The Relation Between Monetary and Macroprudential Policy

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Contents

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This paper analyzes the interaction between monetary and macroprudential policies with different levels of cooperation among policy authorities: non-cooperation, full cooperation, and leader-follower relation.

In non-cooperation, each policy authority's optimal response is to tighten its policy measures when the inflation gap, the output gap and the credit gap expand, and when other authorities' policy measures are loosened. This indicates that the two policies are substitutes for each other. The condition for the response functions to converge to a Nash equilibrium and the speed of convergence depend on the authorities' preferences and the economic structure. If the financial supervisory authority (FSA) puts greater importance on the output gap, the probability of non-convergence increases and the speed of convergence declines even when the condition of convergence is satisfied. When the policy authorities fully cooperate with each other, they can establish an optimal combination of policy responses to each of the three gaps.

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Ⅰ. Introduction

Since the global financial crisis, many central banks around the world have introduced financial stability as one of their key mandates. This is mainly driven by the change in policymakers' views that a central bank's role is very important in achieving macroprudential soundness in the economy. Especially when there is either too much or too little credit supply in financial markets, there has been a growing demand for aggressive actions by central banks.

On the other hand, it is expected that policy authorities around the world will introduce counter-cyclical capital buffers (CCB) in the near future. The main purpose of the CCB is to accumulate capital buffer during boom periods, which can be used to protect banks and help them carry out their financial intermediation functions steadily even during periods of recession. One of the other important aims of the CCB is to reduce the build-up of financial risks in advance.

As the levels of required CCB can vary over business cycles or credit cycles, it is evident that the CCB policy affects output and inflation, which are the main target variables for monetary policy. This makes the coordination between macroprudential policy and monetary policy one of the most important tasks for policymakers.

There has been some research on the coordination between monetary and macroprudential policies. Some studies analyze this coordination with DSGE models. For example, Angelini et al. (2012), using a DSGE model with the banking sector, analyze the European financial market and argue that macroprudential policies are beneficial especially when there are shocks in the financial or housing markets rather than shocks from the supply side. Beau et al. (2012), with a DSGE model for the euro area, find that macroprudential policies have either a limited or a stabilizing effect on inflation. Paoli and Paustian (2013) set a DSGE model with nominal rigidities and credit constraints, and find that if faced with cost-push shocks, policy authorities need to cooperate and commit to a given course of action to maximize social welfare.

Though these DSGE models are capable of measuring the relative effectiveness of macroprudential policies compared to monetary policies, they have limitations in analysing one policy authority's response to the other's actions, apart from the fact that the results depend on parameter calibration.

The second strand of studies in this area directly derive agents' response functions. Cecchetti and Kohler (2014), using a simple model, analyze the behavior of policy authorities. They find that capital adequacy requirements and policy interest rates might be substitutes for each other in meeting the objective of stabilizing price and output volatility, while the relation does not hold when policymakers try to achieve financial stability as well as price and output stability at the same time. Due to this relation, they argue that policymakers need to coordinate macroprudential and monetary policy. Using a model with fiscal and monetary authorities, Davig and Gürkaynak (2015) show that assigning multiple mandates to CBs may reduce other policymakers' incentives to actively use their policy tools in addressing their primary objectives, raising the possibility of a lower level of social welfare. Their result can also be applied to the relation between monetary policy and macroprudential policy. On the other hand, Smets (2014) mentions that if macroprudential instruments are not effective, then monetary policy instruments can be used to stabilize the financial market.

In many papers, including Cecchetti and Kohler (2014) and Paoli and Paustian (2013), loan interest rates or the gap between loan interest rates and the policy interest rate are used as a financial stability indicator. What brings about a financial market crisis is an excessive expansion of credit supply rather than of credit demand. Considering that the gap between loan interest rates and the policy interest rate tends to expand when loan supply as well as loan demand increase, responding to changes in the gap may mislead policymakers. As a financial stability indicator, this paper employs the credit to GDP ratio. Drehmann et al. (2011) and Drehmann and Juselius (2013) from the BIS suggest that it is desirable to use the credit to GDP ratio, as it performs better than any other indicator in predicting a financial crisis. When credit demand expands, both the numerator and denominator of the credit to GDP ratio tend to increase simultaneously, leaving the ratio relatively stable. These authors also propose that in order to remove the effects of structural changes in the financial market, the cyclical components of the credit to GDP ratio need to be used as an indicator for financial stability.

This paper derives policy response functions from a simple model, as in the second strand of studies. The model is composed of the IS curve equation, the Phillips curve equation, and the credit to GDP ratio equation. There are two types of policy authorities: monetary and financial supervisory. As policy instruments, the central bank (CB) has the policy interest rate, and the financial supervisory authority (FSA) has the counter-cyclical capital ratio. Each policy authority has its own loss function and exercises its policy measure to minimize loss. Solving the minimization problem of each policymaker's loss function provides their policy response functions, which are expressed in terms of the inflation gap, the output gap, the credit gap and the other policymaker's policy measure.

First, as in Cecchetti and Kohler (2014), this paper shows whether monetary and macroprudential policies can be substituted for each other. Second, this paper examines whether the two policy response functions converge to one point, and finds that the condition of convergence depends on the policymakers' objectives and the structure of the economy. A non-convergence outcome can happen when the FSA puts too much importance on output gap stability in its loss function or when a stronger financial stability mandate is assigned to the CB, which does not have proper macroprudential tools besides the policy interest rate. Finally, this paper compares the effectiveness of assigning mandates to each of the policy authorities, which have a limited number of policy measures. It finds that assigning a small number of mandates is more efficient than assigning a large number of them, as the speed of convergence to the equilibrium is slower in the latter case than in the former. Thus, this result is broadly in line with that from Davig and Gürkaynak (2015). However, if there is uncertainty in the effectiveness of policy instruments or in the objectives of each policy authority, then it may be more effective for each authority to pursue multiple objectives rather than a single objective, as mentioned by Smets (2014).

Ⅱ. Policy Authorities' Optimal Behavior

1. The structure of the model

The model construction employs the equations for the IS curve and the Phillips curve, along with the equation for the credit to GDP ratio. Considering that generally, economic agents forecast future inflation based on information available at a current point in time, a forward looking IS curve is introduced.1) Output (y_{t+1}) is affected by the real policy interest rate $(i_t - E_t[\pi_{t+1}])$ and the credit to GDP ratio (cyr_{t+1}),2) inflation (π_{t+1}) by the output gap $(y_{t+1} - y^n_{t+1})$ and the credit to GDP ratio,3) and the credit to GDP ratio by the real policy interest rate and the regulatory capital ratio (car_t).4) The two policy measures, the nominal policy interest rate (i_t) and the regulatory capital ratio, affect the three endogenous variables — output, inflation, and credit to GDP ratio — with a time lag. Policymakers adjust their instruments preemptively on the basis of their expectations for the next period's output gap, inflation gap and credit to GDP ratio gap (credit gap hereafter).

<IS curve>

$$y_{t+1} = a_0 + a_1 y_t - a_2(i_t - E_t[\pi_{t+1}]) + a_3 cyr_{t+1} + \epsilon_{y,t+1} \tag{1}$$

<Phillips Curve>

$$\pi_{t+1} = b_0 + b_1\pi_t + b_2(y_{t+1} - y^n_{t+1}) + b_3 cyr_{t+1} + \epsilon_{\pi,t+1} \tag{2}$$

<Credit to GDP ratio (cyclical part)>

$$cyr_{t+1} = c_0 + c_1 cyr_t - c_2(i_t - E_t[\pi_{t+1}]) - c_3 car_t + \epsilon_{c,t+1} \tag{3}$$

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1) This is also useful in incorporating the effects of the forward guidance of monetary policy into the model.

2) This is in line with the fact that monetary policy affects the real economy through the interest channel and the credit channel.

3) As credit and liquidity (or money) are two sides of the same coin, an increase in credit tends to raise inflation, fitting into the quantity theory of money.

4) x^n_{t+1} is denoted as the potential, natural or target value of x_{t+1}.

