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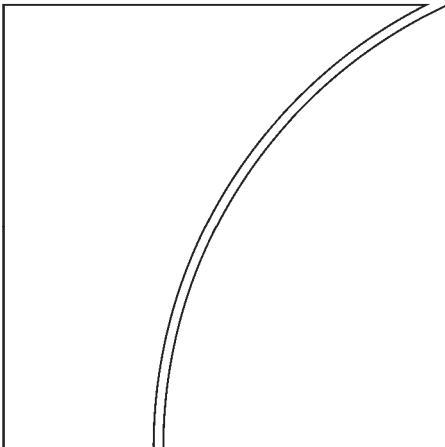
No 379

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(and when they are not)

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Monetary and Economic Department

May 2012



JEL classification: E5, G2

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ISSN 1020-0959 (print)

ISSN 1682-7678 (online)

When capital adequacy and interest rate policy are substitutes (and when they are not)

Stephen G Cecchetti and Marion Kohler^{*}

Abstract

Prudential instruments are commonly seen as the tools that can be used to deliver the macroprudential policy goals of reducing the frequency and severity of financial crises. And interest rates are traditionally viewed as the means to deliver the macroeconomic stabilisation goals of low, stable inflation and sustainable, stable growth. But, at the macroeconomic level, these two sets of policy tools have quite a bit in common.

We use a simple macroeconomic model to study the extent to which capital adequacy requirements and interest rates might be substitutes in meeting the objective of stabilising the economy. We find that in our model both are substitutes for achieving conventional monetary policy objectives. In addition, we show that, in principle, they can both be used to meet financial stability objectives.

This implies a need to coordinate the use of macroprudential and traditional monetary policy tools, a need that has clear implications for the construction of the policy framework designed to deliver the joint objectives of macroeconomic and financial stability.

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1. Introduction

The transatlantic financial crisis of 2007–09 has served as a reminder of the importance of financial stability. And, as former BIS Economic Adviser William R White observed so presciently in 2006, price stability is not enough.¹ Low, stable inflation does not necessarily deliver financial stability. In order to try to understand how to effectively promote both, we need to focus on how financial markets and institutions operate, how prudential regulation is structured, and what central banks can do with their balance sheets.²

Since the onset of the crisis five years ago, policymakers have worked to reform the financial system in an effort to make the next crisis both less likely and less severe.³ And, as the discussion about appropriate tools, their implementation and the even more difficult task of defining an operational financial stability objective continues, a number of jurisdictions have put in place new frameworks to improve financial stability policies.

Some countries have created new institutions, while others have revamped old ones. For example, the United Kingdom has created a new Financial Stability Committee parallel to its Monetary Policy Committee, putting both in the same institution, the Bank of England. At the same time, the United States, with the Federal Reserve responsible for traditional monetary policy, has created the Financial Stability Oversight Council. And in the euro area, the ECB is responsible for monetary stability, while financial stability has been put in the hands of the European Systemic Risk Board. But the differences in framework imply different degrees of coordination. Can economic theory help us to understand the degree of coordination that is needed? Should we prefer one model over another? The purpose of this paper is to shed some light on these questions.

We start with a brief discussion of the relationship between financial stability and monetary stability. Following this, in Section 3 we present a simple macroeconomic model to demonstrate the close relationship between interest rates and capital requirements. This leads us to the following conclusion: while prudential instruments are commonly seen as the tools that will deliver macroprudential policy goals, and interest rates as those that deliver monetary stability, at a macroeconomic level they have quite a bit in common. That is, they can both be used for macroeconomic stabilisation purposes. In Section 4, we describe how, if both instruments are used to achieve monetary policy and financial stability objectives, a coordination problem can arise.

2. Monetary stability and financial stability

The ultimate goal of (macro-)economic policies is to increase welfare, providing the foundations for maximum sustainable and stable real growth. This means that monetary stability and financial stability are really complementary – efforts to reduce the amplitude of business cycles and the variability of inflation are of little relevance if financial cycles are both frequent and intense.

Systemic risk – the risk that the entire economic and financial system breaks down catastrophically – affects society as a whole, and no individual can responsibly insure against it. Insofar as there is insurance, it must be provided by public authorities. Ensuring financial

¹ See White (2006).

² For a discussion of central bank balance sheet policies during the crisis, see Caruana (2011), BIS (2011), Chapter IV, and Borio and Disyatat (2009).

³ For an overview of the initiatives under way, see BIS (2011), Chapters I and V.

stability means addressing externalities – costs that, through its actions, one institution imposes on others but does not bear itself.

Two externalities are central to systemic risk. The first is joint failures of institutions resulting from their common exposures to shocks from outside the system and interlinkages among intermediaries at a single point in time. The second externality is what has come to be known as procyclicality: the fact that, over time, the dynamics of the financial system and of the real economy reinforce each other, increasing the amplitude of booms and busts and undermining stability in both the financial sector and the real economy.⁴

For many reasons, including governance issues, conflicts of interest between debt holders and equity holders, and moral hazard arising from the combination of limited liability and government guarantees, financial institutions have a natural tendency to accumulate assets that are too risky and to hold too little capital (both relative to the social optimum). One solution is for authorities to both impose restrictions on asset holdings and require minimum levels of capital. Among policymakers, there is agreement that the level of capital, for a given balance sheet, has to rise above its pre-crisis level. Moreover, in order to address the procyclicality of the financial system, there is a clear desire on the part of policymakers to go beyond existing tools and create new instruments to ensure that financial institutions adjust their capital (and other tools, such as loan provisioning, liquidity standards, etc) cyclically, building up defensive buffers in good times when capital is relatively plentiful and inexpensive and drawing them down in bad times when capital is relatively scarce and costly.⁵

The debate about which tools to use to address financial stability concerns has largely focused on macroprudential tools – instruments typically used in the prudential regulation and supervision of institutions that are then adapted to limit risk in the financial system as a whole.⁶ But we should not forget that fiscal and monetary policies are already designed to either exploit or mitigate the reinforcing feedback between the real economy and the financial system. Through automatic stabilisers and discretionary stimulus, countercyclical fiscal policy works to sustain income and employment, lowering the probability that borrowers will default (as well as increasing the value of what is recovered if they do) and raising the value of assets on financial institutions' balance sheets. Monetary policy, too, acts countercyclically. Seeking to head off a cyclical downturn, policymakers lower policy rates and, in so doing, improve the state of balance sheets of both financial institutions and borrowers in general. Similarly, central bankers increase policy rates to moderate an upturn, slowing credit growth and leaning against asset price booms. And through their interest rate targeting procedures, central banks work to keep financial sector shocks from affecting the real economy. Put another way, by reducing cyclical fluctuations in the real economy, countercyclical fiscal and monetary policies naturally (and intentionally) reduce the procyclicality of financial institutions' capital.

