective function in Equation (23)—we find that the optimal policy entails
a loss that is less than half the size (the simu-
lated losses in Regime I and Regime II are 4.7
and 11.4, respectively).

Transitory Demand Shocks. We examine the
impact of a one–standard deviation transitory
aggregate demand shock with the same
parameter configuration and present the paths
of the output gap, inflation, and the interest
rate under different policy regimes in Figure 2.
That is, we set \( \eta_t = -1 \) for \( t = 1 \), and 0 other-
wise. Again, the banking system is capital con-
strained at the outset.

Not surprisingly, different policy regimes
result in differing output and inflation gaps
as the economy evolves. The optimal policy
lowers the interest rate by enough to return
output and inflation to their optimal paths
almost immediately, something that the sub-
optimal policy fails to do until Period 5. Com-
puting the loss over 100 periods, we find that
the simulated losses in Regime I and Regime II

**FIGURE 2**
Output Gap, Inflation Gap, and Interest Rate with Different Monetary Policies:
After a Transitory Demand Shock

---

Notes: Central banks account for the impact of capital requirements in Policy Regime I but do the opposite in Policy Regime II. This figure plots output gaps, inflation, and interest rates for both policy regimes following a transitory supply shock given the configuration of parameter values in Table 1.
are 0.24 and 0.52, respectively. The difference between two policy regimes is significant.

As for the volatility of interest rates, the optimal interest rate is slightly variable than the suboptimal interest rate, with standard deviations being 0.25 and 0.21 over 100 periods, respectively. But the relatively high volatility of the interest rate under Regime I comes entirely from the strong initial reaction to the combined shock and bank capital constraint. After Period 1, the interest rate is less variable under Regime I.

V. WHAT WERE CENTRAL BANKS DOING?

The simulation gives us some sense of how monetary policymakers should account for capital constraints. The next natural question is whether central banks in fact follow a strategy like the one our model suggests. In other words, do banks’ balance sheets and capital requirements play a material role in central banks’ decisions? In this section, we examine data to see what central banks were actually doing. To characterize the actions of central banks, we adopt the now-standard framework of estimating policy reaction functions, or the Taylor rule, for the central banks of three major countries in the world: United States, Germany (preunification), and Japan.

In his original work, Taylor (1993) characterized his now-famous policy rule as a description of the Federal Reserve behavior from the mid-1980s through the early 1990s. That is, he suggested that what the Federal Open Market Committee (FOMC) actually did was to set the nominal federal funds rates so that

$$i_t = r^* + \pi_t + 0.5(\pi_t - \pi^*) + 0.5y_t,$$

where $i_t$ is the nominal federal funds rate at period $t$, $r^*$ is the natural real interest rate (Taylor set this to 2%), $\pi_t$ is current inflation, $\pi^*$ is the inflation target (Taylor set this to 2%), and $y_t$ is the percentage deviation of actual output from a measure of potential or trend output. Clarida, Gali, and Gertler (1998, 2000) have proposed estimating a more realistic forward-looking version of this interest rate rule. That is, they derive a reaction function of the form:

$$i^*_t = r^* + \pi^* + \gamma_{\pi}(E_{t}\pi_{t+k} - \pi^*)$$
$$+ \gamma_{y}E_{t}y_{t,q},$$

where $i^*_t$ is the target rate for the nominal short-term interest rate in period $t$, $\pi_t$, $k$ is the inflation from Period $t$ to Period $t + k$, $y_{t,q}$ is the output gap of period $t + q$, and $E_{t}(\cdot)$ is the expectation conditional on information at $t$. As a sufficient (but not necessary) condition for the model to be well behaved, the coefficient on inflation has to be larger than 1 (recall Taylor’s original rule of thumb was to set $\gamma_{\pi}$ equal to 1.5).

To see whether the central bank’s response to the output gap depends on the state of the banking system (as suggested by the theoretical models), we augment Equation (29) with a measure of the stress in the banking system. We denote the bank stress in downturns and upturns with $s^d_{t-1}$ and $s^u_{t-1}$, respectively. Our augmented version of Equation (29) is

$$i^*_t = r^* + \pi^* + \gamma_{\pi}(E_{t}\pi_{t+k} - \pi^*)$$
$$+ \gamma_{y}E_{t}y_{t,q} + \gamma_{d} s^d_{t-1} + \gamma_{u} s^u_{t-1}.$$

We let $s^d_{t-1}$ be the lagged deviation of the leverage ratio from its Hodrick-Prescott (HP) trend when the output gap is negative, otherwise zero, and $s^u_{t-1}$ be the lagged deviation of the leverage ratio from its HP trend when the output gap is positive, otherwise zero.14 To address the possible endogeneity of the leverage ratio—and its response to the interest rate—we estimate the relationship with a one-quarter lag.