After predicting both sides of equations (1) ~ (3), the expected values of the three endogenous variables can be derived in terms of the two policy measures as the following equations (4) ~ (6).

$$E_t[\pi_{t+1}] = (1/\Phi)(B_{\pi,0} - B_{\pi,i}\, i_t - B_{\pi,c}\, car_t) \tag{4}$$

$$\Phi = 1 - (b_3 c_2 + b_2 a_2 + b_2 a_3 c_2)$$
$$B_{\pi,0} = (b_0 + b_2 a_0 + (b_3 + b_2 a_3) c_0 + b_1 \pi_t + b_2 (a_1 y_t - y^n_{t+1}) + c_1 (b_3 + b_2 a_3) cyr_t$$
$$B_{\pi,i} = (b_3 c_2 + b_2 a_2 + b_2 a_3 c_2),\ B_{\pi,c} = (b_3 c_3 + b_2 a_3 c_3)$$

$$E_t[y_{t+1}] = (1/\Phi)(B_{y,0} - B_{y,i}\, i_t - B_{y,c}\, car_t) \tag{5}$$

$$B_{y,0} = (a_0 + a_2 b_0 + a_3 c_0 + a_3 c_2 b_0 + a_2 b_3 c_0 - a_0 b_3 c_2) + b_1 (a_2 + a_3 c_2) \pi_t$$
$$+ a_1 (1 - b_3 c_2) y_t - b_2 (a_2 + a_3 c_2) y^n_{t+1} + c_1 (a_3 + a_2 b_3) cyr_t$$
$$B_{y,i} = (a_3 c_2 + a_2),\ B_{y,c} = (a_3 c_3 + a_2 b_3 c_3),$$

$$E_t[cyr_{t+1}] = (1/\Phi)(B_{c,0} - B_{c,i}\, i_t - B_{c,c}\, car_t) \tag{6}$$

$$B_{c,0} = (c_0 + c_2 b_0 + c_2 b_2 a_0 - c_0 b_2 a_2) + c_1 (1 - b_2 a_2) cyr_t + c_2 b_1 \pi_t + b_2 c_2 (a_1 y_t - y^n_{t+1})$$
$$B_{c,i} = c_2,\ B_{c,c} = c_3 (1 - a_2 b_2)$$

The sign Φ in the above three equations and $(1 - a_2 b_2)$ in equation (6) need to be positive for the effects of the policy interest rate and the regulatory capital ratio on output, inflation and the credit to GDP ratio to have the expected signs.

Let $E_t[\widetilde{x_{t+1}}]$ be the expected value of x_{t+1} at time t, when $\triangle i_t = 0$ and $\triangle car_t = 0$, which means that there is no change in the policy measures from the previous period. Let $\triangle i_t$ be $i_t - i_{t-1}$ and $\triangle car_t$ be $car_t - car_{t-1}$. Then, the expected values of the above three endogenous variables can be expressed in terms of their values in case of no policy change and changes in the policy variables as the following functions (7) ~ (9).

$$E_t[\pi_{t+1}] = E_t[\widetilde{\pi_{t+1}}] - (B_{\pi,i}/\Phi)\triangle i_t - (B_{\pi,c}/\Phi)\triangle car_t \tag{7}$$

$$E_t[y_{t+1}] = E_t[\widetilde{y_{t+1}}] - (B_{y,i}/\Phi)\triangle i_t - (B_{y,c}/\Phi)\triangle car_t \tag{8}$$

$$E_t[cyr_{t+1}] = E_t[\widetilde{cyr_{t+1}}] - (B_{c,i}/\Phi)\triangle i_t - (B_{c,c}/\Phi)\triangle car_t \tag{9}$$

2. Non-cooperation equilibrium

A. The central bank's behavior

In a non-cooperative situation, each policy authority observes the other's behavior and makes decisions to maximize its own utility function. When the financial stability mandate is assigned to a CB, its objective can be described as minimizing the inflation gap, the output gap and the credit gap as the following equation (10).[5)6)] γ and δ refer to the weights for the output gap and the credit gap, respectively.

$$\begin{aligned} \min\ LS_t = & (E_t[\pi_{t+1}] - \pi^n_{t+1})^2 + \gamma(E_t[y_{t+1}] - y^n_{t+1})^2 + \delta(E_t[cyr_{t+1}] \\ & - cyr^n_{t+1})^2 \end{aligned} \tag{10}$$

w.r.t. $\triangle i_t$

The optimal policy interest rate, which minimizes the above loss function, is expressed as the following equation (11) in terms of the inflation gap, the output gap, the credit gap and the regulatory capital ratio.

$$\begin{aligned} \triangle i_t^{CB*} = & \nu_\pi(E_t[\widetilde{\pi_{t+1}}] - \pi^n_{t+1}) + \nu_y(E_t[\widetilde{y_{t+1}}] - y^n_{t+1}) + \nu_c(E_t[\widetilde{cyr_{t+1}}] - cyr^n_{t+1}) \\ & - \nu_{car}\triangle car_t \end{aligned} \tag{11}$$

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5) The credit gap refers to the difference between the credit to GDP ratio and its long term trend or target level set by the authorities.

6) Cúrdia and Woodford (2009) mention that this type of loss function can be obtained when there are financial frictions. On the other hand, we can also use this type of loss function just assuming that the CB has the three mandates and acts according to the Taylor type rule.

$$\nu_\pi = (1-\Phi)^2\Phi/\widetilde{A},\ \ \nu_y = \gamma(a_2+a_3c_2)\Phi/\widetilde{A},\ \ \nu_c = \delta c_2\Phi/\widetilde{A},$$
$$\nu_{car} = c_3\left((1-\Phi)(b_3+a_3b_2)+\gamma(a_3+a_2b_3)(a_2+a_3c_2)+\delta c_2(1-a_2b_2)\right)/\widetilde{A}$$
$$\widetilde{A} = \left((1-\Phi)^2+\gamma(a_2+a_3c_2)^2+\delta(c_2)^2\right)$$

Equation (11) shows that the CB raises the policy interest rate in response to an expansion in the inflation gap, the output gap and the credit gap. And, as either the weight of the output gap (γ) or that of the credit gap (δ) in the loss function rises, the intensity of response of the policy interest rate to each gap (ν_y, ν_c) becomes stronger. When there is a rise in the regulatory capital ratio, the CB cuts its policy interest rate, which implies there is a substitutive relation between the two policies. Contrary to the results shown by Cecchetti and Kohler (2014), the substitutive relation holds even when the financial stability mandate is included in the CB's loss function. This is because the policy interest rate and the regulatory capital ratio affect the credit gap in the same direction.[7)]

Compared to the situation where the CB does not have a financial stability objective ($\delta = 0$), the intensity of response of the policy interest rate to the output gap and the inflation gap becomes smaller.[8)] By responding to the credit gap, the CB can reduce the need to strongly respond to the output gap and the inflation gap, as the shrinkage of the credit gap tends to reduce the other two gaps. Meanwhile, the intensity of response of the policy interest rate to changes in the regulatory capital ratio (ν_{car}) becomes larger when the financial stability objective is included.[9)]

B. The financial supervisory authority's behavior

The FSA may have different objectives from the CB, and its decision and optimal behavior tend to vary depending on its objectives. This section considers three cases according to the number of the FSA's objectives.

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7) Cecchetti and Kohler (2014) use the gap between loan interest rates and the policy interest rate as an indicator for financial stability. In their model, a rise in the policy interest rate reduces the gap, while a rise in the regulatory capital ratio expands the gap.

8) The value of $\widetilde{A}$ in equation (11) becomes larger as $\delta(c_2)^2$ is included.

9) $\partial\nu_{car}/\partial\delta = a_2c_2c_3\Phi\left(b_2(1-\Phi)+\gamma(a_2+a_3c_2)\right)/(\widetilde{A})^2 > 0$

(1) The FSA's objective 1: achieving financial stability

When the FSA has the single objective, lessening credit gap volatility, its loss function can be set as the following equation (12).

$$\min \ L_t^{FS} = (E_t[cyr_{t+1}] - cyr_{t+1}^n)^2 \quad (12)$$
$$\text{w.r.t. } \triangle car_t$$

The optimal regulatory capital ratio is derived as a function of the credit gap and the policy interest rate.

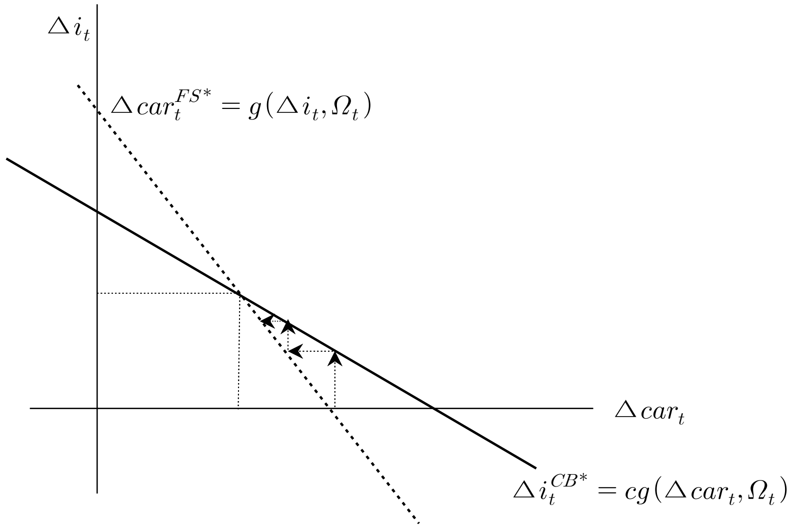
$$\triangle car_t^{FS*} = \frac{\Phi(E_t[\widetilde{cyr_{t+1}}] - cyr_{t+1}^n) - c_2 \triangle i_t}{c_3(1 - a_2 b_2)} \quad (13)$$

Equation (13) shows that as the effect of the regulatory capital ratio on the credit to GDP ratio (c_3) increases, the intensity of responses of the regulatory capital ratio to the credit gap and to the policy interest rate decreases. The FSA reduces its regulatory capital ratio when the policy interest rate is raised. This is because a rise in the policy interest rate can bring about a shrinkage in the credit gap. With the CB's policy interest rate and the FSA's regulatory capital ratio changes affecting each other, the movements can either converge to an equilibrium or diverge as time passes.