⁴ Adrian and Shin (2008) discuss how this problem is exacerbated by the procyclicality of leverage.

⁵ The international agreements contained in the Basel III capital standards contain a substantial increase in both the level and the quality of capital banks must hold. More to the point, they include required buffers. For a detailed description of these agreements and their implications, see BIS (2011), Chapter VI.

⁶ For a discussion of macroprudential tools, see, for example, FSB, IMF and BIS (2011), CGFS (2010) and Galati and Moessner (2011).

3. Capital adequacy and interest rates: substitutes?

Discussion about the design of a policy framework for delivering macroeconomic stability sometimes assumes that the two objectives of monetary stability and financial stability can be delivered using two instruments: interest rates and capital requirements. But, as the discussion in the previous section suggests, monetary (and fiscal) policy can be used to address financial stability concerns. With that in mind, we now construct a small macroeconomic model to show how capital requirements could, in principle, be used to address conventional macroeconomic stability concerns.

3.1 The transmission process of monetary policy and capital requirements

Regardless of the technicalities of implementation, it is interesting to think about the relationship between dynamic capital adequacy requirements and traditional monetary policy tools. Our contention is that these are very similar, so we cannot, and should not, think about them separately.

To understand this correspondence, it is useful to review of the channels of monetary policy transmission which underpin many macroeconomic models:

- **Interest rates:** Lower interest rates reduce the cost of investment, making more projects profitable.
- **Exchange rates:** Lower interest rates reduce the attractiveness of domestic assets, depressing the value of the currency and increasing net exports.
- **Asset prices:** Lower interest rates lead to higher stock prices and real estate values, which, through collateral value and household wealth effects, fuel an increase in both business investment and household consumption.
- **Bank lending:** An easing of monetary policy raises the level of bank reserves and bank deposits, increasing the supply of funds.
- **Firms' balance sheets:** Lower interest rates raise firms' profits, increasing their net worth and reducing the problems of adverse selection and moral hazard.
- **Household net worth:** Lower interest rates raise individuals' net worth, improving their creditworthiness and allowing them to increase their borrowing.

This textbook list may seem varied, but in an important way it is not. Remember, commercial banks are the central bank's point of contact with the financial system. It is by changing banks' ability and willingness to issue deposits and make loans that monetary policy has any impact at all. At a very technical level, the starting point for monetary policy is to change the interest rate on reserve deposits at the central bank. Policymakers can do this directly, by announcing the level of remuneration for reserve balances, by controlling the supply of reserves so that the market price is at or near its target, or by some other means. Regardless, adjustments in this riskless short-maturity interest rate will influence banks' cost of doing business, changing all other interest rates and asset values in the economy. Particularly relevant here is that policy rate changes influence the value of banks' own assets and liabilities, affecting the level of banks' capital and risk-taking capacity.

Now consider the impact of changes in capital adequacy requirements. By changing the amount of capital a bank is required to hold, regulators are again influencing banks' cost of doing business.

Once you start to think about the correspondence between interest rate policy and capital adequacy policy, it is clear that there are a variety of ways to explain it. With this in mind, we introduce an alternative policy tool into a simple macroeconomic model with a stylised banking system.

But before starting, we note that several years ago Kashyap and Stein (2004) suggested the creation of what they called “capital relief certificates”, the idea being that a bank could meet its capital requirement by either holding real capital or through the purchase of the certificates. If, as those authors suggest, there were a market for the certificates, their price would be related to the shadow cost of capital in the banking system. A variety of arguments can be marshalled for and against this proposal. Our interest here is not to debate the efficacy of these certificates, but rather to note that if they existed, the authorities could choose to control their price, thereby providing another channel through which authorities could influence the cost of lending.

With this as a motivation, we now turn to the simplest macroeconomic model that allows integration of capital requirement policy and then a financial stability objective.

3.2 A simple, static, linear model

Following Cecchetti and Li (2008), consider the following aggregate demand-aggregate supply model that includes a banking system, written as log-linear deviations from the steady state. In the manner of Bernanke and Blinder (1988), write aggregate demand y^d as

$$y^d = -\alpha(\rho - \pi^e) - \beta(i - \pi^e) - \delta\pi + \eta; \quad \alpha, \beta, \delta > 0 \quad (1)$$

where i is the short-term nominal interest rate, ρ is the nominal loan rate, π^e is expected inflation, π is inflation, and η is a white noise random variable. The interest rate i is set by policymakers, while the loan rate ρ is determined by equilibrium in the lending market.

For simplicity, assume that bank lending is constrained by the capital that banks hold.⁷ Then, loan supply is given by⁸

$$L^s = -\kappa \cdot k + \tau \cdot B \quad \kappa, \tau > 0 \quad (2)$$

where k is the capital requirement and B is the level of bank capital. Furthermore, assume that the real value of bank capital rises with the level of real output, so

$$B = by; \quad b > 0. \quad (3)$$

Next, loan demand depends on the level of both the real loan rate and real output, so

$$L^d = -\phi(\rho - \pi^e) + \omega y; \quad \phi, \omega > 0. \quad (4)$$

And, finally, there is a standard aggregate supply curve in which output supplied, y^s , depends on unexpected inflation plus an additive white noise error ε that is uncorrelated with the demand shock η :

$$y^s = \gamma(\pi - \pi^e) + \varepsilon; \quad \gamma > 0. \quad (5)$$

The model is closed with the equilibrium conditions

$$y^s = y^d = y \text{ and } L^s = L^d. \quad (6)$$

⁷ Without loss of generality, we could make bank lending depend on a combination of the level of capital and the risk-taking capacity. This could be modelled by adding a random element to equation (2).

