“Marrying Monetary Policy with Macroprudential Regulation: Countercyclical Capital Buffer and Optimal Monetary Policy”

by

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Marrying Monetary Policy with Macroprudential Regulation: Countercyclical Capital Buffer and Optimal Monetary Policy*

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Abstract

Since the eruption of the global financial crisis in 2008, macroprudential regulation has become a mantra in the regulatory world. The soon-to-be-widespread adoption of macroprudential tools will inevitably affect the dynamics of the economy and consequently have a direct bearing on the conduct of monetary policy. This paper explores theoretically several issues surrounding the interplay between Basel-III-type countercyclical capital regulatory rule and monetary policy. Among the key issues examined are the implications of the former on the monetary transmission mechanism, optimal monetary policy conduct, and the optimal policy combination.

JEL classification: E32, E44, E50, E58
Keywords: monetary policy, macroprudential regulation

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1. Introduction

The recent global financial crisis has brought to prominence the macroprudential approach to financial regulation. Although the idea that the traditional “microprudential” approach of ensuring safety and soundness of individual financial institutions is not adequate to safeguard the financial system as a whole and therefore needs to be complemented by the macroprudential approach that takes a system-wide perspective dates back to the late 1970s at the BIS meetings (Clement, 2010), it only came to the limelight after the near collapse of financial systems in many developed countries in the fall of 2008. Since then, macroprudential regulation has found strong acceptance across jurisdictions, with the Basel Committee’s Basel III reforms (BCBS 2010b, 2011) adding further to its legitimacy.

The soon-to-be-widespread adoption of macroprudential tools by the regulatory authorities will inevitably affect the dynamics of the financial system and the economy and hence have a direct bearing on the conduct of monetary policymakers, the traditional guardians of economic stability. However, despite the substantial progress on the implementation of macroprudential policy, little is known about its interplay with monetary policy. Among the key policy questions that come up time and again in international policy forums are the tradeoff, the complementarities and the substitutability between the two policies, and the appropriate policy combinations.

At the core of Basel III is the new global minimum capital standards that comprise, among other things, a higher minimum capital ratio, a conservation capital buffer, and a countercyclical buffer add-on. The interest of this paper is on the countercyclical capital buffer scheme which is macroprudential in nature and also the most likely to implicate the bank lending channel of monetary policy transmission.

A few recent papers have investigated the interaction between countercyclical capital requirement and monetary policy. Angeloni and Faia (2009) and N’ Diaye (2009) both find that countercyclical capital requirement is good for monetary policymakers and the economy as a whole. The same finding is reported by Angelini et al. (2010) except for the case when the macroprudential authority has more bargaining power than the monetary policy authority in a game theoretic setting in which the optimal capital rule is perversely procyclical. However, these works are based on a complex DSGE setup which not only makes them vulnerable to model-specific results but also makes it difficult to delineate the mechanisms in which the two policies interact. In this paper, we take a step back and analyze the
interactions between countercyclical capital requirement and monetary policy in a standard macroeconomic model commonly used for monetary policy analysis. Specifically, we use a hybrid new Keynesian macro model modified to incorporate a simple banking sector to study the implications of a countercyclical buffer add-on on optimal monetary policy and optimal policy combination.

The rest of the paper is organized as follows. Section 2 lays out the theoretical model. Section 3 discusses model parameterization and the simulation results. Section 4 analyses the implications of countercyclical capital requirement for a simple policy rule such as the Taylor rule. Section 5 explores optimal policy combination. Finally, Section 6 concludes.

2. The model

The model employed in this section is a variant of the dynamic model used by Cecchetti and Li (2005) to study optimal monetary policy design in the presence of a fixed minimum capital requirement for banks. Basically, what they did is to append a simple banking sector a la Bernanke and Blinder (1988) to an otherwise standard macroeconomic model. We build on their contribution by considering further the case of a countercyclical capital buffer add-on for the Basel III capital regime.¹

The evolution of the model economy when there is no capital requirement for banks is described by the following set of equations:

\[ x_t = \theta x_{t-1} + (1 - \theta)E_t x_{t+1} - \sigma (i_t - E_t \pi_{t+1}) - \theta (i_t^b - E_t \pi_{t+1}) + \varepsilon_t, \quad \theta \in [0,1], \sigma, \theta > 0, \quad (2.1) \]

\[ \pi_t = \alpha \pi_{t-1} + (1 - \alpha)E_t \pi_{t+1} + \kappa \gamma + u_t, \quad \alpha \in [0,1], \kappa > 0, \quad (2.2) \]

\[ b_t^d = b_x x_t - b_i (i_t^b - E_t \pi_{t+1}), \quad b_x, b_i > 0, \quad (2.3) \]

\[ b_t^s = \left(1 - \frac{N}{B}\right) d_t + \frac{N}{B} n_t, \quad (2.4) \]

\[ d_t = d_x x_t - d_i (i_t - E_t \pi_{t+1}), \quad d_x, d_i > 0, \quad (2.5) \]

\[ n_t = n_x x_t, \quad n_x > 0, \quad (2.6) \]

