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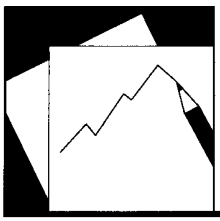

IMF Working Paper

Managing Non-core Liabilities and Leverage of the Banking System: A Building Block for Macroprudential Policy Making in Korea

Ali Alichi, Sang Chul Ryoo, and Cheol Hong

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Prepared by Ali Alichi, Sang Chul Ryoo, and Cheol Hong [1]

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Abstract

Korea has been active in implementing targeted macroprudential policies to address specific financial stability concerns. In this paper, we develop a conceptual model that could serve as a building block for the broader framework of macroprudential policy making in Korea. It is assumed that the policy maker imposes taxes on key aggregate financial ratios in the banking system to mitigate excessive leverage over the economic cycle. The model is calibrated for Korea. The results illustrate how countercyclical tools, such as simple taxes on key financial ratios, could be incorporated to enrich the broader macroprudential policy framework in the Korean context.

JEL Classification Numbers: E58, G18, G28

Keywords: Macroprudential Policies, Macroprudential Model, Systemic Risk

Authors E-Mail Addresses: aalichi@imf.org, scr29@bok.or.kr, and tigerwannabe@bok.or.kr

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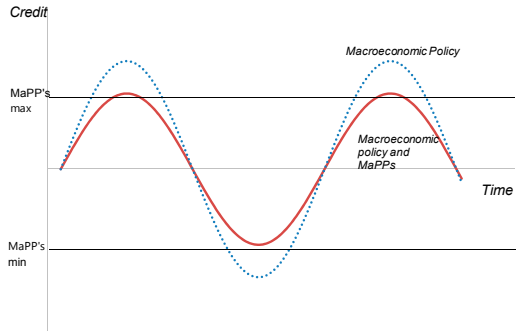
I. INTRODUCTION

1. **Macroprudential policies are broadly defined as a set of financial policies aimed at limiting, mitigating or reducing systemic financial risk**. A recent Fund survey, IMF (2011a), suggests that there is broad agreement among many country authorities on this definition of macroprudential policies (MaPPs), although there is no single way of defining systemic (financial) risk.[2] In particular, systemic risk could be defined based on movements of some aggregate financial stability metrics over the economic cycle. Alternatively, to capture the cross-sectional dimension of systemic risk, metrics that focus on interconnectedness of financial institutions could be used. In this paper, we focus only on the time-series dimension of systemic risk in formulating a stylized model for MaPPs.[3] The recent experience in the period leading up to the crisis has reopened the debate on the role of conventional macroeconomic policies, and in particular monetary policy, in financial stability. Although there is accumulating evidence, including for Korea, that incorporating financial stability considerations into monetary policy decisions would reduce the real impact of financial shocks, there is also broad agreement that macroeconomic policy may not be sufficient to address all financial stability concerns.[4] This recognizes that interest rates are a blunt tool to address specific financial risks, which may be better targeted with MaPPs in specific areas. For example, monetary policy could go a long way in preventing periods of excessive credit growth by altering the price of risk in the financial system, but in an open economy, cross-border linkages could nonetheless lead excess external liquidity to fuel domestic credit growth, beyond the control of monetary policy. Likewise, macroeconomic policies may be ineffective to deal with price bubbles under low inflation. In addition, macroeconomic policies may be blunt tools when asset price bubbles are prominent only in particular sector. For cases like this, MaPPs could have a complementary role in preventing leverage from increasing beyond cyclical norms (Text Figure 1). In other words, MaPPs would be a lever, in addition to appropriate macroeconomic policy, for limiting, mitigating or reducing systemic risk. [5]

Text Figure 1. Illustration of MaPPs' Role



[2] See IMF (2011c) for more detailed information on systemic risk and its indicators.

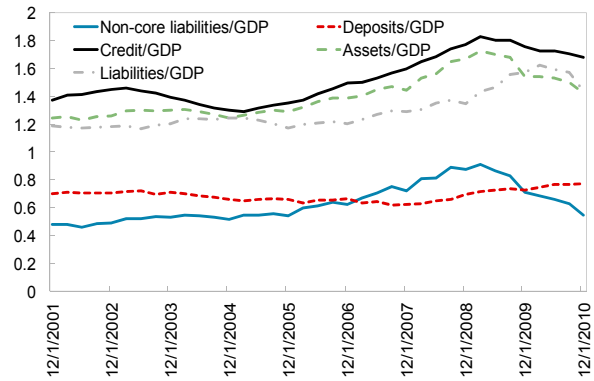
[3] Aydin et. al. (2011) addresses the cross-sectional dimension of systemic risk in the Korean banking system.

[4] See the Selected Issues Paper titled "Formalizing Financial Stability Consideration in the Conduct of Monetary Policy in Korea", in IMF (2011b) and Aydin and Volkan (2011).