⁸ This is the linearised form of a loan supply function where $L^s = (1/k) \cdot B$. We also note that, in this formulation, capital requirements bear a close similarity to reserve requirements. For a fixed reserve requirement, the interest paid on reserves will be closely related to the capital requirement here.

To solve this simple, linear, static model, first assume that agents have rational expectations, so expected inflation and output can both be normalised to zero. That is, $\pi^e = 0$. Next, using the loan and goods market equilibrium conditions, solve for output and inflation in terms of the two shocks, η and ε , and the policy interest rate i . This yields a solution for output and inflation that is linear in the shocks and the policy instruments:

$$y^* = \left(\frac{\delta\phi}{A}\right) \cdot \varepsilon + \left(\frac{\gamma\phi}{A}\right) \cdot \eta - \left(\frac{\beta\gamma\phi}{A}\right) \cdot i - \left(\frac{\alpha\gamma\kappa}{A}\right) \cdot k \quad (7)$$

$$\pi^* = \left(-\frac{\alpha(\omega - b\tau) + \phi}{A}\right) \cdot \varepsilon + \left(\frac{\phi}{A}\right) \cdot \eta - \left(\frac{\beta\phi}{A}\right) \cdot i - \left(\frac{\alpha\kappa}{A}\right) \cdot k \quad (8)$$

with $A = \alpha\gamma(\omega - b\tau) + \phi(\gamma + \delta)$, $A > 0$ for $\omega > b\tau$.⁹

Note that the equilibrium values of output and inflation are also functions of the level of the capital requirement, k . For both a higher capital requirement and a higher (policy) interest rate, equilibrium output and inflation are lower. In contrast, loan rates will be lower if policy interest rates rise, while they rise with higher capital requirements, as can be seen from the equilibrium solution for the loan rate:

$$\rho^* = \left(\frac{\delta(\omega - b\tau)}{A}\right) \cdot \varepsilon + \left(\frac{\gamma(\omega - b\tau)}{A}\right) \cdot \eta - \left(\frac{\beta\gamma(\omega - b\tau)}{A}\right) \cdot i + \left(\frac{\kappa(\gamma + \delta)}{A}\right) \cdot k \quad (9)$$

An increase in interest rates affects this economy through its effect on goods demand (lowering both consumption and investment). The result is lower output and lower inflation. Lower output reduces bank lending (loan supply) through its effect on the value of bank capital, and it reduces loan demand. If loan demand falls by more than loan supply ($\omega > b\tau$), the market clearing loan rate will be lower. This, in turn, leads to a second-round increase in goods demand, reversing some of the initial impact of the fall in output. In the new equilibrium, interest rates will be higher, output and inflation will be lower, and lending and loan rates will be lower.

An increase in capital requirements will lead to a reduction in loan supply. Loan rates have to rise to reduce excess demand in the loan market, reducing goods' demand. Inflation and output will have to fall to reduce excess output. This in turn will lead to a second round, reducing both loan supply and demand. If loan demand falls by more than loan supply, loan rates fall and output rises (reversing some of the first-round effect). Ultimately, capital requirements will be higher, lending will be lower and loan rates will be higher, and output and prices will be lower.

As is standard in monetary policy models, we assume that policymakers choose the optimal interest rate to minimise the sum of the weighted square loss of the inflation and output gap. Normalising the inflation target and potential output to zero, we write the policymaker's problem as

$$\min_i L_{MP} = \pi^2 + \lambda \cdot y^2 \text{ subject to (7) and (8), where } \lambda > 0. \quad (10)$$

⁹ By assuming that $\omega > b\tau$, we ensure that the coefficients have the expected sign. If A is positive, a positive productivity shock increases output and decreases inflation; a positive demand shock increases both output and inflation; and a rise in policy rates decreases both output and inflation. The condition that $\omega > b\tau$ is sufficient for A to be positive (but not necessary); the condition means that loan demand rises more in response to an increase in y than loan supply (other things equal). It also ensures that the equilibrium loan rate is a positive function of output.

This yields a policy rule

$$i^*(k) = \left(-\frac{\alpha(\omega - b\tau) + \phi(1 - \gamma\delta\lambda)}{\beta\phi(1 + \gamma^2\lambda)} \right) \cdot \varepsilon + \frac{1}{\beta} \cdot \eta - \frac{\alpha\kappa}{\beta\phi} \cdot k. \quad (11)$$

That is, interest rates adjust to both demand and supply shocks. And, interestingly, the optimal interest rate depends on the capital requirement, k , with the response decreasing in k (since $-(\alpha\kappa)/(\beta\phi) < 0$). That is, the higher the capital requirement, the smaller the optimal interest rate adjustment for a given supply shock ε . In other words, the more the capital requirement does, the less the interest rate needs to do.

Indeed, looking back at the derivation of the optimal *interest rate* policy rule (11), we can see that everything could have been done in terms of the capital requirement k instead. Solving (10) for k as a function of i , we get:

$$k^*(i) = \left(-\frac{\alpha(\omega - b\tau) + \phi(1 - \gamma\delta\lambda)}{\alpha\kappa(1 + \gamma^2\lambda)} \right) \cdot \varepsilon + \frac{\phi}{\alpha\kappa} \cdot \eta - \frac{\beta\phi}{\alpha\kappa} \cdot i. \quad (12)$$

The result is an optimal capital requirement policy rule, with k^* responding to η and ε and the coefficient dependent on the level of the interest rate, i . The optimal k is a decreasing function of the level of interest rates since $-(\beta\phi)/(\alpha\kappa) < 0$. So, the higher the interest rate level, the lower the optimal capital requirement needed to stabilise the economy after a given supply shock, ε . That is, the more the interest rate does, the less the capital requirement needs to do.

Importantly, the equilibrium loss (the value of L_{MP} in equation 10) is the same regardless of whether we use interest rate or capital requirement policy:

$$L_{MP}^* = \left(\frac{\varepsilon^2 \lambda}{1 + \gamma^2 \lambda} \right) \text{ for either } i = i^* \text{ or } k = k^*. \quad (13)$$

This result follows because, in this simple macroeconomic model, interest rate policies and capital adequacy policies are full substitutes.¹⁰ As a consequence, it is not possible to improve upon the equilibrium outcome by moving one instrument if the other instrument is already set at its optimal value.