¹ The other main difference between our model and that of Cecchetti and Li (2005) is that their macroeconomic block is purely backward looking whereas ours also features the roles of the expected future output gaps and expected future inflation in determining the current output gap and current inflation as emphasized by modern macro economic analysis.
where $x_t$ is the output gap, $\pi_t$ is inflation, $i_t$ is the nominal interest rate (the central bank’s monetary policy instrument), $i^h_t$ is the nominal lending rate, $\varepsilon_t$ is a demand shock, $u_t$ is a cost-push shock, $b^d_t$ is real loan demand, $b^s_t$ is real loan supply, $d_t$ is real deposits, $n_t$ is real bank capital, and $E_t$ is the expectation operator. The two stochastic disturbances are assumed to be independent and serially uncorrelated with variances equal to $\sigma_\varepsilon^2$ and $\sigma_u^2$, respectively.

Equation (2.1) describes a forward-looking aggregate demand equation (an expectational IS curve). It differs from a conventional hybrid IS curve in the presence of the ex ante real lending rate term. As specified, the contemporaneous output gap depends positively on its lagged and expected future values, but negatively on the ex ante real policy rate and the ex ante real lending rate. Equation (2.2) is a standard hybrid new Keynesian Phillips curve that relates current inflation to both lagged and expected future inflation, the output gap and a cost-push shock. Equations (2.3)-(2.6) make up our banking sector block. Real loan demand (equation (2.3)) is assumed to be increasing in the level of economic activity, but decreasing with the real lending rate. The evolution of real loan supply is described by equation (2.4) which is a log-linearized version of a simple bank balance sheet identity ($B_t = D_t + N_t$) where the uppercase letters without the time subscript denote the steady-state values of the respective variables. Real (non-interest-bearing) bank deposits vary positively with the output gap, but negatively with the real policy rate, while real bank capital is assumed to be increasing only in the output gap. In a limiting case when the structural parameters $\theta$ and $\alpha$ which capture the degree of backwardness in equations (2.1) and (2.2) are both equal to unity, the above model economy reduces to the one examined by Cecchetti and Li (2005).

In this model, monetary policy works through two channels. The first is the conventional interest rate channel. The second is the bank lending channel, captured by the presence of the lending rate term in the aggregate demand equation and the specifications of the banking sector block. By making bank capital a positive function of output, there is no need to resort to a binding reserve requirement constraint as typically assumed in the literature. In our model, an increase in the central bank’s policy rate lowers the level of both real deposits and economic activity which in turn lead to the reduction on the right-hand side of bank balance sheet and through the balance sheet identity a simultaneous reduction in bank loan supply on the left-hand side. Provided that real loan demand is not too sensitive to the
output gap, the lending rate will increase with the policy rate, effectively amplifying the impact of the monetary policy contraction.

Before proceeding, we note that the model can be simplified further. Equating the expression for loan demand to the expression for loan supply and substituting the expressions for deposits and bank capital into the resulting loan market equilibrium condition yields the equilibrium real lending rate in terms of output gap and the real policy rate. Plugging the expression for the equilibrium real lending rate into equation (2.1) results in a familiar conventional hybrid IS curve:

\[ \omega^u x_t = \theta x_{t-1} + (1 - \theta) E_t x_{t+1} - (\sigma + \Delta)(i_t - E_t \pi_{t+1}) + \varepsilon_t, \]

(2.1')

where \( \omega^u = 1 - \frac{\delta}{\gamma} \left( \frac{Y}{B} \right) \) and \( \Delta = \frac{\delta}{\gamma} \left( \frac{N}{B} \right) \). The superscript \( u \) denotes that this is the unconstrained case. Equation (2.1') together with equation (2.2) gives a complete description of our model economy when banks are unconstrained by the regulatory capital requirement.

In order to analyze optimal monetary policy, we assume that the central bank’s objective is to minimize an intertemporal loss function of the form

\[ L_t = \frac{1}{2} E_t \sum_{\tau=0}^{\infty} \beta^\tau [\pi_{t+\tau}^2 + \lambda x_{t+\tau}^2 + \nu (i_{t+\tau} - i_{t+\tau-1})^2], \]

(2.7)

where \( \beta \) is the discount factor. This specification of the central bank’s loss function reflects the widespread agreement over the practical objectives of monetary policy in the literature.\(^2\) The parameters \( \lambda \) and \( \nu \) represent respectively the weights on output gap stabilization and interest rate smoothing relative to inflation stabilization.

To study the implications of countercyclical capital regulation on optimal monetary policy, we assume that the prudential authorities impose the following minimum requirement on bank capital:

\[ N_t \geq \left( c + \frac{1}{\gamma_1 Y} \right)^{\gamma_2} B_t, \]

(2.8)

where \( Y_t \) and \( Y \) denote respectively output and its steady state, \( c \) and \( \gamma_1 \) are positive constants, and \( \gamma_2 \geq 0 \). In what follows, we refer to the case in which \( \gamma_2 = 0 \) as the fixed-capital-

\(^2\) See, for example, Rudebusch and Svensson (1999) and Ehrmann and Smets (2003).
requirement case and the case in which \( \gamma_2 > 0 \) as the countercyclical-capital-requirement case.