Based on Equations (24a) and (24b), all other things equal, the policy-controlled interest rate should be lower when the leverage ratio is above the trend in a downturn and higher when the leverage ratio is above the trend in an upturn. So, if policymakers react to the stress in the banking system optimally, we expect the coefficient on $s^d_{t-1}$, $\gamma_{d}$, to be negative and the coefficient on $s^u_{t-1}$, $\gamma_{u}$, to be positive.

To complete the empirical model, we assume that policymakers respond smoothly to output and inflation gaps, so the observed

14. Ideally, we would like to include a measure that tracks only the banks that are under stress—what might be thought of as the marginal stress in the banking system. Our average leverage ratio is a proxy for this marginal measure since high average measure implies that there have been a relatively large number of banks with relatively high leverage ratios.
interest rate adjusts according to the partial adjustment equation:

\[ i_t = \Psi(L)i_{t-1} + [1 - \Psi(1)]i^*_t + \nu_t, \]

where \( \Psi(L) \) is a polynomial in the lag operator \( L \) and \( \nu_t \) is an i.i.d. random variable that we can think of as a monetary policy control error resulting from things like unanticipated shifts in the demand for bank reserves. Substituting Equation (30) into Equation (31) gives the final form for estimation.

We substitute Equation (30) into Equation (31) and estimate the result using the generalized method of moments on quarterly data with 2 lags in the interest rate adjustment equation—\( \Psi(L) \) is a second-order polynomial, assuming that expectation horizon for inflation is 4 quarters. In Table 2, we reported the results for two expectation horizons of output gap (0 and 4 quarters). The instrument set for the estimation includes a constant, 3 lags of short-term interest rates, inflation, output gaps, producer price inflation, M2 growth (M3 for Germany), the term spreads between the long-term bond rate and short-term interest rate, and leverage ratios.

For the United States, our sample runs from 1989 to 2000, coinciding roughly with the Greenspan Fed but avoiding the change in banking regulation during the 1980s and ending prior to the sharp stock market decline in 2000. For Germany, we start in 1979 and end in 1989 to avoid the impact of the unification. And for Japan, we examine the data beginning in 1979 and, to avoid the period of deflation and zero nominal interest rates, ending in 1994.

Turning to the data, for each country, we measure the policy interest rate as the overnight rate that is controlled by the central bank, inflation using the consumer price index, and the output gap as the deviation of gross domestic product (GDP) from its potential. The leverage ratio is computed as total loans of the banking system divided by the sum of bank equity and subordinated debts for the United States, and total assets divided by bank capital plus reserves for Germany and Japan. Details of the sources and construction are described in the Appendix.

Estimation also requires that we make assumptions about both the target inflation (\( \pi^* \)) and the target natural real interest rate (\( r^* \)). For the United States, we assume these both to be 2%. For Germany, the inflation target is set at 2%, and the natural real interest rate is embedded in the constant in the estimation. And for Japan, the inflation target is set as an HP filtered trend, and the natural real interest rate is estimated.

Before examining the estimation results, it is useful to take a brief look at the data on the leverage ratio. The three panels of Figure 3 display data for each of the countries we study over the sample period we examine. We note that a general downward trend in both the German and the Japanese data is likely related to changes in regulatory standards. For the United States, leverage rose dramatically beginning in 1999.

Estimates

Estimates of the various policymakers’ reaction functions are summarized in the three panels of Table 2. For each country, we report estimates both with and without the leverage ratios (lagged and multiplied by the dummy variable that is 1 when output is above or below potential) and for two settings of the assumed expectation horizons for the output gap (\( q = 0 \) and 4). The \( p \) values of the tests of overidentifying restrictions for all specifications validate the moment conditions we use. And the \( R^2 \)'s suggest that the models fit relatively well.