The simplicity of our model suggests a number of caveats; for example: we assume neither instrument faces a constraint, which is not the case when the interest rate is at the zero bound; the two instruments have other important channels of transmission such as exchange rates that are not explicitly modelled here; the structure of a national financial system is likely to matter for the result; and richer modelling of the financial sector (and the addition of dynamics) may introduce a difference between financial cycles and normal business cycles. Nonetheless, other authors – using richer, more complicated models of both the general equilibrium and the partial equilibrium type – have found that there is some degree of substitutability also in those models (Stein (2010), Angelini et al (2010), Bean et al (2010)). This leads us to conclude that the result from our simple analysis is likely to carry over to larger, more complex macroeconomic models.

¹⁰ In their comment on the original version of this paper, du Plessis and du Rand (2012), note the correspondence between this result and that on monetary policy instruments in the seminal paper by Poole (1970).

4. A broader objective: monetary and financial stability

While there is consensus that monetary policy objectives can be summarised by the two-part objective function in equation (10), there is much less agreement about how to formalise financial stability objectives. One approach, followed by Angelini et al (2010) is to target/smooth the ratio of credit to GDP. However, in our model, the ratio of credit to GDP is constant, except when policy changes the capital requirement variable k . An alternative approach is to follow Cúrdia and Woodford (2010) and note that purely financial frictions result in welfare-reducing changes in credit spreads.¹¹ In the same way that nominal frictions give rise to policy that responds to price changes, in the Cúrdia and Woodford setup, optimal policy strives to eliminate the deadweight loss created by the movement in the spread in the presence of financial frictions.

The simplest way to add this financial stability objective into our model is to amend the policymaker's objective function in equation (10) and then solve the following problem:

$$\min_i L_{joint} = \pi^2 + \lambda \cdot y^2 + \zeta \cdot (\rho - i)^2 \text{ subject to (7), (8) and (9), where } \lambda, \zeta > 0. \quad (14)$$

$(\rho - i)$ is the spread between the loan rate and the policy (or funding) rate; ζ is the weight of the financial stability objective in the loss function.

As above, minimising the loss function with respect to either the interest rate or the capital requirement yields an optimal policy reaction identical in form to (11) and (12). That is, each instrument is a linear function of the demand and supply shocks, as well as the setting of the other instrument:

$$\begin{aligned} i_{joint}^*(k) = & \left(\frac{-\alpha\beta(1+\gamma^2\lambda)\phi + \zeta(\gamma+\delta) \cdot (\gamma(\alpha+\beta)(\omega-b\tau) + (\gamma+\delta)\phi)}{C} \right) \cdot k \\ & + \left(\frac{\beta\phi^2(\gamma\delta\lambda-1) - (\omega-b\tau)\alpha\beta\phi + \zeta(\omega-b\tau)\delta[\gamma(\omega-b\tau)(\alpha+\beta) + \phi(\gamma+\delta)]}{C} \right) \cdot \varepsilon. \quad (15) \\ & + \left(\frac{\beta(1+\gamma^2\lambda)\phi + \zeta((\alpha+\beta)(\gamma^2(\omega-b\tau)^2) + (\gamma+\delta)\gamma\phi(\omega-b\tau))}{C} \right) \cdot \eta \end{aligned}$$

with $C = \beta^2(1+\gamma^2\lambda)\phi^2$

$$\begin{aligned} k_{joint}^*(i) = & \left(\frac{-\alpha\beta\phi(1+\gamma^2\lambda) + \zeta(\gamma+\delta) \cdot (\gamma(\alpha+\beta)(\omega-b\tau) + (\gamma+\delta)\phi)}{\kappa\alpha^2(1+\gamma^2\lambda) + \zeta \cdot \kappa(\gamma+\delta)^2} \right) \cdot i \\ & - \left(\frac{(\omega-b\tau)\alpha^2 + \alpha\phi(1-\gamma\delta\lambda) + \zeta \cdot \delta(\gamma+\delta)(\omega-b\tau)}{\kappa\alpha^2(1+\gamma^2\lambda) + \zeta \cdot \kappa(\gamma+\delta)^2} \right) \cdot \varepsilon. \quad (16) \\ & + \left(\frac{\alpha\phi(1+\gamma^2\lambda) + \zeta(\gamma(\gamma+\delta)(\omega-b\tau))}{\kappa\alpha^2(1+\gamma^2\lambda) + \zeta \cdot \kappa(\gamma+\delta)^2} \right) \cdot \eta \end{aligned}$$

¹¹ They consider two types of friction associated with financial intermediation. First, financial intermediation requires real resources in the process of originating loans. Second, a certain number of borrowers take out loans without repaying them. Both frictions create costs for the financial intermediation process. Allowing these costs to shift over time introduces purely financial disturbances that will be associated with changes in credit spreads. See also Woodford (2012) and Svensson's (2012) related discussion.

Note that for $\zeta = 0$ the reaction function reduces to the functions in (11) and (12), respectively.

The losses associated with these optimal policies are higher than in the simple monetary problem, except for the case where *both* instruments are set at their respective optima.¹² This was not true in the simpler case considered earlier, as the minimum losses could be reached with just one instrument, irrespective of the value of the other instrument. The instruments are also no longer necessarily substitutes: if the weight of the financial stability objective ζ is high enough, higher capital requirements call for even higher optimal interest rates (ie the coefficient on k in (15) becomes positive). The same holds for optimal capital requirements in (16).

The intuition for why losses are higher and why the instruments are potentially not perfect substitutes is straightforward. While an increase in either instrument moves the first two objectives – inflation and output variability – in the same direction, the third, new objective creates a conflict. To see this, note that an increase in capital requirements naturally raises the loan rate (ρ , see equation (9)), thereby increasing the spread ($\rho - i$). In contrast, higher interest rates, a rise in i , decrease the loan rate ρ and decrease the spread. Unsurprisingly, adding a term to the policymaker's objective function that creates a potential conflict like this increases minimum losses in most cases.

All of this brings up a number of questions: If we can use only one instrument, which should we choose? Or, if we can use two instruments, what would happen if we split the objective into two parts, giving one part to an authority with one of the instruments and one to officials with the other?