The specification (2.8) is intended to mimic the newly announced Basel III capital regime. The parameter \( c \) can be thought of as the sum of the minimum capital ratio and the capital conservation buffer while the second term in the bracket captures the essence of countercyclical capital buffer add-on in which the amount of the required extra capital rises and falls with economic cycle.$^{3}$

For simplicity, we assume that, once imposed, the capital-requirement constraint holds with equality. While this assumption is admittedly unrealistic, we note that it is a rather common assumption in the literature. See, for example, Angeloni and Faia (2009), N’Daiye (2009) and Covas and Fujita (2010). In addition, if we take the results from Cecchetti and Li (2005) that optimal monetary policy conduct in the face of a capital requirement in their model has the central bank switch back and forth between two interest rate rules that correspond to two distinct states of the world: one in which the capital constraint always binds and one in which it never does, for the sake of elucidating the impacts of the capital constraint on the dynamics of the economy and optimal monetary policy, it may not be too costly to abstract from the state of the world in which the capital constraint binds on and off.

Intuitively, imposing an always binding capital constraint turns an upward-sloping loan supply curve into a vertical one (Figure 1a). To illustrate the procyclical effect of a fixed capital requirement and the countercyclical property of the Basel III-type requirement in our model, let us assume momentarily that the loan demand schedule is unaffected by output movements$^{4}$ and that the output elasticities of loan supply are the same for the no-capital-requirement case and the fixed-capital-requirement one. The second assumption$^{5}$ forces the loan supply schedules in both cases to shift by the same horizontal distance for a given change in the output amount which together with the first assumption simplifies graphical presentation.

$^{3}$ BCBS (2010a) recommends the use of the aggregate private sector credit-to-GDP gap as a conditioning variable for the countercyclical capital buffer but leaves open to national authorities as to what should be used in the end. The ideal choice of a conditioning variable should presumably be the one that best reflects the buildup of system-wide risk. Given that such criterion is irrelevant for the model in this paper, we simply follow the literature in using the deviation of GDP from its steady state as the reference cycle.

$^{4}$ This is exactly the condition assumed by Cecchetti and Li (2005) for their dynamic model.

$^{5}$ In our model, this is accomplished by setting the elasticity with respect to the output gap of real deposits equal to that of real bank capital. In reality, the latter is generally larger than the former, implying a larger shift of the vertical supply curve which strengthens the degree of procyclicality induced by the fixed capital requirement.
From a partial equilibrium perspective, an increase in aggregate economic activity shifts the loan supply schedules in both the unconstrained and the fixed-capital-requirement cases to the right (Figure 1b). Compared to the unconstrained case, the fixed-capital-requirement case has the loan supply schedule intersect the loan demand schedule at a higher loan amount and a lower real lending rate. Given the specification of aggregate demand, the lower real lending rate would stimulate output even further. Thus, despite the fact that we fix the initial shifts of the two supply schedules to be the same, the final equilibrium in the fixed capital requirement case would have the vertical supply schedule move further rightward due to a multiplier effect.

Having shown the association between one form of financial-sector procyclicality (in which procyclical bank lending amplifies the business cycle) and the fixed capital requirement in our model, we turn to the countercyclical property of a Basel III-type capital requirement. In this latter case, the required capital ratio rises with an economic expansion, forcing banks to moderate their loan book expansion and effectively pulling the loan supply schedule back to the left. Compared with those under the fixed-capital-requirement case, the equilibrium bank loans under the countercyclical-capital-requirement case will be lower while the equilibrium loan rate will be higher and as a result output will be less stimulated. Put differently, with countercyclical capital requirement, bank loans will be less procyclical and the business cycle will be less amplified.

Log-linearizing equation (2.8) yields

\[ b_t^* = n_t - \frac{\gamma_2}{\gamma_1 c + 1} x_t. \]  

(2.9)
Replacing equation (2.4) with equation (2.9) and following the same simplification steps yields
\[
\omega^c x_t = \theta x_{t-1} + (1 - \theta)E_t x_{t+1} - \sigma(i_t - E_t \pi_{t+1}) + \epsilon_t, \tag{2.1''}
\]
where \( \omega^c = 1 - \frac{\phi}{\varphi} \left( \frac{\gamma_2}{\gamma_2 - \gamma_{c+1} - \gamma_c} \right) \). The superscript \( c \) denotes that this is the capital-constrained case. It is noteworthy here that the presence of a capital constraint affects only the aggregate demand equation, with the aggregate supply equation unchanged.

3. Optimal monetary policy in the presence of a countercyclical capital requirement

3.1 Model parameterization

Rather than estimating the model from the data, we adopt the following calibration strategy. First, we deliberately parameterize relevant parameters in a way that makes \( \omega^u \) equal to one. With this parameterization, the aggregate demand equation under the unconstrained case (2.1’) becomes isomorphic to a standard hybrid aggregate demand equation which allows us to adopt certain parameter values that have already been estimated by others. Given that the unconstrained case largely characterizes the real world when viewed over a long time series, our parameterization scheme is not too unreasonable. On the plus side, it allows us to sidestep certain data and estimation issues which are not central to our illustrative analysis while at the same time still providing some realism.