[5] We acknowledge that the issue of whether MaPPs are needed in addition to macroeconomic policies is still under debate in the literature and policy circles. The recent financial crisis provides some support to our reasoning for the need for MaPPs. In addition, we are not aware of any strong evidence that optimal macroeconomic policy alone would be sufficient to deal with systemic risk.

2. **The Korean authorities have implemented several MaPPs in recent years.** The Korean banking system has shown resilience to many shocks since 1997 and especially during the global crisis. Nonetheless, in an economy with a large banking system and an open capital account, rapid credit expansion, funded mostly by non-core external liabilities, is considered to be a key financial vulnerability. In the period leading up to the global crisis, Korean banks' loan-to-deposit ratios rose above 140 percent, with credit growth hovering around 20 percent per annum, while bank deposits remained stable. With the onset of the crisis, sudden stop in external flows led to a sharp slowdown in credit growth, despite policy measures to mitigate a credit crunch. After the global financial crisis, new MaPPs were introduced to address banks' reliance on wholesale funding, avoid excessive credit growth, and limit banks' external short-term debt. These measures included a 100 percent loan-to-deposit ratio limit and a macroprudential levy on short-term debt, and other measures announced since November 2009.[6] The concerns of the authorities were well grounded given Korea's financial inter-linkages with the rest of the world in the context of an export-driven economy and an open capital account. While deposits have been very stable in Korea over the last decade, including during the global financial crisis, non-core liabilities (defined as non-deposit liabilities in this paper) and bank credit have moved beyond the cycle—credit to GDP has increased (Text Figure 2). The stability of deposits could be attributed to depositor confidence due to Korea's solid deposit insurance scheme and soundness of the banking system. On the other hand, non-core liabilities have been mostly driven by capital inflows.[7] As most of the non-core liabilities of Korean banks are wholesale funding and short-term external debt, the authorities focused on policies to curb these two sources of funding, especially in light of the vulnerability that a sudden stop in capital inflows could pose. In addition, the loan-to-deposit ratio limit was addressing the fact that non-core liabilities were seen as the main vehicle for expansion of bank credit beyond the cycle.

Text Figure 2. Korea, Recent Trends of Banking System's Assets and Liabilities



Source: Korean authorities.

3. **MaPPs would be more effective if incorporated in a coherent framework.** While the Korean authorities' aforementioned MaPPs were effective in limiting wholesale finding and short-term external debt in the banking system, they were seen more targeted to specific

[6] The levy is less than 0.5 percent and is determined by remaining maturity of non-core liabilities. It is 0.2 percent for maturities of less than one year; 0.1 percent for maturities of one to three years; 0.05 percent for maturities of three to five years; and 0.02 percent for maturities over five years. For the period of rapid capital inflows, however, the government has discretion to impose a maximum surcharge of 0.5 percent that varies depending on net capital inflows. The overall levy cannot exceed 1.0 percent, and the surcharge cannot be imposed for more than six months.

[7] Currently, about 70 percent of non-core liabilities of the Korean banking system are external.

concerns, leaving the overall policy framework unclear. For example, it is unknown under what circumstances the levy will be abolished. Are there thresholds of short-term debt below which the authorities would abolish the levy? Would the authorities' decision to strengthen or abolish or weaken the levy depend on the GDP growth rate? What other factors would contribute to changing the levy? The current ad hoc choice of levy makes it difficult to answer these questions for economic agents. Ideally, there should be a broader macrofinancial framework, in which MaPPs are decided consistent with macroeconomic policies. Our paper does not attempt to build a full-fledged macrofinancial framework, but presents a stylized model for macroprudential policy settings which could be a building block within such a macrofinancial framework. A full-fledged macrofinancial framework would ideally analyze the macroprudential and macroeconomic policies jointly. Nonetheless, the building block we offer for MaPPs aims to lower buildup of systemic risk over the business cycle, which is consistent with any sound macroeconomic policy that has the same objective of smoothing the business cycle.

4. **We offer an example of a key building block for a broader MaPP framework.** We do not offer a comprehensive framework, but introduce the idea of model-based simple tax rates on systemic risk indicators[8] that could be used as MaPP tools. One such tax rate is on non-core liabilities to GDP. This is broadly similar to the macroprudential stability levy being introduced by the Korean authorities to limit the buildup of short-term external bank debt. This MaPP tax rate is intended to prevent non-core liabilities from rising too fast or too slow over the economic cycle. One advantage of a MaPP tax rate is that it responds to the macroeconomic cycle, to ensure smooth and timely response to any buildup of vulnerabilities due to non-core liabilities, and reduces the buildup of balance sheet vulnerabilities. Furthermore, the tax rate is determined by considering the system-wide aggregates of the banking system, leaving the supervision of bank specific indicators to microprudential policies. While our model could be a building block for MaPPs, it should not be seen as the only possibility. Alternative models, for instance by introducing countercyclical capital requirements could be built to deliver similar results. In the absence of alternative models for Korea, however, it would be difficult to assess comparative strengths and weaknesses of our model. Moreover, the model does not address the setting of macroeconomic policies over the economic cycle, and instead takes these decisions as given. If macroeconomic policy is not optimal, the MaPP authority responds to counter the systemic risk created by it, which is desirable. For instance, if interest rates are set below their optimal level for the stage of the business cycle, the optimal MaPP tax rates obtained from this model will be higher than when interest rates are at their optimal level. However, a limitation of our model is the assumption that macroeconomic policy is not affected by MaPPs. Nonetheless, the model could help frame the discussion within the context of the economic cycle and the related macroeconomic policy settings. The model should be seen as a first step toward future work which would incorporate macroeconomic channels that this paper takes as given.