The condition for converging to an equilibrium can be expressed as the following equation (14). The speed of convergence becomes faster as the value of equation (14) increases.[10)]

10) For convergence, the slope of the response function of the policy interest rate ($=\partial \triangle i_t^{CB*} / \partial \triangle car_t$) in Figure (1) needs to be smaller than that of the regulatory capital ratio ($=1/(\partial \triangle car_t^{FS*} / \partial \triangle i_t)$), which means that the relation $\partial \triangle i_t^{CB*} / \partial \triangle car_t < 1/(\partial \triangle car_t^{FS*} / \partial \triangle i_t)$ needs to hold. Meanwhile, as the difference between the slopes of the two response functions expands, the value of equation (14) increases and the speed of convergence becomes faster.

Figure 1: The Response Functions of the CB and the FSA



Note: The solid (dotted) line is the response function of the CB (the FSA) and Ω_t is the set of information available at time t.

$$1-\left(\frac{\partial\triangle i_t^{CB*}}{\partial\triangle car_t}\right)\left(\frac{\partial\triangle car_t^{FS*}}{\partial\triangle i_t}\right) > 0 \tag{14}$$

In this situation, where the FSA focuses on reducing credit gap volatility, the condition of convergence is satisfied as the following equation (15) is always positive.

$$1-\left(\frac{\partial\triangle i_t^{CB*}}{\partial\triangle car_t}\right)\left(\frac{\partial\triangle car_t^{FS*}}{\partial\triangle i_t}\right) = \frac{a_2 b_2(1-\Phi)+\gamma a_2(a_2+a_3 c_2)}{\widetilde{A}(1-a_2 b_2)} > 0 \tag{15}$$

As the FSA uses one instrument to achieve one goal in this case, at the equilibrium, the credit gap converges to zero. The speed of convergence, however, may differ depending on the preferences and parameter values. If the weight of the output gap (γ) in the CB's loss function increases or that of the credit gap (δ) decreases, the speed of convergence becomes faster.[11)]

11) The partial derivatives of the right hand side of the equation (15) with respect to γ and δ have a positive sign and a negative one, respectively.

(2) Objective 2: achieving financial and output stability

In this case, the FSA's loss function is expressed as a function of output gap volatility as well as credit gap volatility.

$$\min \; L_t^{FS} = (E_t[y_{t+1}] - y_{t+1}^n)^2 + \kappa (E_t[cyr_{t+1}] - cyr_{t+1}^n)^2 \quad (16)$$
$$\text{w.r.t. } \triangle car_t$$

When the FSA has a keen interest in microprudential stability, supporting individual banks' profitability is important, which can again be backed by improving overall business activity. In this sense, the FSA may have a great deal of interest in reducing the output volatility relative to credit volatility, causing the value of κ in equation (16) to become small.[12] The solution of the loss-minimizing function (16) produces the optimal regulatory capital ratio in terms of the credit gap, the output gap and the policy interest rate.

$$\triangle car_t^{FS*} = \frac{(a_3 + a_2 b_3)(E_t[\widetilde{y_{t+1}}] - y_{t+1}^n) + \kappa(1 - a_2 b_2)(E_t[\widetilde{cyr_{t+1}}] - cyr_{t+1}^n) - \tau_i \triangle i_t}{c_3\left[\kappa(1 - a_2 b_2)^2 + (a_3 + a_2 b_3)^2\right]} \quad (17)$$

$$\tau_i = \kappa c_2 (1 - a_2 b_2) + (a_3 + a_2 b_3)(a_2 + a_3 c_2)$$

The condition for convergence of the response functions can be expressed as the following equation (18). It can be satisfied only when the value of $\kappa \xi_1$ in the numerator of the right-hand side of equation (18) is greater than the value of ξ_2.

$$1 - \left(\frac{\partial \triangle i_t^{CB*}}{\partial \triangle car_t}\right)\left(\frac{\partial \triangle car_t^{FS*}}{\partial \triangle i_t}\right) = \frac{a_2 \Phi (\kappa \xi_1 - \xi_2)}{\widetilde{A}\left[\kappa(1 - a_2 b_2)^2 + (a_3 + a_2 b_3)^2\right]} \quad (18)$$

$$\xi_1 = (1 - a_2 b_2)\left[(\gamma + (b_2)^2)(a_3 c_2 + a_2) + b_2 b_3 c_2\right]$$
$$\xi_2 = (a_3 + a_2 b_3)\left[(b_3)^2 c_2 + a_2 b_2 b_3 + a_3 b_2 b_3 c_2 + \delta c_2\right]$$

12) As the FSA is a government body influenced by national elections, it may have short-sighted views, putting greater importance on output growth than on financial market stabilization.

When the FSA has more interest in output stability than in financial stability, the value of κ becomes smaller, increasing the possibility of non-convergence.[13] This result implies that it is desirable for macroprudential measures to be used primarily for lessening the credit gap, but not for the output gap. Meanwhile, when the CB has a strong mandate of financial stability, the values of δ and ξ_2 in equation (18) become larger, increasing the likelihood of non-convergence. Either an increase in the value of δ or a decrease in κ also tends to reduce the speed of convergence to an equilibrium.[14] A large value of γ means that the CB considers output stability as an important task. The relation in equation (18) indicates that if the value of γ increases, the probability of convergence and the speed of converging to an equilibrium tend to rise.

(3) Objective 3: achieving financial, output, and inflation stability

In this case, the FSA has the same loss function as the CB as in equation (10), and uses the regulatory capital ratio to minimize the function. The FSA's optimal regulatory capital ratio is obtained as equation (19).

$$\begin{aligned}\triangle car_t^{FS*} &= \rho_\pi \left(E_t[\widetilde{\pi_{t+1}}] - \pi_{t+1}^n\right) + \rho_y\left(E_t[\widetilde{y_{t+1}}] - y_{t+1}^n\right) \\ &\quad + \rho_c\left(E_t[\widetilde{cyr_{t+1}}] - cyr_{t+1}^n\right) - \rho_i \triangle i_t \end{aligned} \tag{19}$$

$\rho_\pi = (b_3 + a_3 b_2)\Phi/\widetilde{C}, \quad \rho_y = \gamma(a_3 + a_2 b_3)\Phi/\widetilde{C}, \quad \rho_c = \delta(1 - a_2 b_2)\Phi/\widetilde{C},$

$\rho_i = \left[(b_3 + b_2 a_3)(a_2 b_2 + c_2(b_3 + b_2 a_3)) + \gamma(a_2 b_3 + a_3)(a_3 c_2 + a_2) + \delta c_2(1 - a_2 b_2)\right]/\widetilde{C}$

$\widetilde{C} = c_3\left((b_3 + a_3 b_2)^2 + \gamma(a_2 b_3 + a_3)^2 + \delta(1 - a_2 b_2)^2\right)$

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13) In the model, the regulatory capital ratio directly affects the credit to GDP ratio, while the policy interest rate directly affects the output level as well as the credit to GDP ratio. This makes the policy interest rate have a comparative advantage over the regulatory capital ratio in lessening the output gap and the inflation gap, and the regulatory capital ratio have it over the policy interest rate in lessening the credit gap. Thus, it is not effective for the regulatory capital ratio to be used for controlling the output gap, as the regulatory capital ratio needs to change by a large amount to have a significant influence on the output gap. If the regulatory capital ratio moves in such a manner, the credit gap changes significantly, in which case the policy interest rate would also need to move greatly because the policy interest rate is not an effective instrument in controlling the credit gap compared to the regulatory capital ratio. This chain reaction can lead to non-convergence.

14) The partial derivative of the right hand side of the equation (18) with respect to δ has a negative sign, while those with respect to κ and γ have positive signs.