Second, we note that the aggregate demand equation when banks are constrained by a capital requirement differs from the aggregate demand equation when banks are unconstrained (2.1’) in two places: the coefficient on the current output gap and the coefficient on the ex ante real interest rate, of which only the former depends on the degree of countercyclicality of the capital constraint. To highlight their respective implications on the dynamics of the economy and optimal monetary policy, we also parameterize \( \omega^c \) when \( \gamma_2 = 0 \) to one so that the aggregate demand equation in the fixed capital requirement case differs from the unconstrained case only to the extent of interest rate elasticity of output.
Table 1. Baseline parameter values

<table>
<thead>
<tr>
<th>IS equation</th>
<th>Value</th>
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<tbody>
<tr>
<td>$\theta$</td>
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<tr>
<td>$\sigma$</td>
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</tr>
<tr>
<td>$\vartheta$</td>
<td>0.025</td>
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<tr>
<td>$\sigma^2_u$</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AS equation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
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</tr>
<tr>
<td>$\kappa$</td>
<td>0.18</td>
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<tr>
<td>$\sigma^2_u$</td>
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</table>

<table>
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<tr>
<th>Banking sector block</th>
<th>Value</th>
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<tr>
<td>$b_x$</td>
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</tr>
<tr>
<td>$b_y$</td>
<td>0.1</td>
</tr>
<tr>
<td>$d_x$</td>
<td>1.5</td>
</tr>
<tr>
<td>$d_y$</td>
<td>0.045</td>
</tr>
<tr>
<td>$n_x$</td>
<td>1.5</td>
</tr>
<tr>
<td>$N/B$</td>
<td>0.105</td>
</tr>
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</table>

<table>
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<tr>
<th>Capital constraint</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>$c$</td>
<td>0.105</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>1,000</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>110</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Central bank loss function</th>
<th>Value</th>
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</thead>
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<tr>
<td>$\beta$</td>
<td>0.96</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.5</td>
</tr>
<tr>
<td>$\nu$</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Table 1 lists the values of our model parameters. For $\theta, \alpha, \kappa, \sigma^2_x$, and $\sigma^2_u$, we use the values from the estimated euro area model of Ehrmann and Smets (2003). We choose the Ehrmann and Smets model for our illustrative analysis for two reasons. First, European banks had been at the center of the Basel III discussions before its eventual announcement. Second, the model is in annual frequency which matches the 12-month time horizon that undercapitalized banks need to meet the additional countercyclical capital requirement under the Basel III regime. The unconventional parameters $\vartheta, b_x, b_y, d_x, d_y, n_x$ are chosen under the constraints $\omega^y = \omega^x (\gamma_2 = 0) = 1$ and $\sigma + \Delta = 0.06$ (the value of interest elasticity of the output gap in the Ehrmann and Smets (2003) model). The ratio $N/B$ and $c$ are set to 0.105, the sum of the minimum capital ratio and the conservation capital buffer under Basel III. This left $\gamma_1$ and $\gamma_2$ as the free parameters for the countercyclical capital buffer calibration. For the baseline parameterization, we set them equal to 1,000 and 110,
respectively, which together with the above parameter values give $\omega = 1.3$. In obtaining these values, we simulate the model under the fixed-capital-requirement case 1,000 times and search for $\gamma_1$ and $\gamma_2$ that make the simulated countercyclical capital buffer not only falling within a range of 0-2.5% but also staying near zero most of the time as prescribed by the Basel III announcement. Figure 2 shows the simulated path of the overall capital requirement for the first 150 time periods.

**Figure 2.** Simulated capital ratio

![Figure 2](image)

Finally, we assume for the central bank’s period loss function that $\lambda = 0.5$ and $\nu = 0.1$ and that the discount factor $\beta = 0.96$ given that the Ehrmann and Smets (2003) model is based on annual data.

### 3.2 A simple limiting case

As a prelude to the simulation results, it is instructive to examine a simple limiting case where a closed-form solution is available. As it is well known, closed-form solutions can be derived when the central bank is not concerned about interest rate variability and the underlying model economy is either purely backward looking or forward looking. Given that the backward-looking case has been worked out in detail by Cecchetti and Li (2005), we choose the forward-looking case for the analysis in this subsection.

In this case, the central bank’s problem is given by

$$
\min L_t = \frac{1}{2} E_t \sum_{\tau=0}^{\infty} \beta^\tau (\pi_{t+\tau}^2 + \lambda x_{t+\tau}^2)
$$

subject to

(2.10)
\[ \alpha x_t = E_t x_{t+1} - \sigma(i_t - E_t \pi_{t+1}) + e_t, \]  
(2.11)  
\[ \pi_t = \beta E_t \pi_{t+1} + \kappa \pi_t + u_t, \]  
(2.12)

where, given the aforementioned calibration scheme, \( \omega \) (unconstrained case) = \( \omega \) (fixed requirement case) = 1 < \( \omega \) (countercyclical requirement case) and \( \sigma \) (unconstrained case) > \( \sigma \) (fixed requirement case) = \( \sigma \) (countercyclical requirement case). Without loss of generality, we replace the Phillips curve (2.2) with a standard new Keynesian Phillips curve (2.12) so as to also enable comparison with a basic new Keynesian model.