[8] We only study two indicators. For a broader set of indicators and evidence for effectiveness of MaPPs associated with these indicators see IMF (2011c).

5. **In our stylized partial equilibrium model, MaPPs mitigate excessive buildup of leverage over the economic cycle.** We assume that the task of smoothing the real economic cycle is left to macroeconomic policy. Therefore, we consider MaPPs with the exclusive focus on systemic financial vulnerabilities, which are related to non-core liabilities and assets of the banking system. Our main focus is on non-core liabilities because they have been recognized as one of the main causes of the two previous crises in 1997 and 2008 in Korea.[9] Nonetheless, we also target assets in our model, albeit in relation to non-core liabilities.[10] The objective function of the macroprudential policy maker minimizes a quadratic loss function that depends on the banking system's deviations from its desired financial ratios related to banking system's non-core liabilities and assets, adjusted for the economic cycle. The MaPP policy tools are taxes on the entire banking system to ensure that the system's financial ratios are within the policymaker's desired thresholds. The partial equilibrium framework does not allow for an assessment of the optimality of these thresholds—a topic for future research. We present numeric simulations based on relative preferences of the macroprudential policy maker for different financial ratios, akin to a central banker's preferences in the trade-off between growth and inflation, or its degree of tolerance for inflation.

II. Banking System's and Macroprudential Policy Maker's Problems

6. **We set up a two stage model with a profit maximizing banking system and a macroprudential policy maker, who minimizes loss function related to systemic risk**. We assume the banking system consists of only one bank as our model is a macroprudential model, which means we are only interested in macro level variables. This bank holds the aggregate financial variables of the economy. The policy maker sets thresholds on the banking system's financial ratios of interest and imposes direct taxes on banks proportional to the quadratic deviations from the set thresholds. We first present and solve the banking system's problem, which takes MaPPs' tax rates as given and solve for non-core liabilities to GDP and assets to non-core liabilities (leverage). In the second stage, the macroprudential policy maker (MPM) chooses these tax rates to minimize the system's deviation from the desired thresholds, subject to the reaction function of the banking system optimized in the first stage, minimizing the MPM's loss function. This function includes i) the deviation of the non-core liabilities to GDP ratio from a target; and ii) the deviation of assets to non-core liabilities from a target. Both of these targets have threshold levels adjusted based on the output gap and next period growth of the GDP relative to potential. The threshold over each ratio is set to ensure that banks comply with minimum capital adequacy ratios.

[9] Non-core liabilities peaked during these two crisis episodes. Shin and others (2011) link the 1997 and 2008 in Korea to excessive non-core liabilities.

[10] The analysis could be extended to other financial vulnerabilities in future work through incorporating other indicators in the asset side such as loan to value (LTV) ratios, which have also been used by the Korean authorities.

A. Banking System's Problem

7. **The banking system maximizes its profits net of cost of funding and macroprudential taxes**. We follow the standard assumption that the banking system maximizes its economic value added (EVA), which is defined as revenue earned less the financing cost of banking system's capital and taxes paid, in each period. The financing cost of the banking system is the sum of cost of liabilities and the opportunity cost of capital. We assume operating costs, cost of core liabilities and cost of capital are all fixed. We also assume capital is fixed in this section, but we relax this assumption in a following section. As for MaPP taxes, we assume they are imposed on quadratic ratios of the banking system's non-core liabilities to GDP and assets to non-core liabilities. Bank' non-core liabilities capture the unstable portion of bank leverage, whereas bank's assets to non-core liabilities, captures the leverage of the non-financial private sector as a ratio of bank leverage. Notice that the MaPP is taxing both assets and non-core liabilities over the cycle and, therefore, needs two tax rates. These tax rates are of macroprudential nature and are imposed uniformly on all banks, depending on the total banking system's ratios, and should not be confused with microprudential requirements that depend on individual bank ratios. The quadratic form is used to represent the sensitivity of MaPPs to higher volatility in assets and liabilities of the banking system, especially as size of the banking system increases.[11] The banking system's problem is as follows:

$$\max_{A,\mathrm{L}} \; r_a A - c_l L - \frac{1}{2}\tau_1 \frac{L^2}{Y} - \frac{1}{2}\tau_2 \frac{A^2}{L}$$