We summarize the overall result as follows. For the United States, the estimated coefficients on the inflation gap are larger than unity, implying stability, and close to the original Taylor benchmark of 1.5. The coefficients on the output gap are close or larger than the benchmark value of 0.5. Looking at the results for where the policymaker is assumed to react to both current and future output gap (\( q = 0 \) and 4), we first see that, while the signs of \( \gamma_d \) are negative in both cases, the data do not support adding \( \gamma_d \) to the policy rule. That is, the FOMC did not react strongly to the

15. Our estimation method relies on the assumption that all the variables are stationary. We use the augmented Dickey-Fuller test to reject the null hypothesis that there is a unit root in the interest rate or inflation for the United States, Germany, and Japan.
TABLE 2
The Reaction Functions of the United States, Germany, and Japan

<table>
<thead>
<tr>
<th>Countries</th>
<th>Horizon Output Gap (q)</th>
<th>Constant</th>
<th>Inflation Gap (γ_p)</th>
<th>Output Gap (γ_y)</th>
<th>Bank Stress</th>
<th>Adjusted Coefficient (W)</th>
<th>J test</th>
<th>Adjusted R^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>1989q2–2000q4</td>
<td>0</td>
<td>1.28 (0.21)</td>
<td>0.61*** (0.09)</td>
<td>-0.20 (0.33)</td>
<td>1.10*** (0.29)</td>
<td>0.92*** (0.01)</td>
<td>0.87</td>
</tr>
<tr>
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<td></td>
<td>4</td>
<td>1.85*** (0.23)</td>
<td>0.51*** (0.15)</td>
<td>-0.16 (0.48)</td>
<td>1.31*** (0.39)</td>
<td>0.92*** (0.02)</td>
<td>0.88</td>
</tr>
<tr>
<td>Germany 1979q1–1989q4</td>
<td>0</td>
<td>3.62*** (0.25)</td>
<td>1.05 (0.13)</td>
<td>-0.02 (0.29)</td>
<td>6.26 (1.41)</td>
<td>-0.67*** (0.12)</td>
<td>0.74*** (0.04)</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>3.02*** (0.55)</td>
<td>0.93 (0.14)</td>
<td>0.47 (0.49)</td>
<td>1.18* (0.10)</td>
<td>0.87*** (0.03)</td>
<td>0.94</td>
</tr>
<tr>
<td>Japan 1979q1–1994q4</td>
<td>0</td>
<td>3.08*** (0.19)</td>
<td>0.30*** (0.17)</td>
<td>-1.07*** (0.28)</td>
<td>6.65*** (1.62)</td>
<td>-0.66*** (0.12)</td>
<td>0.73*** (0.04)</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>3.16*** (0.22)</td>
<td>0.16*** (0.27)</td>
<td>0.34 (0.19)</td>
<td>0.34 (0.19)</td>
<td>0.75*** (0.05)</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.00*** (0.32)</td>
<td>1.00 (0.39)</td>
<td>-0.11 (0.51)</td>
<td>1.36*** (0.29)</td>
<td>-0.78*** (0.27)</td>
<td>0.77*** (0.02)</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Notes: Estimates are by the generalized method of moments, using the correction for heteroskedasticity and autocorrelation of unknown form with a lag truncation parameter of 4. The instrument set includes a constant, plus lags 1–3 of short-term interest rates, output gaps, inflation rates (CPI), changing rates of PPI and term spreads, growth rates of M2 (M3 for Germany), and leverage ratios. Robust standard errors are reported in parentheses. The sum of two adjustment coefficients (2 lags of adjustment equation for interest rate) is presented, while the reported standard error is for the sum of two adjustment coefficients. The null hypothesis for the coefficient before inflation is γ_p = 1. The numbers of observation for the United States, Germany, and Japan are 39, 37, and 57, respectively.

***, **, and * indicate that the estimations are significant at 1%, 5%, and 10% levels, respectively.
state of banking system during economic downturns. Although the standard error for $\gamma_d$ is large, it is still helpful to get some ideas of the economic magnitude of the response. In this case, a one-standard deviation increase in the leverage ratio equals 1.82 and that this is estimated to result in a 0.36% cut in the federal funds rate, all other things equal.

Next, we see that the signs of $\gamma_u$ are positive and significant in both cases; the data do support adding $\delta_{t-1}$ to the reaction rule. That is, the FOMC did raise federal funds rate when the leverage ratio is high than trend during an upturn, all other things equal.\textsuperscript{16} The point estimate of the coefficient is large, implying that a one-standard deviation rise in the leverage ratio causes a 2.8% rise in the federal funds rate, all other things equal.

Turning to the German case, we start by noting that the coefficients before inflation and output gap are close to the original Taylor

\textsuperscript{16} The high leverage ratio during an upturn could be the result of credit expansion due to loan demand rather than bank capital deterioration, so we must interpret this result carefully.
values. Turning to the banking system stress variable, to the extent that the Bundesbank did react, it did so in a way that appears to have made matters worse. The estimate of \( \gamma_d \) is significantly positive, and the sign of \( \gamma_u \) is both negative and significant. These coefficients imply that a one–standard deviation increase in leverage ratio will raise call money rate by 5% in a downturn and lower it by 0.9% in an upturn.