When each of the three gaps expands and the policy interest rate falls, the FSA raises the regulatory capital ratio. In this case, with the same objective function, the condition for convergence of the response functions is expressed as the following equation and the condition is satisfied.

$$1-\left(\frac{\partial \triangle i_t^{CB*}}{\partial \triangle car_t}\right)\left(\frac{\partial \triangle car_t^{FS*}}{\partial \triangle i_t}\right) = \frac{c_3(a_2\Phi)^2\left(\gamma\delta+\gamma(b_3)^2+\delta(b_2)^2\right)}{\widetilde{A}\,\widetilde{C}} > 0 \qquad (20)$$

3. Full cooperation equilibrium

If the CB and the FSA have the same objective, then they can decide to fully coordinate and exercise the two instruments simultaneously in order to achieve their common goal. This full cooperation equilibrium can also be applied to a case when the CB can exercise the regulatory capital ratio as its instrument. The two authorities' common loss function is expressed as equation (21).

$$\min\ LS_t = (E_t[\pi_{t+1}]-\pi_{t+1}^n)^2+\gamma(E_t[y_{t+1}]-y_{t+1}^n)^2+\delta(E_t[cyr_{t+1}]-cyr_{t+1}^n)^2 \qquad (21)$$

w.r.t. $\triangle i_t$, $\triangle car_t$

In the case of full cooperation, the optimal policy interest rate and the optimal regulatory capital ratio are expressed in terms of the output gap, the inflation gap and the credit gap as equations (22) ~ (23).

(Optimal policy interest rate)

$$\triangle i_t^* = \frac{\theta_\pi(\widetilde{E_t[\pi_{t+1}]}-\pi_{t+1}^n)+\theta_y(\widetilde{E_t[y_{t+1}]}-y_{t+1}^n)+\theta_c(\widetilde{E_t[cyr_{t+1}]}-cyr_{t+1}^n)}{a_2\left(\gamma\delta+\gamma(b_3)^2+\delta(b_2)^2\right)} \qquad (22)$$

$\theta_\pi = (\delta b_2(1-a_2b_2)-\gamma b_3(a_3+a_2b_3))$, $\theta_y = \gamma(b_3(b_3+a_3b_2)+\delta(1-a_2b_2))$,

$\theta_c = -\delta(\gamma(a_3+a_2b_3)+b_2(b_3+a_3b_2))$

(Optimal regulatory capital ratio)

$$\triangle car_t^* = \frac{\mu_c(E_t[\widetilde{cyr_{t+1}}]-cyr_{t+1}^n)+\mu_\pi(E_t[\widetilde{\pi_{t+1}}]-\pi_{t+1}^n)+\mu_y(E_t[\widetilde{y_{t+1}}]-y_{t+1}^n)}{c_3 a_2\left(\gamma\delta+\gamma(b_3)^2+\delta(b_2)^2\right)} \tag{23}$$

$$\mu_c = \delta(\,(a_2+a_3c_2)(\gamma+(b_2)^2)+b_2b_3c_2\,),\ \mu_\pi = \gamma b_3(a_2+a_3c_2)-\delta b_2c_2$$
$$\mu_y = -\gamma\,(b_3(a_2b_2+b_3c_2+a_3b_2c_2)+\delta c_2),$$

Equation (22) shows that the optimal policy interest rate rises either when the output gap expands ($\theta_y > 0$) or when the credit gap shrinks ($\theta_c < 0$). As the regulatory capital ratio rises when the credit gap expands, it may be effective for the CB not to raise the policy interest rate in response to the credit gap expansion and to focus on the other objectives instead. The CB's response to the inflation gap (θ_π) varies depending on the preferences and the values of the parameters. In the case either when the effect of the output gap on inflation (b_2) is large or when the weight for the output gap in the loss function (γ) is relatively small compared to that for the credit gap (δ), the optimal policy interest rate rises in response to the widening inflation gap ($\theta_\pi > 0$).

While the optimal regulatory capital ratio rises in equation (23) either when the credit gap expands ($\mu_c > 0$) or when the output gap shrinks ($\mu_y < 0$), its response to the inflation gap (μ_π) depends on the parameter values. This result implies that monetary policy and macroprudential policy need to be focused on areas where they have a comparative advantage over each other in exercising policy measures.

In this case, the loss function can be expressed in terms of the three gaps as the following equation (24). It shows that when the three gaps converge to zero, so does the value of the loss function.

$$(LS_t\,|\,\triangle i_t=\triangle i_t^*,\triangle car_t=\triangle car_t^*)=$$
$$\frac{\gamma\delta\left((E_t[\widetilde{\pi_{t+1}}]-\pi_{t+1}^n)-b_2(E_t[\widetilde{y_{t+1}}]-y_{t+1}^n)-b_3(E_t[\widetilde{cyr_{t+1}}]-cyr_{t+1}^n)\right)^2}{\gamma\delta+\gamma(b_3)^2+\delta(b_2)^2} \tag{24}$$

Meanwhile, when the two authorities have the same objective function, the non-cooperation equilibrium converges to the full cooperation equilibrium. In terms of social welfare, however, the non-cooperation equilibrium may be inferior to the full cooperation equilibrium as it requires a certain period of time for convergence.

4. Leader-follower equilibrium

A. The FSA as a leader

An agent may act as a Stackelberg leader. Previous studies have considered the FSA as a leader, and the CB as a follower, because the policy interest rate can be changed frequently while the regulatory capital ratio cannot. When the FSA is a leader, it knows the CB's response function fully, and uses this function as one of its constraints so that it can move first. One of the necessary conditions for an agent to become a leader is that it needs to know the others' response functions. Monetary policy tends to follow a rule similar to the Taylor rule, while the FSA prefers to use its discretion in exercising its measures. This could make monetary policy more predictable than macroprudential policy, and thus it is relatively easier for the FSA to behave as a leader.

Let's assume that the loss function of the FSA is LS_t^{FS} and the CB's response function is $\triangle i_t^{CB*} = cg(\triangle car_t, \Omega_t)$. Then, the FSA derives the optimal regulatory capital ratio to minimize its loss function as in equation (25).

$$\min LS_t^{FS} = f(\triangle car_t, \triangle i_t^{CB*}, \Omega_t) = f(\triangle car_t, cg(\triangle car_t, \Omega_t), \Omega_t) \qquad (25)$$
$$\text{w.r.t. } \triangle car_t$$

When the FSA's objective is to minimize credit gap volatility as shown in equation (12), its optimal policy is expressed as the following equation (26), which shows that the optimal regulatory capital ratio depends not only on the credit gap but also on the inflation gap and the output gap.

$$\triangle car_t^* = \frac{\psi_c(E_t[\widetilde{cyr_{t+1}}]-cyr_{t+1}^n)+\psi_\pi(E_t[\widetilde{\pi_{t+1}}]-\pi_{t+1}^n)+\psi_y(E_t[\widetilde{y_{t+1}}]-y_{t+1}^n)}{a_2c_3((1-\Phi)b_2+\gamma(a_3c_2+a_2))} \quad (26)$$

$$\psi_c = (1-\Phi)^2+\gamma(a_3c_2+a_2)^2,\ \psi_\pi = -c_2(1-\Phi),\ \psi_y = -\gamma c_2(a_3c_2+a_2)$$

The FSA raises the regulatory capital ratio when the credit gap expands ($\psi_c > 0$) and lowers it when the inflation gap and the output gap expand ($\psi_\pi < 0$ and $\psi_y < 0$). As it expects that the CB will raise the policy interest rate in response to the expansion of the inflation gap and the output gap, the FSA focuses on reducing the credit gap, which is its sole objective. The FSA's response to the gaps depends on the CB's preferences and the other parameters. If a stronger mandate for output stability is given to the CB, the FSA's response to the credit gap and the inflation gap becomes smaller and the response to the output gap becomes larger.15) This implies that, as Davig and Gürkaynak (2015) predict, an agent's response to its objectives is affected by the structure of other agents' loss functions.

On the other hand, when the FSA's objective is to reduce both the output gap and the credit gap, the FSA raises the regulatory capital ratio in response to credit gap expansion and output gap shrinkage, while its response to the inflation gap depends on the parameter values (refer to the Appendix).16)

B. The CB as a leader

As information advantage enables an agent to become a leader, the CB may become a leader under certain circumstances. If the counter-cyclical capital ratio is exercised under a pre-committed rule, the CB could know the FSA's response function, making it easier for the CB to become a leader. If the CB acts as a leader, it will minimize its loss function as in equation (10), predicting the FSA responses

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15) This relation can be verified by obtaining $\partial\triangle car_t^*/\partial\gamma$ from equation (26). Let NM_{26} be the denominator of equation (26). Then, it is found that $\partial(\psi_c/DM_{26})/\partial\gamma < 0$, $\partial(\psi_\pi/DM_{26})/\partial\gamma > 0$ and $\partial(\psi_y/DM_{26})/\partial\gamma < 0$.