where, A is banking system's assets, L is non-core liabilities, Y is nominal GDP, r_a is return on assets, c_l is unit cost of non-core liabilities. τ_1 and τ_2 are MaPP tax rates on non-core liabilities to GDP and assets to non-core liabilities, respectively. These tax rates are conceptually similar to the actual levy employed by the Korean authorities (see footnote 3) in targeting non-core liabilities to contain the buildup of systemic risk during the periods of massive capital flows. They, however, differ in their calibration from the authorities'. The actual levy has a fixed rate determined by remaining maturity and a variable rate, which is only imposed during the period of capital surge. This is in contrast to τ_1 and τ_2, which vary smoothly depending on the deviation of early warning indicators from threshold levels, rather than switching discretely from normal and extreme time. Above all, while calibration of the actual levy appears to have been ad hoc (to the best of our knowledge), τ_1 and τ_2 are derived optimally from the model.

Initially, bank capital and deposits are assumed to be fixed. As a result, if the banking system decides to expand its assets by one dollar, it has to increase its non-core liabilities by one dollar. The first order conditions of the banking system's problem are as follows:

[11] A similar idea of minimizing variances of MaPP policy tools has been adopted in Angelini et. al. (2011).

$$r_a - \tau_2 \frac{A}{L} = 0 \qquad (1)$$

$$-c_d - \tau_1 \frac{L}{Y} + \frac{1}{2}\tau_2 \frac{A^2}{L^2} = 0 \qquad (2)$$

The FOCs determine solutions for $\frac{A^*}{Y}$, $\frac{L^*}{Y}$ as follows:

$$\frac{A^*}{Y} = \frac{r_a}{\tau_1 \tau_2}\left[\frac{1}{2\tau_2}(r_a)^2 - c_l\right] \qquad (3)$$

$$\frac{L^*}{Y} = \frac{1}{\tau_1}\left[\frac{1}{2\tau_2}(r_a)^2 - c_l\right] \qquad (4)$$

$$\frac{A^*}{L^*} = \frac{r_a}{\tau_2} \qquad (5)$$

Equations (3)-(5), imply that higher tax rates of τ_1 and τ_2 result in lower ratios of assets/GDP, non-core liabilities/GDP, and assets/non-core liabilities. In the next stage, the MPM sets these tax rates optimally.

B. MPM's Problem

8. **We setup the MPM's problem based on minimization of a quadratic loss function.** In the absence of much literature on modeling the problem of the macroprudential policy maker and following a reasonable parallel with monetary policy under inflation targeting, we assume that the policy maker chooses financial ratios that s/he deems most important (in our case non-core liabilities as a share of GDP and assets to non-core liabilities) but cannot be addressed through macroeconomic policy settings. S/he sets targets for these ratios and minimizes a quadratic loss function based on deviations of the banking system from these targets. Below we discuss how the policy maker sets these targets and formally present its optimization problem.

9. **MPM sets targets for its policy financial ratios based on the stage of the economic cycle**. The MPM's target ratios are chosen based on the output gap and how fast GDP is growing compared to potential. For non-core liabilities to GDP the target is $(\alpha_1 - \alpha_2 y - \alpha_3 g)$ and for assets to liabilities the target is $(\beta_1 - \beta_2 y - \beta_3 g)$, where $y = \frac{GDP - GDP_n}{GDP_n}$ is the output gap and $g = \frac{GDP_{+1} - GDP}{GDP} - \frac{GDP_{n_{+1}} - GDP_n}{GDP_n}$ is the relative growth of output relative to potential output, where GDP denotes real output, GDP_n is potential output and GDP_{+1} and $GDP_{n_{+1}}$ are next period's output and potential output, respectively. When output is at potential ($y = 0$) and is growing at its potential rate (g= 0), the MPM imposes the threshold of α_1 on non-core liabilities as a ratio of output and β_1 on assets to non-core liabilities. α_2 and β_2 are parameters that adjust these targets based on the output gap, while α_3 and β_3 adjust the targets based on how fast the output gap is closing. If output is above potential

($y > 0$) or growing above potential (g> 0), the MPM's thresholds decrease, reflecting the fact that policy leans against the wind.

10. **Accordingly, the MPM decides optimal values of the tax rates on non-core liabilities and assets to non-core liabilities τ_1 and τ_2 by solving the following problem**:

$$\min_{\tau_1,\tau_2} \left(\frac{L^*}{Y} - (\alpha_1 - \alpha_2 y - \alpha_3 g)\right)^2 + \left(\frac{A^*}{L^*} - (\beta_1 - \beta_2 y - \beta_3 g)\right)^2$$

$s.t.$ (4) and (5); and
$0 < \tau_1 < \tau_{1max}$ and $0 < \tau_2 < \tau_{2max}$

Substituting (4) and (5) into MPM's objective function results in:

$$\min_{\tau_1,\tau_2} \left(\frac{1}{\tau_1}\left[\frac{1}{2\tau_2} {r_a}^2 - c_l\right] - (\alpha_1 - \alpha_2 y - \alpha_3 g)\right)^2 + \left(\frac{r_a}{\tau_2} - (\beta_1 - \beta_2 y - \beta_3 g)\right)^2$$

The solution is obtained by solving the FOCs for τ_1, τ_2.