4.1 One instrument but two (merged) objectives

On the first question – if we can have only one instrument but the broader objective – unsurprisingly we can show that losses for interest rates as the instrument are usually not the same as those for capital requirements as the instrument. To see this, we evaluate the loss function in (14) for i^* (from (15)), setting k (which is the change in capital requirements from their steady state value) equal to zero; and for k^* (from (16)), setting i equal to zero.

$$L_{jo\ int}(i_{jo\ int}^*, k \text{ unchanged}) = \left(\frac{\phi^2(1 + \gamma^2\lambda)}{C} \right) \cdot \eta^2 + \left(\frac{2\phi^2[(\gamma\delta\lambda - 1) - (\alpha + \beta)(\omega - b\tau)]}{C} \right) \cdot \varepsilon\eta \quad (17)$$

$$+ \left(\frac{\beta^2\lambda\phi^2}{C} + \frac{\zeta}{C} \cdot ((\alpha + \beta)^2(\omega - b\tau)^2 + 2(\alpha + \beta)\phi(\omega - b\tau) + (1 + \delta^2\lambda)\phi^2) \right) \cdot \varepsilon^2$$

$$L_{jo\ int}(k_{jo\ int}^*, i \text{ unchanged}) = \left(\frac{\alpha^2\lambda + \zeta(1 + \delta^2\lambda)}{\kappa\alpha^2(1 + \gamma^2\lambda) + \zeta \cdot \kappa(\gamma + \delta)^2} \right) \cdot \varepsilon^2 + \quad (18)$$

$$+ \left(\frac{2(\gamma\delta\lambda - 1)}{\kappa\alpha^2(1 + \gamma^2\lambda) + \zeta \cdot \kappa(\gamma + \delta)^2} \right) \cdot \varepsilon\eta + \left(\frac{(1 + \gamma^2\lambda)}{\kappa\alpha^2(1 + \gamma^2\lambda) + \zeta \cdot \kappa(\gamma + \delta)^2} \right) \cdot \eta^2$$

It is obvious that the losses in (17) and (18) are usually not the same. This leads us to ask whether one policy instrument is preferable to the other. While we are unable to answer this question definitively, what we can say is that for a large range of parameters the following pattern holds. When demand shocks dominate, losses are lower when interest rates are the

¹² For i^* there is a unique k for which losses reach a minimum. This minimum is the same as in the simple monetary policy problem. Therefore, for all other k losses are higher.

policy instrument; while for supply shocks, capital requirements deliver the better outcome in many cases.¹³ And, if minimising output variability is important enough (that is, λ is large), interest rates deliver lower losses for both types of shocks.

The intuition for this result is as follows. A positive demand shock increases ρ and, for fixed i , the spread $(\rho - i)$. We know from our earlier discussion that, with the standard objective (10), interest rates or capital requirements would need to rise to stabilise the economy. Using capital requirements to do this, however, increases the spread since this increases loan rates further. In contrast, higher interest rates offset the initial widening in the spread in two ways: through higher funding (policy) rates and through lower lending rates. As a result, for a large range of parameter values interest rates deliver the better outcome.¹⁴

A positive supply shock also increases ρ and the spread $(\rho - i)$. When only considering output and inflation variability, as with the objective function (10), the optimal reaction of interest rates and capital requirements depends on the weight of inflation relative to output. If λ is zero (the case of a strict inflation targeter), interest rates or capital requirements would ease. In this case, moving capital requirements narrow the initial widening of the spread, while moving interest rates exacerbate it. Capital requirements should then be the preferred policy instrument. If λ is large enough, so that policy would seek to tighten in the face of a supply shock, the result reverses, and interest rates become the preferred instrument.

4.2 Two instruments and two objectives

Turning to the case of two instruments, since the objective is complex, including terms representing both macroeconomic and financial stability, it is natural to examine the independent use of the policy instruments to meet possibly independent objectives.

There are three possibilities:

1. In the first (“no coordination”), each policymaker has his or her own objective, and optimises the instrument available to him or her independently. We can show that regardless of which instrument is assigned to which objective – interest rates or capital requirements to macroeconomic or financial stability – the first-best cannot be achieved.
2. In the second (“full coordination”), each policymaker has his or her own instrument and objective, but takes the other policymaker’s action into account. In other words, the externalities created by setting one instrument are taken into account when setting the other. In our framework, the second setup is equivalent to joint optimisation of the broader objective. In this case, it is possible to achieve the same minimum losses as in the simple monetary policy problem.
3. In the third (“partial coordination”), one policymaker moves first, ignoring the subsequent reaction of the other. The second policymaker then sets his or her instrument taking into account the policy decisions of the first mover. We see this game as particularly interesting, as it mirrors the case in which one authority leads, setting capital requirements first (and less frequently) in an effort to achieve a financial stability objective. Then the monetary policymaker follows, setting the interest rate to minimise the traditional macroeconomic stabilisation objective

¹³ This result is reminiscent of the original Poole (1970) conclusion that interest rates dominated monetary aggregates depending on the relative importance of money demand and money supply shocks.

¹⁴ If interest rates have to move by very much, the spread may widen enough in the other direction to overturn this result.

knowing the outcome of the leader's decision. Not surprisingly, the outcome is always inferior to the fully coordinated one. But we are also able to show that the losses in this case can be larger than those in the one with no coordination at all – the first case.

4.2.1 No coordination

Turning to the first setup, we can derive the reaction function and minimal losses, if i targets the monetary policy objective and k targets financial stability by minimising $(\rho - i)^2$.

The reaction function for interest rates is then given by equation (11), setting k to zero.

$$i_{MP, indep}^* = \left(-\frac{\alpha(\omega - b\tau) + \phi(1 - \gamma\delta\lambda)}{\beta\phi(1 + \gamma^2\lambda)} \right) \cdot \varepsilon + \frac{1}{\beta} \cdot \eta. \quad (19)$$

The reaction function for k is given by

$$k_{FS, indep}^* = -\frac{(\delta\varepsilon + \gamma\eta)(\omega - b\tau)}{(\gamma + \delta)\kappa}. \quad (20)$$

In this case, because monetary policymakers have not taken account of the changed capital requirements, the losses for the monetary policy objective will be higher than in (13). For a demand shock, for example, interest rates will do too little: they offset the stimulatory effect of the shock, but not the further stimulus from the lower capital requirements (20). For a supply shock, interest rates do too much if interest rates would have to fall following a positive shock (for example, in the case of an inflation targeter) or too little if interest rates had to rise (high weight on output variability); in both cases, the problem is that lower capital requirements have not been taken into account. Similarly, the financial stability outcome could have been improved taking into account the impact on the objective that changes in interest rates have.