16) The coefficient of the regulatory capital ratio's response on the inflation gap is more likely to have a negative sign as the weight for the credit gap in the FSA's loss function (κ) becomes large (see the Appendix).

according to equation (13) if the FSA's objective is to reduce credit gap volatility. The CB's optimal policy can be obtained by substituting equation (13) for the regulatory capital ratio ($\triangle car_t$) in its loss function and minimizing it.[17] This process produces the CB's optimal policy as the following equation (27). The policy interest rate rises when either the inflation gap or the output gap expands, and it falls when the credit gap expands. <Table 1> in the Appendix shows that a leader is not trying to reduce all of the three gaps, leaving a follower to bear the burden.

$$\triangle i_t^* = \frac{\tau_\pi (E_t[\widetilde{\pi_{t+1}}] - \pi_{t+1}^n) + \tau_y (E_t[\widetilde{y_{t+1}}] - y_{t+1}^n) + \tau_c (E_t[\widetilde{cyr_{t+1}}] - cyr_{t+1}^n)}{a_2((b_2)^2 + \gamma)} \quad (27)$$

$$\tau_\pi = b_2(1 - a_2 b_2),\ \tau_y = \gamma(1 - a_2 b_2),\ \tau_c = -[\gamma(a_2 b_3 + a_3) + b_2(a_3 b_2 + b_3)]$$

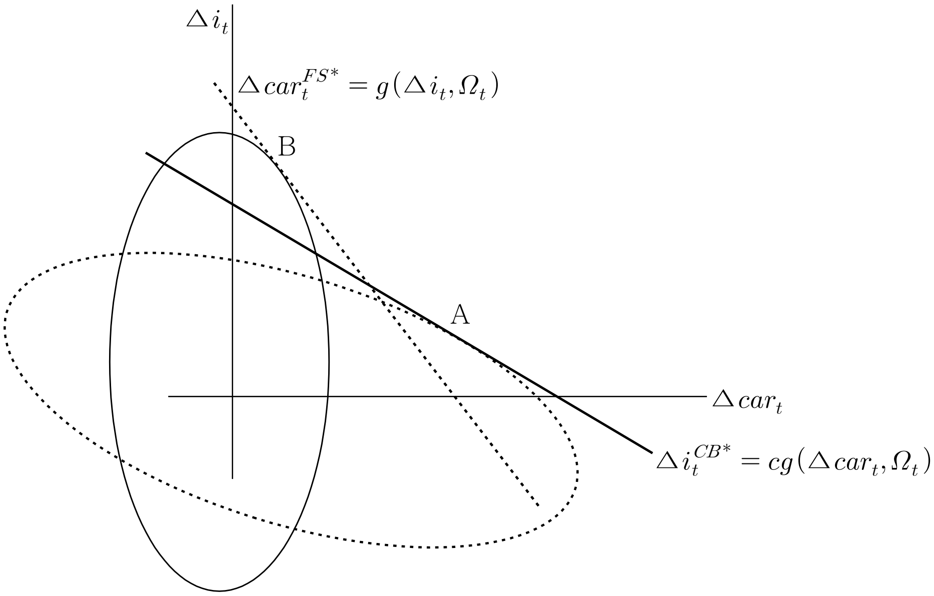
When the two policy authorities know each other's response functions, both of them may try to become a leader. This situation can be referred to as a "leader-leader model." In this situation, there is no convergence of response functions and each authority sets its own instrument to maximize its utility function.

<Figure 2> shows an example of the response functions and indifference curves for each authority. The authority's indifference curves have an oval shape as the loss function of an institution has the form $\sum_{j=1}^{n}(E_t[GAB_{j,t+1}] - \alpha_{1,j}\triangle i_t - \alpha_{2,j}\triangle car_t)^2$.[18] An authority's utility increases as the ellipse becomes smaller. If the FSA is a leader, it will set the regulatory capital ratio at point A. And if the CB is a leader, the policy interest rate is set at point B. Point A is optimal for the FSA in the long run. The FSA may temporarily increase its utility by moving leftward and downward from point A. Its moving, however, causes the CB to move alongside its response function line, eventually decreasing the FSA's utility at that point compared to at point A.

17) If the FSA's objective is to reduce the volatility of the output gap as well as the credit gap, then equation (17) can be used for the substitution.

18) If an authority has a single objective, then its indifference curve is a straight line.

Figure 2: The Response Functions and Indifference Curves



Note: The solid (dotted) straight line is the response function of the CB (the FSA). The solid (dotted) ellipse is the indifference curve of the CB (the FSA). Ω_t is the set of information available at time t.

5. Comparison of policy effectiveness

This section examines whether assigning a small number of mandates to authorities is more effective than assigning a large number of them. The aim of this analysis is the same as that of Davig and Gürkaynak (2015), who study the relation between fiscal and monetary policies.[19] The difference is that this paper evaluates the different ways of assigning mandates in terms of their efficiency in restoring an equilibrium. For the analysis, two situations are considered: one with a single objective for each policy authority and the other with multiple objectives. In both

19) Through the simulation, they show that the level of social welfare can fall when multiple objectives are assigned to the CB.

situations, the CB has the policy interest rate as its own instrument, and the FSA has the regulatory capital ratio. In the first situation, the CB's objective is to reduce inflation gap volatility while the FSA's objective is to reduce credit gap volatility. With one objective and one policy measure for each policymaker, each gap becomes zero in the equilibrium. The CB's optimal policy interest rate is $\triangle i_t^*$ that satisfies $\partial(E_t[\pi_{t+1}]-\pi_{t+1}^n)^2/\partial\triangle i_t=0$, and the FSA's optimal regulatory capital ratio is $\triangle car_t^*$ that satisfies $\partial(E_t[cyr_{t+1}]-cyr_{t+1}^n)^2/\partial\triangle car_t=0$.

In the second situation, each authority has two objectives: reducing inflation gap volatility and credit gap volatility with its own instrument. As the economy in this situation has two objectives and two policy measures as a whole, each gap converges to zero in the equilibrium following the Tinbergen rule. Thus, in the equilibrium of the second situation, the same outcome can be obtained as in the first situation.[20) Let the CB have the following equation (28) as its objective function and the FSA have equation (16) as its objective function. The CB's optimal policy interest rate, $\triangle i_t^*$, needs to satisfy the relation $\partial LS_t^{CB}/\partial\triangle i_t=0$, and the FSA's optimal regulatory capital ratio, $\triangle car_t^*$, needs to do the same for $\partial LS_t^{FS}/\partial\triangle car_t=0$.

$$\min\ LS_t^{CB}=(E_t[\pi_{t+1}]-\pi_{t+1}^n)^2+\delta(E_t[cyr_{t+1}]-cyr_{t+1}^n)^2 \tag{28}$$

For each of the two situations, the policy response functions and the speed of convergence to an equilibrium can be derived. The optimal policy is expressed as the following equations (29) $\sim$ (32).

(Optimal policy with a single objective)

$$\triangle i_t^*=\frac{\Phi(E_t[\widetilde{\pi_{t+1}}]-\pi_{t+1}^n)-c_3(b_3+b_2a_3)\triangle car_t}{(1-\Phi)} \tag{29}$$

20) If there is an additional instrument that can directly affect inflation, then with three objectives, the three gaps can be zero in an equilibrium (see Appendix).

$$\triangle car_t^* = \frac{\Phi(E_t[\widetilde{cyr_{t+1}}] - cyr_{t+1}^n) - c_2 \triangle i_t}{c_3(1-a_2 b_2)} \tag{30}$$

(Optimal policy with multiple objectives)

$$\triangle i_t^* = \frac{\Phi(1-\Phi)(E_t[\widetilde{\pi_{t+1}}] - \pi_{t+1}^n) + \delta c_2 \Phi(E_t[\widetilde{cyr_{t+1}}] - cyr_{t+1}^n) - \psi_{car} \triangle car_t}{(1-\Phi)^2 + \delta(c_2)^2} \tag{31}$$

$$\psi_{car} = c_3\left((b_3 + a_3 b_2)(1-\Phi) + \delta c_2 (1 - a_2 b_2) \right)$$

$$\triangle car_t^* = \frac{\iota_\pi \Phi(E_t[\widetilde{\pi_{t+1}}] - \pi_{t+1}^n) + \iota_c \Phi(E_t[\widetilde{cyr_{t+1}}] - cyr_{t+1}^n) - \iota_{car} \triangle car_t}{c_3\left((b_3 + a_3 b_2)^2 + \kappa(1-a_2 b_2)^2\right)} \tag{32}$$

$$\iota_\pi = (b_2 a_3 + b_3), \quad \iota_c = \kappa(1 - a_2 b_2)$$
$$\iota_{car} = (b_3 + a_3 b_2)(1-\Phi) + \kappa c_2 (1 - a_2 b_2)$$

The speed of convergence for each situation is derived as the following equations (33) $\sim$ (34). The higher the following value is, the faster the speed is.