For the special case of no upper bound on τ_1 and τ_2, it is straightforward to verify that FOCs reduce to the following:

$$\frac{1}{\tau_1}\left[\frac{1}{2\tau_2}(r_a)^2 - c_l\right] - (\alpha_1 - \alpha_2 y - \alpha_3 g) = 0$$

$$\frac{r_a}{\tau_2} - (\beta_1 - \beta_2 y - \beta_3 g) = 0$$

And the solution would be

$$\tau_1^* = \frac{\frac{1}{2}(\beta_1 - \beta_2 y - \beta_3 g) r_a - c_l}{\alpha_1 - \alpha_2 y - \alpha_3 g}$$

$$\tau_2^* = \frac{r_a}{(\beta_1 - \beta_2 y - \beta_3 g)}$$

For the general case, where there are upper bounds on τ_1 and τ_2, we solve the model numerically.

Notice that, even though we keep capital and deposits constant ($\overline{K}, \overline{D}$) in the banking system's problem, the MPM chooses β_1 such that banks keep their capital adequacy ratio at policy maker's desired (regulatory) level. It is easy to verify that to achieve the capital

adequacy of k_{min}, MPM should set $\beta_1 = \frac{1}{1-k_{min}(1+\frac{\overline{D}}{K})}$ to ensure banks comply with the minimum capital adequacy ratio requirement.

III. Model with Direct Capital Constraint

A. Banking System's Problem

11. **In this section, we relax the assumption of fixed capital.** However, we continue assuming constant deposits given the stable nature of them in Korea in the past decade. The capital regulation requires the banking system to hold capital K at least as much as the risk weighted assets, $K \geq wA$. Since holding capital is costly, and abstracting from informational asymmetries which could lead to above minimum capital holdings, the banking system always keeps the minimum regulatory capital ratio of $k_{min} = \frac{\mathrm{K}}{wA}$. [12] Defining $\lambda = wk_{min}$ and using the banking system's balance sheet identity would yield the level of liabilities as a function of assets: $L = A - K - \overline{D} = (1-\lambda)\mathrm{A} - \overline{D}$. The banking system's problem then would be simplified to only determining the optimal level of assets. As a result, in this case, MaPPs would only consist of one tax rate τ, which we assume is imposed on assets to GDP, $\frac{A}{Y}$.

Banking system's problem in this case would be:

$$\max_{A,L,K} \; r_a A - c_l L - c_d \overline{D} - c_k K - \frac{1}{2}\tau\frac{A^2}{Y}$$

s.t.:

$$L = (1-\lambda)\mathrm{A} - \overline{D}$$

$$K = \lambda A$$

Where $\overline{D}$ is the level of deposits, which we take as given and $\mathrm{c_d}$ is the deposit rate. Substituting the constraints in the objective function would yield:

$$\max_A \; r_a A - c_l[(1-\lambda)A - \overline{D}] - c_d\overline{D} - c_k\lambda A - \tfrac{1}{2}\tau\tfrac{A^2}{Y}$$

FOC:

$$r_a - c_k\lambda - c_l(1-\lambda) - \tau\tfrac{A}{Y} = 0 \qquad (6)$$

[12] Notice that while in the previous section the nominal capital was assumed fixed, in this section the capital as a ratio of risk-weighted assets is held fixed by banks in equilibrium.

From the FOC the optimal level of $\frac{A}{Y}$ is obtained as below:

$$\frac{A^*}{Y} = \frac{r_a - (1-\lambda)c_l - c_k\lambda}{\tau} \qquad (7)$$

Equation (7) shows that the banking system increases the optimal level of A, as return on assets, r_a, increases and lowers A, with higher cost of non-core funding, c_l, including that of capital, c_k , and as taxes τ increase.[13] Note that r_a, c_l and c_k are determined by market conditions such as risk premium and leverage, and λ is determined by banks' balance sheets.[14] A lower λ would raise the funding costs c_l and c_k, but since our model is a partial equilibrium model, we assume this possibility away.[15]

From equation (7), we can also draw the policy implication that the effectiveness of τ in controlling $\frac{A^*}{Y}$ depends on market conditions and banks' balance sheets as follows:

$$\frac{\partial(A^*/Y)}{\partial\tau} = -\frac{r_a - (1-\lambda)c_l - c_k\lambda}{\tau^2} \qquad (8)$$

Equation (8) shows that imposing τ becomes more effective in containing $\frac{A^*}{Y}$, under the conditions of the higher leverage ratio and/or the risk premium.