Of course, a similarly suboptimal outcome arises if we use capital requirements to address monetary policy objectives and interest rates to address the financial stability objective. In this case k^* is given by equation (12) with i equal to zero,

$$k_{MP, indep}^* = \left(-\frac{\alpha(\omega - b\tau) + \phi(1 - \gamma\delta\lambda)}{\alpha\kappa(1 + \gamma^2\lambda)} \right) \cdot \varepsilon + \frac{\phi}{\alpha\kappa} \cdot \eta \quad (21)$$

and the reaction function of i minimising the financial stability objectives is given by

$$i_{FS, indep}^* = \frac{(\delta\varepsilon + \gamma\eta)(\omega - b\tau)}{(\alpha + \beta)\gamma(\omega - b\tau) + \phi(\gamma + \delta)}. \quad (22)$$

Again, both policymakers could do better.

4.2.2 Full coordination

This all suggests that the outcome can be improved by coordination where each instrument is set taking account of the impact of the other. And it can.

To see the point, consider choosing i and k simultaneously to minimise the loss function (14). The result is:

$$i_{joint, Coop}^* = \left(-\frac{(1 - \gamma\delta\lambda)}{(\alpha + \beta)(1 + \gamma^2\lambda)} \right) \cdot \varepsilon + \left(\frac{1}{(\alpha + \beta)} \right) \cdot \eta. \quad (23)$$

$$k_{joint, Coop}^* = \left(-\frac{(\alpha + \beta)(\omega - b\tau) + \phi(1 - \gamma\delta\lambda)}{(\alpha + \beta)\kappa(1 + \gamma^2\lambda)} \right) \cdot \varepsilon + \frac{\phi}{(\alpha + \beta)\kappa} \cdot \eta. \quad (24)$$

The loss in equilibrium is the same as the minimum loss from the monetary policy problem in Section 3 described in (13). That is,

$$L_{\text{joint, coop}}^* = \left(\frac{\varepsilon^2 \lambda}{1 + \gamma^2 \lambda} \right) \text{ for } i = i_{\text{joint, coop}}^* \text{ and } k = k_{\text{joint, coop}}^*. \quad (25)$$

When externalities are fully internalised, the financial stability objective is fully achieved (the loss is zero) while the monetary policy losses are at the minimum given by the basic output-inflation variability trade-off. Importantly, however, here the outcome can only be achieved by the unique setting of k and i at their optima, while in the earlier case an infinite number of combinations yielded the same minimum loss.

Two additional observations are worth making before continuing. First, we could set up the coordination problem as one in which two actors minimise two separate objectives, but take account of the other's reaction function. The outcome would be the same as in (23) and (24). And, interestingly, in this case it makes no difference which policymaker has which tool: the optimal value (and the loss) is always the same (remember that both tools can affect both objectives). Second, while in our model coordination can yield financial stability, the fundamental trade-off of the monetary policy problem remains. This may be different in a more elaborate model, where financial stability concerns create additional instability in output and inflation, and therefore addressing financial stability removes one source of macroeconomic instability.

4.2.3 Partial coordination

A third setup for coordination is a "leader-follower" scenario: one policymaker sets his or her instrument independently of the other instrument, and then the second policymaker takes the actions of the first into account. In terms of coordination, this solution is midway.

To evaluate the outcome of such policy reaction functions, we assume that the "leader" is the policymaker that sets capital requirements to achieve the financial stability objective. The reaction function for capital requirements is then given in (20).

$$k_{FS, \text{leader}}^* = k_{FS, \text{indep}}^* = - \frac{(\delta \varepsilon + \gamma \eta)(\omega - b \tau)}{(\gamma + \delta) \kappa}. \quad (26)$$

The monetary policymaker sets interest rates to minimise his or her loss function, knowing that capital requirements will be set according to (26). The result is a special case of equation (11):

$$i_{MP, \text{Follower}}^* = \left(\frac{\alpha \gamma (\omega - b \tau) + \phi(\gamma + \delta)}{\beta \phi (1 + \gamma^2 \lambda)(\gamma + \delta)} \right) \cdot \left(-(1 - \gamma \delta \lambda) \cdot \varepsilon + (1 + \gamma^2 \lambda) \cdot \eta \right) \quad (27)$$

Losses for this set of reaction functions are then:

$$L_{MP, \text{Follower}}^* = \left(\frac{\varepsilon^2 \lambda}{1 + \gamma^2 \lambda} \right). \quad (28)$$

$$L_{FS, \text{Leader}}^* = \left(\frac{(\alpha + \beta) \gamma (\omega - b \tau) + \phi(\delta + \gamma)}{\beta \phi (1 + \gamma^2 \lambda)(\gamma + \delta)} \right)^2 \cdot \left(-(1 - \gamma \delta \lambda) \cdot \varepsilon + (1 + \gamma^2 \lambda) \cdot \eta \right)^2. \quad (29)$$

Not surprisingly, the loss function for the second mover is at the minimum, the basic trade-off for monetary stability in this case. The outcome for the first policymaker, however, could be further reduced by internalising the remaining externality. In the cases we consider, where parameters take non-zero values, financial stability losses are higher than in the case of joint optimisation. So, the sequential-decision outcome will always be inferior to the fully

coordinated one. Not only that, but we are also able to show that the losses in this case can be larger than those with no coordination – the first case.