Our estimates for the Bank of Japan are reported in the bottom panel of Table 2. For the case in which targets are the current level inflation and the contemporaneous output gap (\( q = 0 \)), the coefficient on inflation is less than 1. Regardless of other settings, we find that the data support adding \( s_{t-1}^d \) to the policy rule. But, as in the German case, the resulting coefficient estimates are of the wrong sign. To get some ideas of the economic magnitude of the response, we can compute that a one–standard deviation \( \text{rise} \) in the leverage ratio during a downturn equals 1.12 and that this causes a 1.52% \( \text{rise} \) in the call money rate, all other things equal. As for the coefficient before \( s_{t-1}^u \), they are negative. A one–standard deviation \( \text{rise} \) in the leverage ratio during an upturn is 1.8, and this causes a 1.4% \( \text{fall} \) in the call money rate.

Taken together, these estimates of these policy reaction functions suggest that FOMC’s policy is most consistent with the model prediction, that is, America’s central bankers lower (raise) interest rate in response to the stress in the banking system when the economy is in a downturn (an upturn). By contrast, our results suggest that the policymakers in Germany and Japan raised their overnight interest rates, relative to the baseline, during period when output was below trend and their banks were under stress—the opposite of what our model suggests is optimal.\(^{17}\)

VI. CONCLUSIONS

Changes in bank lending are an important determinant of economic fluctuations. Central banks, in working to meet their stabilization goals, strive to ensure a sufficient supply of loans. In their effort to maintain a stable financial system, regulators can work against this objective. Capital requirements are a clear example. By dictating that all banks must maintain sufficient capital with respect to their risk exposures, capital requirements can limit the lending capacity of the banking system. Although the need for avoiding working at cross-purposes is recognized, it is not clear whether central banks have formulated an optimal strategy, namely, taken into account the impact of the capital requirements.

This paper does three things. First, we confirm the results first derived by Blum and Hellwig (1995) that in the presence of completely passive monetary policy, capital requirements are procyclical. That is, when banks become capital constrained shocks to the economy generate larger movements in output. Second, we establish that optimal monetary policy can neutralize the procyclical impact of capital requirements. That is, the capital adequacy regulation need not encumber monetary policymakers in their pursuit of their goal. Finally, we present evidence suggesting that while the Federal Reserve has been reacting as our model suggests, German and Japanese central banks clearly have not. Blum and Hellwig need not be right in theory, but they may very well be right in practice.

APPENDIX

Solution for the Dynamic Model

This appendix explains how to solve the dynamic model. The solution has four steps: (1) write down Bellman functional equations; (2) conjecture the optimal interest rate policy; (3) find the value function associated with the conjectured policy; and (4) verify that the value function in Step (3) satisfies the Bellman equations in Step (1).

First of all, substituting the equilibrium loan rate back into Equation (21a), we see

\[
A1 \quad y_{t+1} = -\phi^i(j_t - \pi_t) + \phi^l y_t + \eta_{t+1}.
\]

where \( \phi^i \) and \( \phi^l \) are functions of model parameters and have accounted for the impact of bank activities and so differ depending on whether \( j = c \) or \( j = u \). That is,

\[
A2a \quad \phi^u = \alpha_u = \phi^c,
\]

\[
A2b \quad \phi^u = \alpha_u + \alpha_i \beta_u - \alpha_p L_0/L_0 + \alpha_p B_t/L_0 + \alpha_p (1 - 0) D_t/L_0,
\]
\( (A2c) \quad \phi_i^* = \alpha_y + \alpha_i \beta_y - \frac{\alpha_p M_t}{L_p} + \alpha_i c B_y / L_p. \)

**Bellman Equations.** The value function \( (v) \) for the dynamic problem should satisfy the following functional equations:

\[
(A3a) \quad v(\pi, y) = \min \left\{ \frac{1}{2} \left[ E \left[ \pi (\pi + \beta_y y + e) \right] \right] \\
+ (1 - \lambda) \left( \phi_i^* y - \alpha_i (i - \pi) + \eta \right) \right\} \text{ if } y \geq 0;
\]

\[
(A3b) \quad v(\pi, y) = \min \left\{ \frac{1}{2} \left[ E \left[ \pi (\pi + \beta_y y + e) \right] \right] \\
+ (1 - \lambda) \left( \phi_i^* y - \alpha_i (i - \pi) + \eta \right) \right\} \text{ if } y < 0.
\]