It is instructive to iterate equation (2.12) forward to obtain

\[ x_t = E_t \sum_{\tau=0}^{\infty} \left\{ \frac{-\sigma}{\omega^{t+\tau}} (i t_{t+\tau} - \pi_{t+\tau}) + \frac{e_{t+\tau}}{\omega^{t+\tau}} \right\} \]  
(2.13)

Equation (2.13) highlights the monetary transmission mechanism in our model. As in the basic new Keynesian model, the current output gap depends not only on the current policy rate but also on its expected future path. What is new according to equation (2.13) is that the presence of a binding capital constraint weakens the transmission of monetary policy through a smaller \( \sigma \) and a larger \( \omega \) which together lower the sensitivity of the output gap to the current and the expected real policy rates.

It is noteworthy that the effect of \( \sigma \) is constant through time while the effect of \( \omega \) increases over time. Mechanically, \( \omega \) captures the responsiveness of the current output gap to the expected future output gap, with the larger \( \omega \), the smaller the influence of the latter on the former. This further weakens the link between the expected future policy rates and the current output gap which is central to models with forward-looking features.

On the other hand, a larger \( \omega \) reduces the impacts of the current and the expected demand shocks on the current output gap. This latter property will become important when we discuss optimal monetary policy for the full model in the next subsection.

For the problem at hand, the solution to the central bank’s optimization is simple. When the central bank’s loss function contains only output gap and inflation stabilization objectives and there is no constraint on the zero lower bound (ZLB) on the nominal interest rate, optimal monetary policy calls for a complete offset of the impact of the demand disturbance \( u_t \), leaving the dynamics of the equilibrium output gap and inflation independent of the aggregate demand equation. More importantly for our analysis, this means that the presence of a capital requirement constraint, whether fixed or countercyclical, has no bearing on the
equilibrium output gap and inflation processes and consequently the value of the loss function if the central bank conducts its policy optimally. Viewed this way (that the only relevant constraint for the central bank’s optimization problem is the aggregate supply curve), the Cecchetti and Li (2005) result that the equilibrium output gap and inflation processes depend only on the supply shock in a manner that is independent of the capital constraint is not surprising.

It remains to examine the specific form of an optimal monetary policy rule in this simple limiting case. The equilibrium concept we adopt for this purpose is the timeless perspective commitment equilibrium advocated by Woodford (2003). We note however that assuming the generally inferior discretion equilibrium does not alter our conclusions about the implications of the capital constraint on optimal monetary policy, whether in this simple limiting case or a more general one.

Under the commitment equilibrium, the equilibrium output gap and inflation processes are given by

\[ x_t = c_1 x_{t-1} + c_2 u_t, \]

\[ \pi_t = \left( \frac{\lambda}{\kappa} \right) (1 - c_1) x_{t-1} - \frac{\lambda c_2}{\kappa} u_t, \]

where \( c_1 = 0 < \frac{1 + \beta k^2}{2 \beta} \sqrt{\left( \frac{1 + \beta k^2}{2 \beta} \right)^2 - 4 \beta} < 1, \) \( c_2 = -\frac{\kappa}{4 \beta (1 - c_1)^2} < 0. \) See Clarida, Gali, and Gertler (1999) or Walsh (2008) for detailed derivation.

Using the aggregate demand equation (2.11) to back out the equilibrium interest rate behavior under timeless perspective commitment yields

\[ i_t = \left( \frac{\lambda}{\kappa} \right) (1 - c_1) - \frac{1}{\sigma} (\omega - c_1) c_1 x_{t-1} + \left( \frac{\lambda}{\kappa} \right) (1 - c_1) - \frac{1}{\sigma} (\omega - c_1) c_2 u_t + \frac{1}{\sigma} \varepsilon_i. \]  (2.14)

Equation (2.14) reveals two important observations. First, the optimal policy rate response to a demand shock is larger when the capital constraint is binding (due to a smaller \( \sigma \)). Intuitively, the presence of a binding capital constraint reduces the ability of the policy rate to neutralize the effect of a given demand shock. So a larger change in the policy rate is required. The impact of a smaller \( \sigma \) also applies to the policy rate response to a supply shock although in this case the inflation-output stabilization tradeoff causes the central bank to only partially offset the effect of a supply shock.
Secondly, the more countercyclical the capital requirement is (as captured by a larger \( \omega \)), the larger the optimal policy rate response to a supply shock. This is a consequence of our earlier result that the effectiveness of monetary policy transmission mechanism is further reduced by the degree of countercyclicality of the binding capital constraint.