B. MPM's Problem

12. **The MPM decides the optimal value of the tax rate on assets (τ) by solving the following problem**:

$$\min_\tau \left(\frac{A^*}{Y} - (\alpha_1 - \alpha_2 y - \alpha_3 g)\right)^2$$

s.t. (7) ; $0 < \tau < \tau_{max}$

Substituting (7) into MaPP's objective function will result in:

$$\min_\tau \left(\frac{r_a - (1-\lambda)c_l - c_k\lambda}{\tau} - (\alpha_1 - \alpha_2 y - \alpha_3 g)\right)^2$$

[13] A lower λ decreases $c_l(1-\lambda)+ c_k\lambda$ because $c_l < c_k$

[14] Modigliani et. al. (1958), and Mossin (1966).

[15] In a general equilibrium setup, which is beyond the scope of our study, the effect of a lower λ on $\frac{A^*}{Y}$ is ambiguous. However, there exists a boundary of parameters within which a lower λ unambiguously induces an increased level of $\frac{A^*}{Y}$. Note also that the leverage ratio λ, which is the product of w and k_{min}, fluctuates pro-cyclically because of w. This explains why banks would raise their target leverage during the boom phase of the cycle.

The solution would be obtained by solving the FOCs for τ:

$$[\frac{r_a - (1-\lambda)c_l - c_k\lambda}{\tau}] - (\alpha_1 - \alpha_2 y - \alpha_3 g) = 0$$

and is given by:

$$\tau = \frac{r_a-(1-\lambda)c_l-\lambda c_k}{\alpha_1-\alpha_2 y-\alpha_3 g} \qquad (9)$$

Equation (9) confirms that when the regulatory authority sets τ, it should consider not only r_a, c_l and c_k, which are determined by market conditions, but also λ, which is determined by banks' balance sheets.

IV. SIMULATIONS

13. **We calibrate the model to Korean data for 2002-2010 to study the implications of these stylized macroprudential policies on leverage of the banking system.** The model is solved for optimal MaPP tax rates, τ_1 and τ_2, as well as the banking system's assets and non-core liabilities. In the simulations, return on assets and unit cost of non-core liabilities are assumed to be constant at their actual averages of the last 10 quarters of the sample. Results are presented in Figure 1. While α_1 and β_1 are set to long-term averages of non-core liabilities to GDP and assets to non-core liabilities in Korea, α_2, β_2, α_3, and β_3 should be based on how aggressively the policymaker would like to adjust its map targets to the cycle. Unaware of Korean authorities' sensitivity to the cycle, we have set α_2, β_2, α_3, and β_3 at arbitrary levels in the baseline (see Table 1 for values), but have done some sensitivity analysis in alternative scenarios. The baseline scenario (solid black lines) corresponds to the case, where the MPM is assumed to set policies, taking into account the financial indicators in relation to both the GDP growth rate vis-à-vis the potential growth rate and the level of the output gap. In this case, the solution to the optimization problem suggests that the policy maker would set τ_1 and τ_2 in line with the economic cycle; if GDP is above potential and is growing above potential both tax rates would be raised, and if GDP is below potential and growing below potential, the tax rates would be reduced. The parameters of the model are set such that if GDP is above potential, but growing less than potential, the tax rates would still be raised, but less than when GDP is also growing above potential. Likewise, if GDP is below potential, but is growing above potential rate, the tax rates would be cut, but less than when GDP is growing below potential. These policy setting ensure that the target financial ratios (assets/GDP, non-core liabilities/GDP, and assets/non-core liabilities) remain broadly constant over the cycle.

14. **We also consider two other scenarios reflecting different preferences for the macroprudential policy maker.** Solid blue lines show the simulation results for the case, where MaPPs only care about the level of the financial indicators in relation to the output gap ($\alpha_2 > 0, \alpha_3 = 0, \beta_2 > 0, \beta_3 = 0$). The paths of optimal τ_1 and τ_2 for this scenario are broadly similar to that of the baseline, except that they follow the path of output gap more closely.

Finally, the dotted red lines show the results for the other case, where MaPPs only care about the level of the financial indicators vis-à-vis economic growth ($\alpha_2 = 0, \alpha_3 > 0, \beta_2 = 0, \beta_3 > 0$). Once again, the results are broadly similar to the baseline, but in this case, they follow the path of GDP growth (net of potential growth) more closely.

15. **The results also show that our simple illustrative macroprudnetial tools on assets and non-core liabilities go a long way in containing systemic risk.** We have simulated paths of non-core liabilities to GDP, assets to non-core liabilities and assets to GDP and compared to the actual trends (Figure 2), keeping the path of GDP growth the same. Simulated paths of these systemic risk indicator ratios are more dampened than the actual over the cycle, thanks to the MaPPs imposed, albeit with similar trends. In other words, MaPPs have been successful in containing systemic risk related to non-core liabilities and assets over the cycle.