4.2.4 Discussion

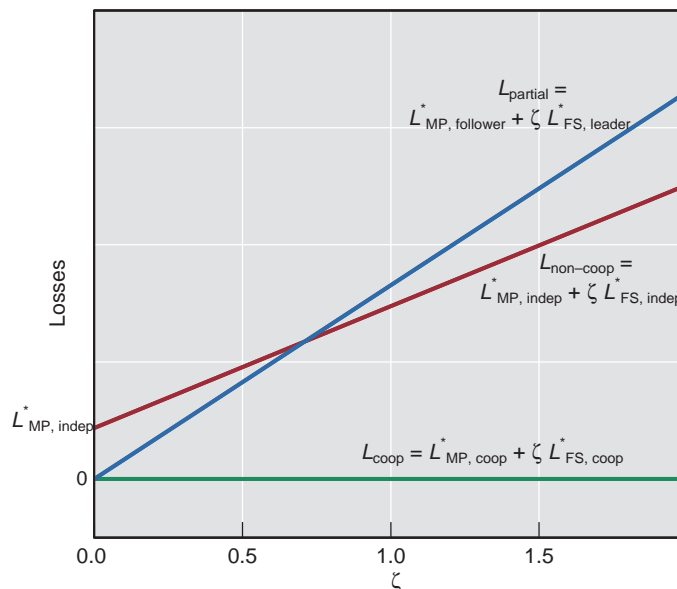
It is worth taking a minute to compare the cases of partial and no coordination. We do this in two steps, first considering the consequences of a demand shock, and then moving on to the case of a supply shock.

Following a demand shock (η), in the full coordination case, the loss is zero. That is, a policymaker controlling both the interest rate and capital requirement, and concerned about the combined objective (14), can neutralise a demand shock. But with either partial or no coordination, there will be a loss. The size of the loss depends on various parameter settings in the model. In addition to the obvious ones – the weights on output and spread variability (λ and ζ) – the loss will depend on the slopes of aggregate demand and aggregate supply given by δ and γ in equations (1) and (5). But, importantly, there is a large set of parameter values for which the leader-follower case yields a larger loss than the case with no coordination at all.

Graph 1 depicts a representative case for $\eta = 1$ and $\varepsilon = 0$. Here, we have set $\lambda = 1$, so the inflation and output variability have equal weight in the loss function. Next, we set the inflation elasticity of aggregate demand and supply equal to 0.1 and 0.1, respectively. Looking at the graph, note first that the loss with full coordination, the green line, is flat at zero. But the slope of the blue line for the leader-follower case is steeper than that for the case with no coordination. As a result, the lines cross. In this example, when the weight on the spread in the objective (ζ) is greater than about 0.7, partial coordination is worse than no coordination at all.

Graph 1

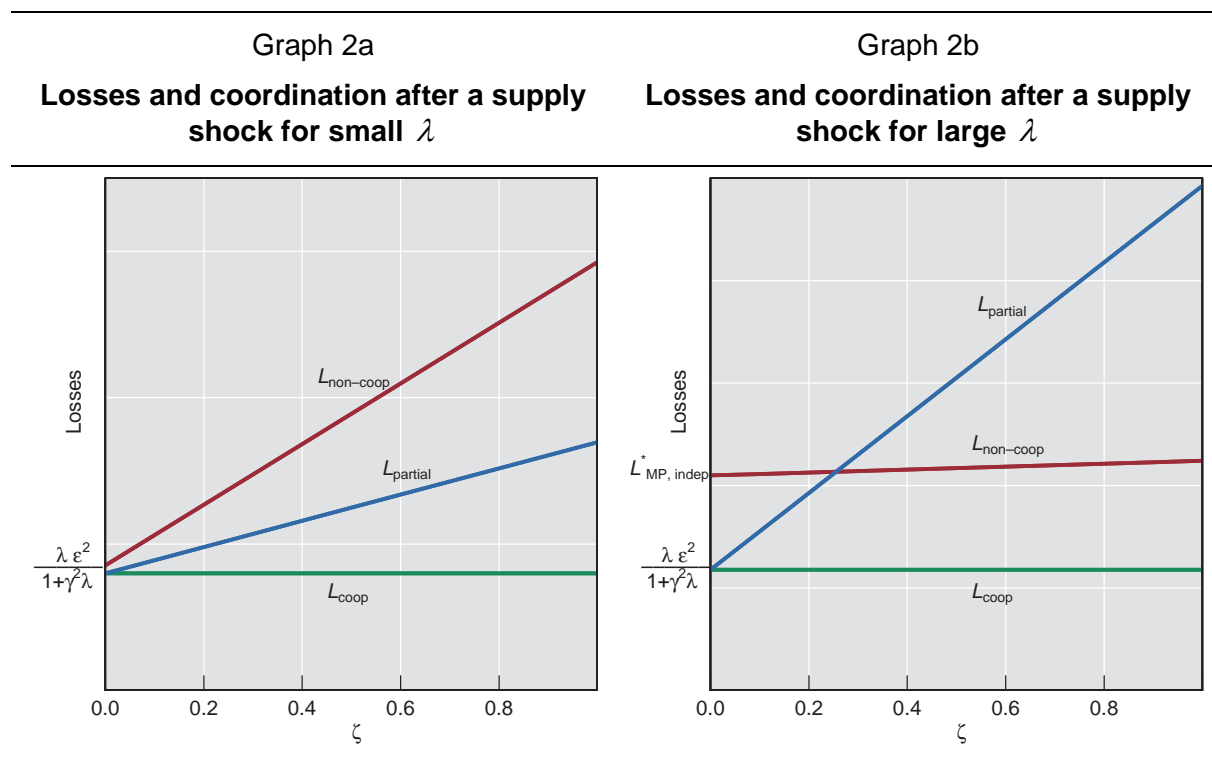
Losses and coordination after a demand shock



To see why this happens, consider the financial stability objective and the monetary stability objective in turn. First, as discussed above, with no coordination, as a consequence of the externality imposed by the authority with financial stability authority, the monetary policymaker responsible for the traditional portion of the objective function cannot fully

neutralise a demand shock. In contrast, under partial coordination the monetary policymaker can fully neutralise the shock, accounting for the externality of the actions by the other policymaker. That means that, so long as $\varepsilon=0$, $L_{MP, Follower}^* = L_{MP, coop}^* = 0$. Furthermore, in the leader-follower setup, the amount by which the interest rate is adjusted will be different than in the case with no coordination. To see this, recall that after a positive demand shock, output, prices and the spread all increase. In response to the last of these, the spread increase, capital requirements should fall. This, however, increases output and prices by even more. Knowing this, the monetary policymaker will increase interest rates by more than he or she would in the case with no coordination at all. This, in turn, moves the spread even further away from the steady state. If the weight on financial stability, ζ , is high enough (in our example in Graph 1, above 0.7), the lower losses for the monetary objective will not outweigh the higher losses for the financial stability objective in the sequential-decision equilibrium (relative to the non-coordinated case), and overall losses will then be larger than if there was no coordination at all.