The time subscripts are omitted since the time horizon is infinite. The condition \( y \geq 0 \) \((y < 0)\) indicates that the capital constraint is not binding (binding) at the period of decision making. The superscript \( u \) \((or \ c)\) of \( \phi_i^* \) \((or \phi_c^*\)\) (defined in Equation \( A1 \)) denotes that the coefficient is associated with the slack (or binding) constraint. Starting from the period that policymakers choose \( \pi \), the output gap next period is given by \( \phi_i^* y - \alpha_i (i - \pi) + \eta \) as in Equation \( A1 \) and the inflation next period is \( \pi + \beta_y y + e \).

**Optimal Interest Rate Policy and Associated Value Function.** Details are available in the appendix to Cecchetti and Li (2005). We only present the optimal policy and associated value function. The optima policy is

\[
(A4) \quad i = (1 - b/a) \pi + \phi_i^* (y - \beta_y y) / \alpha_i = A \pi + A_j y \\
\quad j = u, \ or \ c,
\]

where

\[
b = - \beta_y \delta / (1 - \lambda + \beta_y^2 \delta)
\]

and

\[
l = 0.5 \left[ \lambda - (1 - \lambda) (1 - \delta) \right] / \left[ \sigma_i^2 \delta \right]
\]

\[
+ 0.5 \sqrt{\left[ \lambda + (1 - \lambda) (1 - \delta) \right] / \left( \sigma_i^2 \delta \right)^2 + 4 \lambda (1 - \lambda) / \sigma_i^2}.
\]

The value function associated with the optimal policy is

\[
w(\pi + \beta_y y) = - \left( 1 - \lambda \right) b (\pi + \beta_y y)^2 / \left[ 2 \beta_y (1 + b \beta_y) \right] \\
\quad - \left( 1 - \lambda \right) b \delta \left( \sigma_i^2 + \beta_y^2 \sigma_i^2 + \sigma_i^2 \right) / \left[ 2(1 - \delta) \beta_y (1 + b \beta_y) \right] \\
\quad + \delta \lambda \sigma_i^2 + (1 - \lambda) \sigma_i^2 \left[ / (2(1 - \delta) \right] \text{ if } \lambda \neq 1
\]

\[
w(\pi + \beta_y y) = \delta (\pi + \beta_y y)^2 / 2 + \delta \left( 1 - \lambda \right) \sigma_i^2 / \\
\quad 2(1 - \delta) + \delta \sigma_i^2 / 2(1 - \delta) \text{ if } \lambda = 1.
\]

\( (A5) \)

where \( \sigma_i^2 \) and \( \sigma_i^2 \) denote the standard deviation of demand and supply shock, respectively.

**Converting Data Frequency**

When we convert high-frequency data into low-frequency data, we use the average observation. When interpolating low-frequency to high-frequency data (the leverage ratios of Germany and Japan), we fit a local quadratic polynomial for each observation of the low-frequency series, then use this polynomial to fill in all observations of the high-frequency series associated with the period. The quadratic polynomial is formed by taking sets of three adjacent points from the source series and fitting a quadratic so that the average of the high-frequency points matches to the low-frequency data actually observed. For most points, one point before and one point after the period currently being interpolated are used to provide the three points. For end points, the two periods are both taken from the one side where data are available.

**Data Sources**

14. Germany potential real GDP: quarterly data from Economic Outlook 73 as published by the Organization for Economic Co-operation and Development (OECD).
15. Germany real GDP: quarterly data from Deutsche Bundesbank.
16. Total assets of banks, Germany: OECD bank database. The annual data are interpolated into quarterly data using the conversion method discussed above.
17. Total equity of banks, Germany: OECD bank database. The annual data are interpolated into quarterly data using the conversion method discussed above.
18. Germany money supply (M3) growth: quarterly average of annualized growth of monthly data from International Financial Statistics.


23. Japan potential real GDP: quarterly data from Economic Outlook as published by the OECD.


25. Total assets of banks, Japan: OECD bank database. The annual data are interpolated into quarterly data using the conversion method discussed above.

26. Total equity of banks, Japan: OECD bank database. The annual data are interpolated into quarterly data using the conversion method discussed above.

27. Japan money supply (M2) growth: quarterly average of annualized growth of monthly data from International Financial Statistics.


REFERENCES


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