### 3.3 Simulation results

The simple limiting case examined in the previous subsection provides several important insights into how to think about optimal monetary policy conducts in the presence of a binding capital requirement constraint for banks. However, not all of the results of the previous subsection carry to a more realistic setting where the underlying economy exhibits inertia in the output gap and inflation processes and the central bank faces costs of interest rate adjustment. The latter, in particular, renders a complete offset of demand shocks suboptimal. As a result, the equilibrium output gap and inflation processes will necessarily depend on the specification of the aggregate demand equation and hence the form of the capital constraint. It also follows that the value of the loss function will no longer be invariant to the regulatory regime.

Under commitment, the optimal policy rules and their associated losses in the calibrated model are given by

**Unconstrained** (loss = 42.28)

\[
\begin{align*}
i_t &= 0.58i_{t-1} + 0.60x_{t-1} + 0.38\pi_{t-1} + 1.37\varepsilon_t + 0.78u_t - 0.62\Xi_{x,t-1} - 0.22\Xi_{\pi,t-1} \\
i_t &= 0.63i_{t-1} + 0.63x_{t-1} + 0.40\pi_{t-1} + 1.44\varepsilon_t + 0.83u_t - 0.51\Xi_{x,t-1} - 0.21\Xi_{\pi,t-1} \\
i_t &= 0.71i_{t-1} + 0.35x_{t-1} + 0.68\pi_{t-1} + 0.80\varepsilon_t + 1.41u_t - 0.38\Xi_{x,t-1} - 0.23\Xi_{\pi,t-1}
\end{align*}
\]

where \( \Xi_x \) and \( \Xi_\pi \) are the Lagrange multipliers on the aggregate demand equation and the aggregate supply equation, respectively.

In all three cases, the optimal policy rules call for an increase in the policy rate in response to both positive output gap and inflation developments as captured by their coefficients on the lagged output gap, lagged inflation, and the two stochastic disturbances. With respect to a cost shock, the result is the same as in the simple limiting case. Specifically, the optimal interest rate response to a cost shock when the capital requirement is
counter cyclical is more aggressive than when the capital requirement is constant, which in turn is more aggressive than when banks are unconstrained. The difference from the simple limiting case is with respect to an optimal interest rate response to a demand shock. It is no longer the case that the optimal policy response to a demand shock is invariant to the degree of countercyclicality of the binding capital constraint. Indeed, for the baseline parameterization, an optimal rate response to a demand shock in the presence of a binding countercyclical capital requirement is even smaller than the unconstrained case.

When the dynamics of the economy depends also on the aggregate demand equation, the benefit of a countercyclical capital requirement comes into play. An important insight from the simple limiting case is that countercyclical capital requirement reduces the impact of a demand shock on the current output gap. This property is inconsequential when demand shocks are completely offset. In the present case where there are residual demand shocks, requiring banks to hold more capital during an economic expansion thus aids the central bank’s aggregate demand management.

In terms of central bank’s losses, the loss is the smallest when there is no capital constraint, followed by the countercyclical-capital-requirement case, with the fixed-capital requirement case delivering the largest loss. This ordering should not be interpreted as the unconstrained case being the first best and the countercyclical-capital-requirement case as the second best however. Later when we analyze the optimal degree of countercyclicality of the capital constraint, we will show that there are instances in which a countercyclical capital requirement is associated with a smaller loss than having no constraint at all. Rather, the key message here is that, despite the fact that a countercyclical capital requirement weakens the transmission mechanism of monetary policy relative to a fixed capital requirement, in the end the central bank is better off with a countercyclical capital requirement than with a fixed capital requirement.

Figure 3 shows the impulse responses of the policy rate, the output gap, bank loans, and inflation to a unitary positive demand shock for the unconstrained case, the fixed-capital-requirement case, and the countercyclical-capital-requirement case. As would have been expected from the preceding discussion, the initial policy response is mildest in the countercyclical-capital-requirement case. That output and bank loans also fluctuate less in this case is also evidenced by their impulse responses. Through the presence of the lagged output gap term in the hybrid aggregate demand equation, a countercyclical capital constraint also reduces the persistence in output gap movements. This further lessens the impact of
demand shocks on the output gap and accordingly bank loans. Finally, while inflation in the countercyclical-capital-requirement regime is less volatile than that in the fixed-capital-requirement regime, it is more volatile than that in the unconstrained regimes which causes the associated policy response to persist longer. This is the adverse consequence of countercyclical capital requirement. Put simply, there is no free lunch. While countercyclical capital requirement helps moderate the impact of demand shocks on output, it reduces the ability of the central bank to control inflation through the weakened monetary transmission mechanism.

**Figure 3.** Impulse responses to a unitary demand shock

The contrast between the benefit and the cost of a countercyclical requirement on macroeconomic dynamics is most visible in Figure 4 which traces out the impulse responses of the policy rate, the output gap, bank loans, and inflation to a unitary cost shock. In the countercyclical-capital-requirement case, a cost shock invokes a very strong policy response, twice to three times as much as the other cases under the given parameterization. Even with such a strong response, inflation remains the most volatile in the countercyclical-capital-requirement case. On the other hand, both the output gap and bank loans are less variable with a countercyclical capital constraint.
Putting all these pieces together, the output gap is least volatile with a countercyclical requirement, followed in order by the unconstrained case and the fixed-capital-requirement case. On the other hand, inflation is most volatile with a countercyclical requirement, followed in order by the fixed-capital-requirement case and the unconstrained case. That is, countercyclical capital requirement is good for output gap stabilization, but bad for inflation stabilization.