(The speed of convergence with a single objective)

$$1 - \left(\frac{\partial \triangle i_t^*}{\partial \triangle car_t}\right)\left(\frac{\partial \triangle car_t^*}{\partial \triangle i_t}\right) = \frac{a_2 b_2 \Phi}{(1-\Phi)(1-a_2 b_2)} > 0 \tag{33}$$

(The speed of convergence with multiple objectives)

$$1 - \left(\frac{\partial \triangle i_t^*}{\partial \triangle car_t}\right)\left(\frac{\partial \triangle car_t^*}{\partial \triangle i_t}\right) = \frac{a_2 b_2 \Phi\left(\kappa \widetilde{\Gamma_1} - \delta \widetilde{\Gamma_2}\right)}{\widetilde{\Gamma_3}} > 0, \quad \text{if } \kappa \widetilde{\Gamma_1} > \delta \widetilde{\Gamma_2} \tag{34}$$

$$\widetilde{\Gamma_1} = (1-\Phi)(1-a_2 b_2), \quad \widetilde{\Gamma_2} = c_2(b_3 + a_3 b_2),$$
$$\widetilde{\Gamma_3} = \left((1-\Phi)^2 + \delta(c_2)^2\right)\left((b_3 + a_3 b_2)^2 + \kappa(1-a_2 b_2)^2\right)$$

The difference between the speed of convergence with a single objective and that with multiple objectives is expressed as equation (35).

$$\frac{a_2 b_2 \Phi\,(\Psi_1 + \Psi_2 + \Psi_3)}{(1-\Phi)(1-a_2 b_2)\,\widetilde{\Gamma_3}} > 0 \tag{35}$$

$$\Psi_1 = \delta\kappa\,(c_2(1-a_2 b_2))^2,\ \ \Psi_2 = (b_3 + a_3 b_2)^2(1-\Phi)^2,$$
$$\Psi_3 = \delta\left((c_2)^2(2-a_2 b_2)(b_3+a_3 b_2)^2 + a_2 b_2 c_2 (b_3 + a_3 b_2)(1-a_2 b_2)\right)$$

The speed of convergence to the equilibrium is faster in the first situation than in the second situation, while the equilibrium outcomes are the same. This implies that the first situation with a single objective for each policy authority is a more efficient way of achieving the objective compared to the second situation.

Another weakness in the case with multiple objectives is that the policy response functions, as shown in equations (29) $\sim$ (32), have more complex expressions than in the single objective situation. Thus, it may be more difficult for policy authorities to find an optimal level of policy instruments, as many parameters are involved in the multiple objective situation.[21)]

This section also compares the difference in convergence speed between assigning one objective to each institution and assigning one to an institution and two to the other. It is found that the former way is still more efficient in arriving at the equilibrium point. Let the speed of convergence with assigning one objective to each institution be $SW11$, assigning two objectives to the CB and one to the FSA be $SW21$, and assigning one to the CB and two to the FSA be $SW12$.[22)] Then the differences between $SW11$ and $SW21$ and between $SW11$ and $SW12$ are expressed as the following equations (36) and (37), respectively.

21) Changes in the structure of an economy tend to bring about changes in the parameters and the way policy instruments are operated. This adverse effect would be more significant in the multiple objective situation than in the single one.

22) When one mandate is given to the CB (or the FSA), reducing the inflation (or credit) gap mandate is assigned.

$$SW11 - SW21 = \frac{\delta a_2 b_2 (c_2)^2 \Phi}{(1-\Phi)(1-a_2 b_2)\left[(1-\Phi)^2 + \delta (c_2)^2\right]} > 0 \tag{36}$$

$$SW11 - SW12 = \frac{a_2 b_2 (b_3 + a_3 b_2)^2 \Phi}{(1-\Phi)(1-a_2 b_2)\left[(b_3 + a_3 b_2)^2 + \kappa (1-a_2 b_2)^2\right]} > 0 \tag{37}$$

There are some caveats with this result. If the objective of the CB is reducing credit gap volatility while the objective of the FSA is reducing inflation gap volatility, then the policy response functions do not converge — a situation that may be less effective than the multiple objective situation. The other caveat is that if there is uncertainty in either the effectiveness of the policy instruments or the objectives of each policy authority, then it is more effective for each authority to pursue multiple objectives than a single objective, as mentioned by Smets (2014).[23] Finally, there may be differences between the CB's evaluation of the gaps and the FSB's evaluation. As the CB has more information on the macro economy than the FSB does, the CB is more likely than the FSA to accurately assess the gaps. In this case, assigning multiple objectives would produce a better outcome.

Ⅲ. Conclusions

Using the IS curve, the Phillips curve, the credit to GDP ratio equation and the policymakers' objective functions, this paper examines the interaction between monetary and macroprudential policies with different levels of cooperation between two policy authorities: non-cooperation, full cooperation, and leader-follower relation. When the policy authorities have the same objectives, then it is more likely that the authorities have full cooperation. If one of the policy authorities has more information on the other's response function, it may act as a Stackelberg leader. In the model, the CB and the FSA can exercise the policy interest rate and the

23) Davig and Gürkaynak (2015) also state that the FSA may be slow in action for various reasons, such as political considerations and the time lag in gathering and analysing information.

regulatory capital ratio, respectively, as their policy instruments. In the non-cooperation situation, each policy authority's optimal response is to tighten its policy measures when the inflation gap, the output gap and the credit gap expand. And, when the other authority's policy measure is tightened, it loosens its policy measure. This substitutive relation holds even when the CB has the financial stability objective as well as the inflation and output stability objectives.

Whether the policy response functions converge to an equilibrium depends on the authorities' preferences and the parameter values in the model. As the FSA puts greater importance on output stability or a stronger financial stability mandate is assigned to the CB, the possibility of non-convergence becomes higher and the speed of convergence to an equilibrium tends to decrease, adding costs to policy operations. Meanwhile, if the CB considers output stability as an important task, the probability of convergence and the speed of converging to an equilibrium are high. When the CB has the financial stability objective, the intensity of response of the policy interest rate to the output gap and the inflation gap decreases compared with the case of the CB with no financial stability mandate.

When the policy authorities fully cooperate with each other, their responses to each gap are different. In response to the widening of the output gap, monetary policy tightening and macroprudential policy loosening are optimal. In the case of credit gap expansion, the optimal responses would be a tightening of macroprudential policy and a loosening of monetary policy. The direction of optimal responses to the widening of the inflation gap depends on the economic structure and the preferences of the policymakers.

Information advantage over the other party enables an agent to act as a Stackelberg leader. If the FSA acts as a leader, it raises the regulatory capital ratio in response to an expansion in the credit gap and to a shrinkage in the output gap. On the other hand, if the CB is a leader, it raises the policy interest rate when the inflation gap and the output gap expand and when the credit gap contracts. In either of the above two cases, a leader tries to reduce only one or two gaps among the three.

Finally, this paper analyses the effectiveness of the way that mandates are assigned to authorities. If there are differences between the CB's evaluation on the gaps and the FSA's, or if the effectiveness of policy instruments is uncertain, then assigning multiple objectives to each agent may be better in stabilizing the economy. On the other hand, if the above anomalies do not exist, then assigning multiple objectives to the authorities, which have a limited number of policy measures, may be less efficient in achieving the goals than assigning a small number of objectives. This is because, in the situation with multiple objectives, it takes more time for the policy response functions to reach a Nash equilibrium. It is also more difficult in that case for policymakers to find the proper levels of policy measures, as the optimal policy response functions have more complex forms.