This description makes clear that the threshold value of ζ beyond which partial coordination is worse than no coordination depends on the extent to which the monetary policymaker moves the interest rate in reaction to a demand shock. This, in turn, is a function of the degree to which the demand shock moves output and inflation away from the steady state levels and the relative weight the policymaker places on the two parts of the loss function. It is straightforward to show two things. First, as λ rises, so does the threshold value of ζ . Second, as the slopes of the aggregate demand and supply curves rise, the interest rate reacts more to a demand shock, so the threshold value of ζ goes down. If, for example, we were to set all of these parameters – λ , δ and γ – equal to one, then the threshold value for ζ would be close to zero.



Turning to the case of a supply shock, things are a bit more complicated. First, the full coordination solution yields a positive loss, as there is no longer any way to fully neutralise the impact. (The value, $L_{joint, coop}^*$, is given by equation (25).) But, more importantly, there is

now a threshold value for λ below which partial coordination always yields a lower loss than no coordination. The two panels of graph 2 show what happens when $\varepsilon = 1$ and $\eta = 0$. On the left, for a low level λ , the blue and red lines do not cross. Again, the aggregate demand and supply curve slopes are critical. For the case in Graph 2, when these parameters equal one (and for a broad set of the rest of the parameters in the model), the threshold value for λ is close to one. As δ and γ go down, the critical value for λ goes up. For example, if $\lambda = \delta = 0.1$, the threshold for λ is above 100. In the example of Graph 2, $\lambda = 0.75$, $\delta = 0.5$, and the threshold for λ to move from the case on the left panel to the one in the right is 3.3.¹⁵

Why, in the case of a supply shocks, are the leader-follower losses lower than those with no coordination when the weight on output stabilisation, λ , is low? To understand this result, recall that in this case, in response to a positive supply shock that lowers inflation interest rates need to fall. Lower interest rates mean higher output and a bigger spread. Capital requirements will then react, falling to lower the spread. But this means that capital requirements are doing some of the job of the interest rate on the monetary stability front, so interest rates will fall by less than they would have in the absence of the capital requirement response. This means there is a smaller spillover from the monetary policymaker to the financial stability objective. And, as we discussed above, for the monetary stability objective, losses in the leader-follower case are always below those in the non-coordinated case. In this case, the sequential-decision equilibrium delivers better outcomes than the equilibrium without coordination, irrespective of the weight on the financial stability objective.

But, if the weight on output stabilisation is high, so λ is large, the results are the same as for the demand shock case. In this case, following a supply shock, the monetary policymaker will want to increase interest rates to reduce the impact on output. Graph 2b then looks just like Graph 1, so sequential-decision-making delivers a worse outcome than no coordination at all when the weight on financial stability is sufficiently high.¹⁶

All of this leads us to conclude that partial coordination is risky. Not only do the potential benefits depend on difficult-to-assess aggregate demand and supply curve slopes, and the weights on the various elements in the policymakers' loss function, but also on the relative variances of demand and supply shocks. In the case we see as most likely, where demand shocks are important and the weight on financial stability, ζ , is large, the solution with no coordination yields a better outcome.

5. Implications for the design of a framework for macroeconomic stability

In this paper, we use a simple macroeconomic model to study the substitutability of interest rates and capital requirements. We find that in our simple model they are full substitutes for achieving a standard monetary policy objective of output and price stability. If the ability to

¹⁵ More generally, in the case of a supply shock, the shift from Graph 2a to Graph 2b depends on whether $\lambda > \frac{1}{\gamma\delta} \left[1 + \left(\frac{\alpha(\omega - b\tau)(\gamma + \delta)}{\alpha\gamma(\omega - b\tau) + 2\phi(\gamma + \delta)} \right) \right]$. For λ above this threshold value, there is a threshold value of ζ beyond which partial coordination is worse than no coordination at all.

¹⁶ In the case of supply shocks, the threshold value of ζ depends on λ . For λ close to its own threshold value (that yields the case in Graph 2b), the threshold ζ initially falls with larger λ before increasing again.

use one is limited, the other can “finish the job”. This result stems from the similarity of the transmission mechanism of the two instruments.

Introducing a financial stability objective affects the substitutability of interest rates and capital requirements. However, the fundamental linkages between these two instruments and any associated objectives remains. These relationships create scope for improving macroeconomic (and financial stability) outcomes through coordination of the instruments. Once fully coordinated, the substitutability reappears differently: it is not important which policymaker uses which instrument as long as their use is coordinated.

We find, however, that the type of coordination matters: if financial stability is important enough, a framework of partial coordination, where the policymaker responsible for financial stability moves first, may deliver worse outcomes than one where both policymakers move simultaneously (as in this case they do not take each other’s reaction into account).

While we identify a coordination problem, its empirical relevance depends on a number of factors. Even for our simple model, there are parameterisations where the coordination gains are small. More importantly, however, our analysis is restricted to a specific type of financial stability: one based on financial frictions that can be measured by an interest rate spread. So, our discussion of financial stability is closer to that associated with the possibility of formulating cyclical capital requirements than it is with work aimed at modifying the structure of the financial system to increase its ability to withstand systemic shocks.

Another aspect of our findings concerns the appropriate choice of instrument for each policy objective. We should be open as to which instrument serves which objective, based on the best possible outcome and not on which system we inherited: interest rates may well be the better instrument to address financial stability, just as prudential instruments could be used for macroeconomic stabilisation.

If we think that financial instability is largely a result of idiosyncratic or sector-specific shocks, then capital requirements may well be the better tool to address it. On the other hand, interest rates can reach those parts of financial intermediation that are not bank-based, allowing policymakers to influence the behaviour of institutions that escape the regulatory perimeter. Building models that integrate more complex financial structures, helping build the policy infrastructure as well as inform policy actions, must be at the top of the research agenda for macroeconomists.

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