Figure 4. Impulse responses to a unitary cost shock

In light of the differential impacts of a countercyclical capital requirement constraint on output and inflation variability, it is natural to examine the output-inflation variability tradeoff advocated by Taylor (1979) for comparison of alternative monetary policy rules. Figure 5a plots combinations of the unconditional variances of the output gap and inflation obtained by varying the central bank’s weight on output gap stabilization ($\lambda$) from 0 to 100 under the three cases of interest. Also labeled in the figure are the points on each of the tradeoff frontier for the baseline parameterization ($\lambda = 0.5$). Figure 5b superimposes on Figure 5a additional tradeoff curves associated with different values of $\omega$. 

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Figure 5. Output-inflation variability tradeoff

Figure 5 highlights several important results. First, under the baseline parameterization, the output-inflation variability tradeoff under the countercyclical-capital-requirement case dominates the fixed-capital requirement case, but is dominated by the unconstrained case. That is, under the baseline parametrization, the unconstrained case dominates the two capital-constrained cases in terms of both the central bank’s loss and the output-inflation variability tradeoff. The same however cannot be said for higher degrees of requirement countercyclicality. As the degree of countercyclicality of a capital requirement increases, the tradeoff frontier pivots to the left. For high values of \( \omega \), parts of the tradeoff frontiers even lie below the tradeoff frontier under the unconstrained case. The superior tradeoff at high values of \( \omega \) however comes at the expense of higher interest rate volatility (simulation results not shown). So it is not clear whether a higher degree of countercyclicality will always be preferred by an optimizing central bank. Subsection 2.6 will take on this issue in detail. Finally, a countercyclical capital constraint shortens the variability frontier. The higher the value of \( \omega \), the shorter the tradeoff curve and the higher the minimum level of inflation variability a central bank can achieve. This is the consequence of our earlier finding that countercyclical capital requirement interferes with the central bank’s inflation stabilization. For an inflation nutter (King, 1997), a fixed capital requirement may be preferred to a countercyclical one.

4. Countercyclical capital requirement and optimal Taylor rules

A large part of the modern monetary policy literature chooses to focus on simple instrument rules like the so-called Taylor (1993) rule that responds to only contemporaneous
the output gap and inflation as opposed to complicated optimal commitment rules. The justifications are that in many cases simple Taylor-like rules yield similar macroeconomic stability to optimal commitment rules and are also a reasonable approximation of actual policy making. It is therefore of interest to also examine the implications of countercyclical capital requirement on the form of optimal Taylor rules and their performances using the same loss function as in the previous subsection.

Table 2 reports the value of the loss function and the optimal reaction coefficients of a Taylor rule with interest rate smoothing for different values of \( \omega \). The same information for the unconstrained case is also reported in the last line of the table for comparison.

<table>
<thead>
<tr>
<th>( \omega )</th>
<th>Loss</th>
<th>( i_{t-1} )</th>
<th>( \pi_t )</th>
<th>( y_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>51.03</td>
<td>0.98</td>
<td>1.53</td>
<td>0.83</td>
</tr>
<tr>
<td>1.05</td>
<td>49.27</td>
<td>0.97</td>
<td>1.51</td>
<td>0.74</td>
</tr>
<tr>
<td>1.10</td>
<td>48.16</td>
<td>0.97</td>
<td>1.51</td>
<td>0.67</td>
</tr>
<tr>
<td>1.15</td>
<td>47.55</td>
<td>0.96</td>
<td>1.51</td>
<td>0.61</td>
</tr>
<tr>
<td>1.20</td>
<td>47.29</td>
<td>0.96</td>
<td>1.51</td>
<td>0.55</td>
</tr>
<tr>
<td>1.25</td>
<td>47.29</td>
<td>0.96</td>
<td>1.51</td>
<td>0.51</td>
</tr>
<tr>
<td>1.30</td>
<td>47.47</td>
<td>0.95</td>
<td>1.51</td>
<td>0.47</td>
</tr>
<tr>
<td>1.35</td>
<td>47.79</td>
<td>0.95</td>
<td>1.52</td>
<td>0.43</td>
</tr>
<tr>
<td>1.40</td>
<td>48.21</td>
<td>0.95</td>
<td>1.52</td>
<td>0.40</td>
</tr>
<tr>
<td>unconstrained</td>
<td>44.36</td>
<td>0.99</td>
<td>1.51</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Several observations deserve to be highlighted. First, as \( \omega \) increases from unity, the central bank’s loss becomes smaller. However, after a certain point, the value of the loss picks up again, suggesting that there is an optimal degree of countercyclicality of the capital constraint. This issue will be explored further in the next subsection.