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Appendix

FSA's optimal response when it acts as a leader with two objectives

$$\triangle car_t^* = \frac{\omega_c(E_t[\widetilde{cyr_{t+1}}] - cyr_{t+1}^n) + \omega_\pi(E_t[\widetilde{\pi_{t+1}}] - \pi_{t+1}^n) + \omega_y(E_t[\widetilde{y_{t+1}}] - y_{t+1}^n)}{c_3 a_2(\kappa(N_1 + \gamma N_2) + \delta N_3 + N_4)} \quad (38)$$

$$\omega_c = \kappa\left[(1-\Phi)^3 b_2 + \gamma(a_2 + a_3c_2)\left((a_2 + a_3c_2)^2(\gamma + 2(b_2)^2) + 3a_3b_2b_3(c_2)^2 + (b_3c_2)^2 + 3a_2b_2b_3c_2\right)\right]$$
$$+\ \delta c_2(a_3c_2 + a_2)\left[b_2b_3(a_3c_2 + a_2) + (b_3)^2 + \delta)c_2\right] \ > \ 0$$

$$\omega_\pi = -\kappa\ (1-\Phi)c_2\left[(1-\Phi)b_2 + \gamma(a_2 + a_3c_2)\right] + (1-\Phi)\left[(a_2 + a_3c_2)((1-\Phi)b_3 + \delta c_2)\right]$$

$$\omega_y = -\kappa\gamma\left[(1-\Phi)(a_2 + a_3c_2)b_2c_2 + \gamma c_2(a_2 + a_3c_2)^2\right] - (1-\Phi)^3 b_3$$
$$-\ \delta c_2\left[(b_2)^2(a_2 + a_3c_2)^2 + (c_2)^2(\delta + 2(b_3)^2) + 3b_2b_3c_2(a_2 + a_3c_2)\right] \ < \ 0$$

$$N_1 = (1-\Phi)^2(b_2)^2$$
$$N_2 = (a_3c_2 + a_2)((2(b_2)^2 + \gamma)(a_3c_2 + a_2) + 2c_2b_3b_2)$$
$$N_3 = c_2(2b_3c_2(b_3 + b_2a_3) + 2b_3b_2a_2 + \delta c_2)$$
$$N_4 = (1-\Phi)^2(b_3)^2$$

The situation with three objectives and instruments

In this situation, the three gaps can be zero in the equilibrium. For the analysis, the macroprudential policy for the foreign exchange market (fcr_t) is additionally introduced. A tightening of the policy reduces the fund inflows from abroad, in turn decreasing the overall liquidity in the domestic financial market and bringing an adverse effect on the output. On the other hand, it increases the demand for foreign currencies and depreciates the domestic currency, thus raising inflation. Considering these relations, the following set of equations is constructed.

<IS curve>

$$y_{t+1} = a_0 + a_1 y_t - a_2 (i_t - E_t[\pi_{t+1}]) + a_3 cyr_{t+1} - a_4 fcr_{t+1} + \epsilon_{y,t+1} \tag{39}$$

<Phillips curve>

$$\pi_{t+1} = b_0 + b_1 \pi_t + b_2 (y_{t+1} - y^n_{t+1}) + b_3 cyr_{t+1} + b_4 fcr_{t+1} + \epsilon_{\pi,t+1} \tag{40}$$

<Credit to GDP ratio>

$$cyr_{t+1} = c_0 + c_1 cyr_t - c_2 (i_t - E_t[\pi_{t+1}]) - c_3 car_t - c_4 fcr_t + \epsilon_{cyr,t+1} \tag{41}$$

The optimal policies that make the three gaps become zero are described as the following equations.

$$\begin{aligned} \triangle i^*_t &= \left(\frac{a_4 - a_2 b_4}{a_2 b_4}\right)(E_t[\widetilde{\pi_{t+1}}] - \pi^n_{t+1}) + \left(\frac{b_4 - a_4 b_2}{a_2 b_4}\right)(E_t[\widetilde{y_{t+1}}] - y^n_{t+1}) \\ &\quad - \left(\frac{a_4 b_3 + a_3 b_4}{a_2 b_4}\right)(E_t[\widetilde{cyr_{t+1}}] - cyr^n_{t+1}) \end{aligned} \tag{42}$$

$$\begin{aligned} \triangle fcr^*_t &= -\left(\frac{1}{b_4}\right)(E_t[\widetilde{\pi_{t+1}}] - \pi^n_{t+1}) + \left(\frac{b_2}{b_4}\right)(E_t[\widetilde{y_{t+1}}] - y^n_{t+1}) \\ &\quad + \left(\frac{b_3}{b_4}\right)(E_t[\widetilde{cyr_{t+1}}] - cyr^n_{t+1}) \end{aligned} \tag{43}$$

$$\begin{aligned} \triangle car^*_t &= \left(\frac{a_2 c_4 - a_4 c_2}{a_2 b_4 c_3}\right)(E_t[\widetilde{\pi_{t+1}}] - \pi^n_{t+1}) - \left(\frac{a_2 b_2 c_4 + c_2 (b_4 - a_4 b_2)}{a_2 b_4 c_3}\right)(E_t[\widetilde{y_{t+1}}] - y^n_{t+1}) \\ &\quad + \left(\frac{b_3 (a_4 c_2 - a_2 c_4) + b_4 (a_2 + a_3 c_2)}{a_2 b_4 c_3}\right)(E_t[\widetilde{cyr_{t+1}}] - cyr^n_{t+1}) \end{aligned} \tag{44}$$

Table 1: Optimal Policy Combination

Relation between policy authorities	Policies	Widening of the inflation gap	Widening of the output gap	Widening of the credit gap
Non Cooperation	Monetary Policy	tightening	tightening	tightening
	MP Policy	tightening[1)]	tightening[2)]	tightening
Full Cooperation	Monetary Policy	t/l[3)]	tightening	loosening
	MP Policy	t/l[3)]	loosening	tightening
The FSA is a leader[4)]	Monetary Policy	tightening	tightening	tightening
	MP Policy	loosening[5)]	loosening	tightening
The CB is a leader[4)]	Monetary Policy	tightening	tightening	loosening
	MP Policy	no response	no response	tightening

Notes: 1) If the FSA does not have the mandate of reducing inflation gap volatility, then this changes to "no response".

2) If the FSA does not have the mandate of reducing output gap volatility, then this changes to "no response".

3) This depends on the parameter values. As the impact of the output gap on inflation becomes larger, or the authorities put less importance on output stability and more importance on financial stability, the optimal monetary policy and the optimal macroprudential policy become tightening and loosening, respectively.

4) This result is obtained in the case when the FSA's objective is to reduce credit gap volatility.

5) If the FSA's objective is to lessen output volatility as well as credit volatility, this changes to "depends on the situation".

‹Abstract in Korean›

통화정책과 거시건전성정책간 관계

강 종 구*

본고는 통화정책과 거시건전성정책간 상호작용을 정책당국의 협력정도에 따라 저협력, 완전협력, 선도-추종 관계 등으로 구분하여 분석하였다.

분석결과를 보면, 중앙은행과 규제당국간 협력정도가 낮은 경우 각 정책당국은 물가갭, 산출갭, 신용갭 등이 확대되거나 상대방 정책당국이 정책수단을 완화할 때 자신의 정책수단을 긴축적으로 운용한다. 이는 통화정책과 거시건전성정책이 상호 대체관계에 있음을 의미한다. 각 정책당국의 상대방 정책에 대한 반응 결과 안정적 균형으로 수렴하는지 여부는 정책당국의 목적함수 등에 따라 다르게 나타난다. 예를 들어 규제당국이 금융안정보다 경기안정을 중시하는 정도가 높을수록 안정적 균형으로 수렴하지 않고 불안정한 상태로 증폭될 가능성이 높아지며 균형으로 수렴하더라도 수렴 속도가 느려진다. 정책당국간 완전협력 상황에서는 중앙은행과 규제당국이 역할을 분담하여 각 갭의 변동에 대해 최적 정책조합을 구성할 수 있다.

핵심 주제어: 통화정책, 중앙은행, 금융규제

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BOK 경제연구 발간목록

한국은행 경제연구원에서는 Working Paper인 『BOK 경제연구』를 수시로 발간하고 있습니다. 『BOK 경제연구』는 주요 경제 현상 및 정책 효과에 대한 직관적 설명 뿐 아니라 깊이 있는 이론 또는 실증 분석을 제공함으로써 엄밀한 논증에 초점을 두는 학술논문 형태의 연구이며 한국은행 직원 및 한국은행 연구용역사업의 연구 결과물이 수록되고 있습니다.
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제**2014** –1	Network Indicators for Monitoring Intraday Liquidity in BOK–Wire+	Seungjin Baek · Kimmo Soram ki · Jaeho Yoon
2	중소기업에 대한 신용정책 효과	정호성 · 임호성
3	경제충격 효과의 산업간 공행성 분석	황선웅 · 민성환 · 신동현 · 김기호
4	서비스업 발전을 통한 내외수 균형성장: 기대효과 및 리스크	김승원 · 황광명
5	Cross–country–heterogeneous and Time–varying Effects of Unconventional Monetary Policies in AEs on Portfolio Inflows to EMEs	Kyoungsoo Yoon · Christophe Hurlin
6	인터넷뱅킹, 결제성예금 및 은행 수익성과의 관계 분석	이동규 · 전봉걸
7	Dissecting Foreign Bank Lending Behavior During the 2008–2009 Crisis	Moon Jung Choi · Eva Gutierrez · Maria Soledad Martinez Peria
8	The Impact of Foreign Banks on Monetary Policy Transmission during the Global Financial Crisis of 2008–2009: Evidence from Korea	Bang Nam Jeon · Hosung Lim · Ji Wu
9	Welfare Cost of Business Cycles in Economies with Individual Consumption Risk	Martin Ellison · Thomas J. Sargent
10	Investor Trading Behavior Around the Time of Geopolitical Risk Events: Evidence from South Korea	Young Han Kim · Hosung Jung
11	Imported–Inputs Channel of Exchange Rate Pass–Through: Evidence from Korean Firm–Level Pricing Survey	Jae Bin Ahn · Chang–Gui Park