16. **Simulation results for the model with variable capital are similar to the baseline (Figure 3)**. In this case also, the solution to the optimization problem suggests that the policy maker would set τ_1 in line with the economic cycle; if GDP is above potential and is growing above potential both tax rates would be raised, and if GDP is below potential and growing below potential, the tax rates would be reduced.

V. CONCLUSION

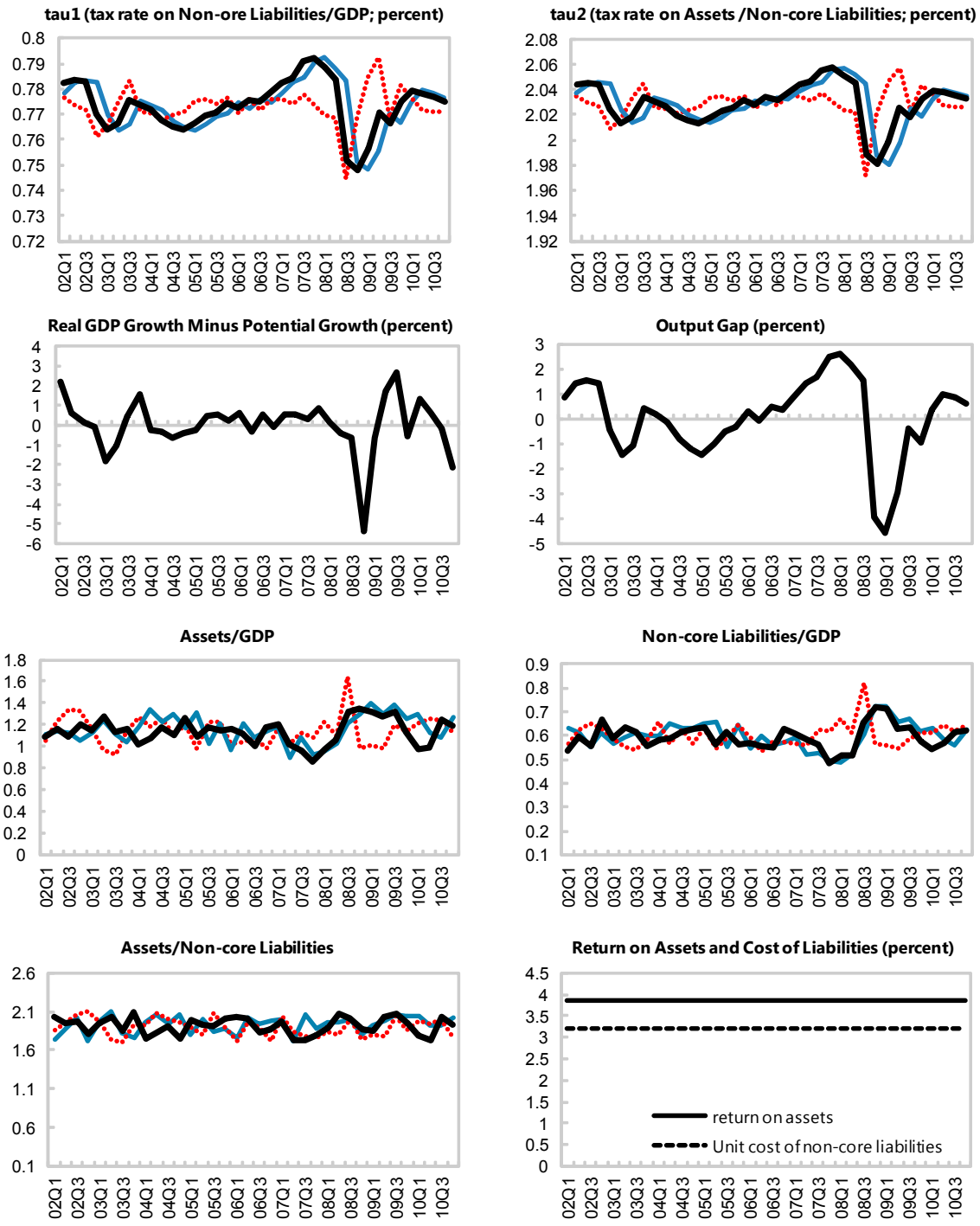
17. **We considered a simple model that could become the building block of a broader macroprudential policy framework**. The policymaker sets tax rates on key financial ratios (assets/non-core liabilities and non-core liabilities/GDP) over the cycle to avoid excessive buildup of leverage in the economy, and that cannot be addressed through macroeconomic policies. Acknowledging that macroprudential policies could not substitute for appropriate macroeconomic policies in managing the economic cycle, we worked with a stylized partial equilibrium model, taking macroeconomic policy settings as given, to capture the key elements of macroprudential policies in complementing these policies.

18. **The model was simulated with Korean data for 2002–10**. The results suggest that even in a stylized partial equilibrium model, MaPPs could act as a second lever to dampen the credit growth and the associated increase in banking system leverage, beyond cyclical norms.