Second, the optimal coefficients on the lagged interest rate and inflation do not change much with the degree of countercyclicality. This observation is in sharp contrast with the third observation which concerns the optimal coefficient on the output gap. For the baseline parameterization (\( \omega = 1.30 \)), the optimal coefficient on the output gap falls by nearly a half from 0.83 to 0.47 from the fixed-capital-requirement case (\( \omega = 1 \)). The reduced output response is a reflection of our earlier result that the greater the degree of countercyclicality of a capital requirement, the smaller the need for the central bank to stabilize output.

Given the significant impact of the degree of countercyclicality on the optimal Taylor rule, it is of interest to see what will happen to the equilibrium outcomes if the central bank is
not aware of the implications of the countercyclical capital constraint on the dynamics of the economy and remains committed to the optimal Taylor rule for the unconstrained case. In this case, the central bank’s loss and the unconditional variances of the output gap, inflation, and the policy rate are respectively 47.87 (compared to 47.47), 0.68 (compared to 0.72), 1.37 (compared to 1.36), and 21.32 (compared to 20.26). Qualitatively, by committing to the Taylor rule under the unconstrained case, the central bank overreacts to output gap developments. The central bank’s non-optimizing behavior brings down output gap variability at the expense of both inflation variability and interest rate variability. Overall, the latter two outweigh the former, resulting in a larger loss for the central bank. Nevertheless, the loss differential is only about one percent, suggesting that the central bank’s failure to internalize the implications of the binding capital constraint may not matter much quantitatively.

5. Optimal degree of countercyclicality

The analysis thus far concerns optimal monetary policy for a given degree of capital requirement countercyclicality. This subsection takes one step further to examine the optimal policy combination. This problem is best addressed by assuming, not too unrealistically, that the central bank is also in charge of the capital buffer calibration. In the context of our model, the central bank would on the outset fix the desired degree of countercyclicality of the capital buffer in conjunction with monetary policy to minimize the value of the loss function.6

For ease of exposition, we assume that the central bank chooses directly the parameter $\omega$ as the additional choice variable. The optimal value of $\omega$ will likely depend on several parameters. Rather than providing a full set of comparative statics, this subsection mentions two considerations that are likely to be of high practical importance.

The first consideration is the relative magnitude of the variances of the demand and the cost shocks. An important result from the earlier subsections is that countercyclical capital requirement is good for offsetting the impact of demand shocks, but bad for the performance of monetary policy in the face of supply shocks. Therefore, the optimal degree of

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6 An alternative approach is to assume a separate macroprudential authorities engaging in cooperative/non-cooperative games with a central bank. See Angelini et al. (2010) for an application of this approach.
countercyclicality in an economy where supply disturbances dominate will be lower than that in an economy where demand disturbances dominate, holding other things equal.

The second consideration concerns the weight the central bank places on output gap stabilization. Because countercyclical capital requirement helps the central bank stabilize the output gap at the expense of inflation stabilization. The optimal degree of countercyclicality should be higher as the central bank’s weight on output gap stabilization increases. Figure 6 confirms this intuition. The optimal value of \( \omega \) indeed rises with the value of \( \lambda \). For our baseline parameterization where \( \lambda = 0.5 \), the optimal value of \( \omega \) is 1.21, below our baseline value of 1.30. For \( \lambda = 1.0 \) (the central bank places an equal weight on output and inflation stabilization), the optimal value of \( \omega \) is 1.46.\(^7\)

**Figure 6.** Central bank’s loss

![Central bank's loss](image)

Figure 6 also illustrates another important point. When \( \lambda \) is high enough, it is possible for the central bank to achieve a lower level of loss with a countercyclical capital requirement than without a capital constraint at all. Thus, provided that the central bank’s objective function approximates well the true social preference, in certain societies, particularly ones that may care strongly about output stabilization, implementing an appropriately calibrated countercyclical capital buffer is ultimately welfare improving.

\(^7\) Interestingly, the optimal value of \( \omega \) for an inflation nutter central bank (\( \lambda = 0 \)) is 0.74, implying that the optimal capital requirement is procyclical. The threshold \( \lambda \) that makes a fixed requirement optimal is 0.17. These conclusions however ignore the financial stability benefit of capital requirement countercyclicality and the financial stability cost of increase bank lending procyclicality which conceptually should result in a higher value of optimal \( \omega \).
6. Conclusions

The 2008-9 global financial crisis has brought a sea of changes to the regulatory landscape. Among them will be the implementation of various forms of macroprudential regulation across jurisdictions. In this paper, we employ a rather standard small macroeconomic model for monetary policy analysis to explore a number of issues surrounding the interactions between Basel III’s countercyclical capital requirement and monetary policy. We find that, purely from a macroeconomic dynamic context, a countercyclical capital requirement is better than a fixed minimum capital requirement in terms of helping an optimizing central bank stabilize the economy. This benefit is despite the fact that a countercyclical requirement is associated with higher inflation variability and further reduces the strength of monetary policy transmission. Other important findings are that a countercyclical capital requirement allows the central bank to respond less to output fluctuations and that actual countercyclical buffer calibration may also need to consider on top of financial stability concern the nature of macro shocks hitting the economy and the economy’s social preference towards output and inflation.

References