제2014 -12	비대칭 금리기간구조에 대한 실증분석	김기호
13	The Effects of Globalization on Macroeconomic Dynamics in a Trade-Dependent Economy: the Case of Korea	Fabio Milani · Sung Ho Park
14	국제 포트폴리오투자 행태 분석: 채권-주식 투자자금간 상호관계를 중심으로	이주용 · 김근영
15	북한 경제의 추격 성장 가능성과 정책 선택 시나리오	이근 · 최지영
16	Mapping Korea's International Linkages using Generalised Connectedness Measures	Hail Park · Yongcheol Shin
17	국제자본이동 하에서 환율신축성과 경상수지 조정: 국가패널 분석	김근영
18	외국인 투자자가 외환시장과 주식시장 간 유동성 동행화에 미치는 영향	김준한 · 이지은
19	Forecasting the Term Structure of Government Bond Yields Using Credit Spreads and Structural Breaks	Azamat Abdymomunov · Kyu Ho Kang · Ki Jeong Kim
20	Impact of Demographic Change upon the Sustainability of Fiscal Policy	Younggak Kim · Myoung Chul Kim · Seongyong Im
21	The Impact of Population Aging on the Countercyclical Fiscal Stance in Korea, with a Focus on the Automatic Stabilizer	Tae-Jeong Kim · Mihye Lee · Robert Dekle
22	미 연준과 유럽중앙은행의 비전통적 통화정책 수행원칙에 관한 고찰	김병기 · 김진일
23	우리나라 일반인의 인플레이션 기대 형성 행태 분석	이한규 · 최진호

제2014-24	Nonlinearity in Nexus between Working Hours and Productivity	Dongyeol Lee · Hyunjoon Lim
25	Strategies for Reforming Korea's Labor Market to Foster Growth	Mai Dao · Davide Furceri · Jisoo Hwang · Meeyeon Kim · Tae-Jeong Kim
26	글로벌 금융위기 이후 성장잠재력 확충	한국은행 경제연구원 2014년 한국은행 국제컨퍼런스 요약집
27	인구구조 변화가 경제성장률에 미치는 영향: 자본이동의 역할에 대한 논의를 중심으로	손종칠
28	Safe Assets	Robert J. Barro
29	확장된 실업지표를 이용한 우리나라 노동시장에서의 이력현상 분석	김현학 · 황광명
30	Entropy of Global Financial Linkages	Daeyup Lee
31	International Currencies Past, Present and Future: Two Views from Economic History	Barry Eichengreen
32	금융체제 이행 및 통합 사례: 남북한 금융통합에 대한 시사점	김병연
33	Measuring Price-Level Uncertainty and Instability in the U.S., 1850-2012	Timothy Cogley · Thomas J. Sargent
34	고용보호제도가 노동시장 이원화 및 노동생산성에 미치는 영향	김승원
35	해외충격시 외화예금의 역할 : 주요 신흥국 신용스프레드에 미치는 영향을 중심으로	정호성 · 우준명
36	실업률을 고려한 최적 통화정책 분석	김인수 · 이명수
37	우리나라 무역거래의 결제통화 결정요인 분석	황광명 · 김경민 · 노충식 · 김미진
38	Global Liquidity Transmission to Emerging Market Economies, and Their Policy Responses	Woon Gyu Choi · Taesu Kang · Geun-Young Kim · Byongju Lee

제2015-1	글로벌 금융위기 이후 주요국 통화정책 운영체계의 변화	김병기・김인수
2	미국 장기시장금리 변동이 우리나라 금리기간구조에 미치는 영향 분석 및 정책적 시사점	강규호・오형석
3	직간접 무역연계성을 통한 해외충격의 우리나라 수출입 파급효과 분석	최문정・김근영
4	통화정책 효과의 지역적 차이	김기호
5	수입중간재의 비용효과를 고려한 환율변동과 수출가격 간의 관계	김경민
6	중앙은행의 정책금리 발표가 주식시장 유동성에 미치는 영향	이지은
7	은행 건전성지표의 변동요인과 거시건전성 규제의 영향	강종구
8	Price Discovery and Foreign Participation in The Republic of Korea's Government Bond Futures and Cash Markets	Jaehun Choi・Hosung Lim・Rogelio Jr. Mercado・Cyn-Young Park
9	규제가 노동생산성에 미치는 영향: 한국의 산업패널 자료를 이용한 실증분석	이동렬・최종일・이종한
10	인구 고령화와 정년연장 연구 (세대 간 중첩모형(OLG)을 이용한 정량 분석)	홍재화・강태수
11	예측조합 및 밀도함수에 의한 소비자물가 상승률 전망	김현학
12	인플레이션 동학과 통화정책	우준명
13	Failure Risk and the Cross-Section of Hedge Fund Returns	Jung-Min Kim
14	Global Liquidity and Commodity Prices	Hyunju Kang・Bok-Keun Yu・Jongmin Yu
15	Foreign Ownership, Legal System and Stock Market Liquidity	Jieun Lee・Kee H. Chung

제2015 –16	바젤Ⅲ 은행 경기대응완충자본 규제의 기준지표에 대한 연구	서현덕 · 이정연
17	우리나라 대출 수요와 공급의 변동요인 분석	강종구 · 임호성
18	북한 인구구조의 변화 추이와 시사점	최지영
19	Entry of Non–financial Firms and Competition in the Retail Payments Market	Jooyong Jun
20	Monetary Policy Regime Change and Regional Inflation Dynamics: Looking through the Lens of Sector–Level Data for Korea	Chi–Young Choi · Joo Yong Lee · Roisin O'Sullivan
21	Costs of Foreign Capital Flows in Emerging Market Economies: Unexpected Economic Growth and Increased Financial Market Volatility	Kyoungsoo Yoon · Jayoung Kim
22	글로벌 금리 정상화와 통화정책 과제	한국은행 경제연구원 2015년 한국은행 국제컨퍼런스 요약집
23	The Effects of Global Liquidity on Global Imbalances	Marie–Louise DJIGBENOU–KRE · Hail Park
24	실물경기를 고려한 내재 유동성 측정	우준명 · 이지은
25	Deflation and Monetary Policy	Barry Eichengreen
26	Macroeconomic Shocks and Dynamics of Labor Markets in Korea	Tae Bong Kim · Hangyu Lee
27	Reference Rates and Monetary Policy Effectiveness in Korea	Heung Soon Jung · Dong Jin Lee · Tae Hyo Gwon · Se Jin Yun
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29	An Analysis of Trade Patterns in East Asia and the Effects of the Real Exchange Rate Movements	Moon Jung Choi · Geun–Young Kim · Joo Yong Lee
30	Forecasting Financial Stress Indices in Korea: A Factor Model Approach	Hyeongwoo Kim · Hyun Hak Kim · Wen Shi

제2016 -1	The Spillover Effects of U.S. Monetary Policy on Emerging Market Economies: Breaks, Asymmetries and Fundamentals	Geun-Young Kim · Hail Park · Peter Tillmann
2	Pass-Through of Imported Input Prices to Domestic Producer Prices: Evidence from Sector-Level Data	JaeBin Ahn · Chang-Gui Park · Chanho Park
3	Spillovers from U.S. Unconventional Monetary Policy and Its Normalization to Emerging Markets: A Capital Flow Perspective	Sangwon Suh · Byung-Soo Koo
4	Stock Returns and Mutual Fund Flows in the Korean Financial Market: A System Approach	Jaebeom Kim · Jung-Min Kim
5	정책금리 변동이 성별·세대별 고용률에 미치는 영향	정성엽
6	From Firm-level Imports to Aggregate Productivity: Evidence from Korean Manufacturing Firms Data	JaeBin Ahn · Moon Jung Choi
7	자유무역협정(FTA)이 한국 기업의 기업내 무역에 미친 효과	전봉걸 · 김은숙 · 이주용
8	The Relation Between Monetary and Macroprudential Policy	Jong Ku Kang