19. **The model could be enhanced on several dimensions**. Further research is needed to incorporate multiple financial vulnerability indicators beyond leverage in the MaPPs' problem. In addition, the model could be enhanced to a general equilibrium setup, in which both MaPPs and macroeconomic policy decisions are studied jointly. In a richer setup, the model could be extended by making interest rates variable with the cycle and market conditions. Another possible extension could be to allow for countercyclical capital requirements. Despite its simplicity, the framework in this paper could provide a useful starting point. It should also be noted that while the model's results may be a useful guide to

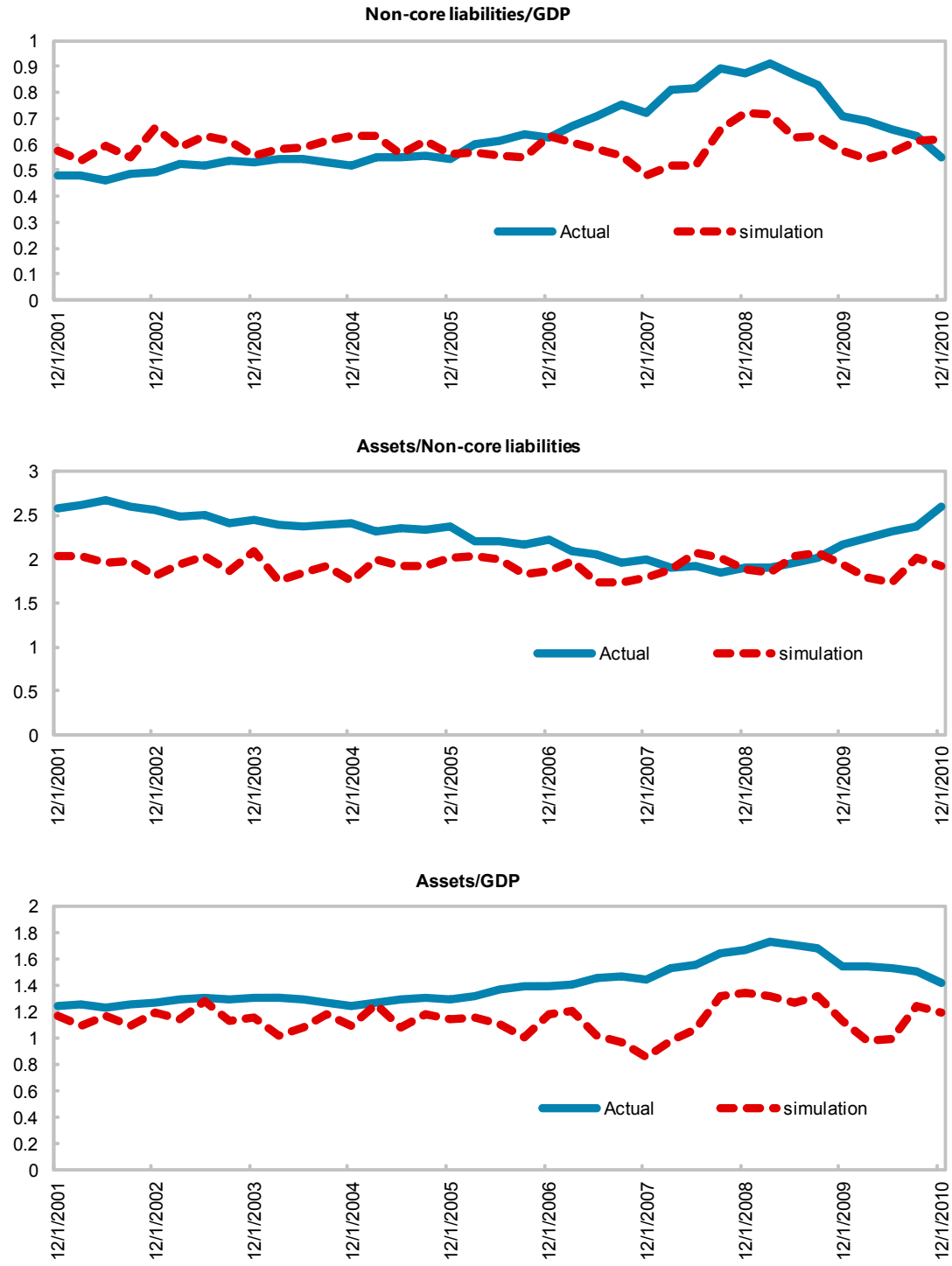
such a framework, actual implementation of such a tax—including the macroprudential stability levy in Korea—should be transparent and predictable. They should also avoid frequent adjustments even though the model may suggest changes, similar to monetary policy under inflation targeting that avoids frequent interest rate adjustments even if the underlying Taylor rule indicates incremental shifts in the appropriate interest rate stance.

Figure 1. Korea: Macroprudential Model Simulations, 2002-2010 /1



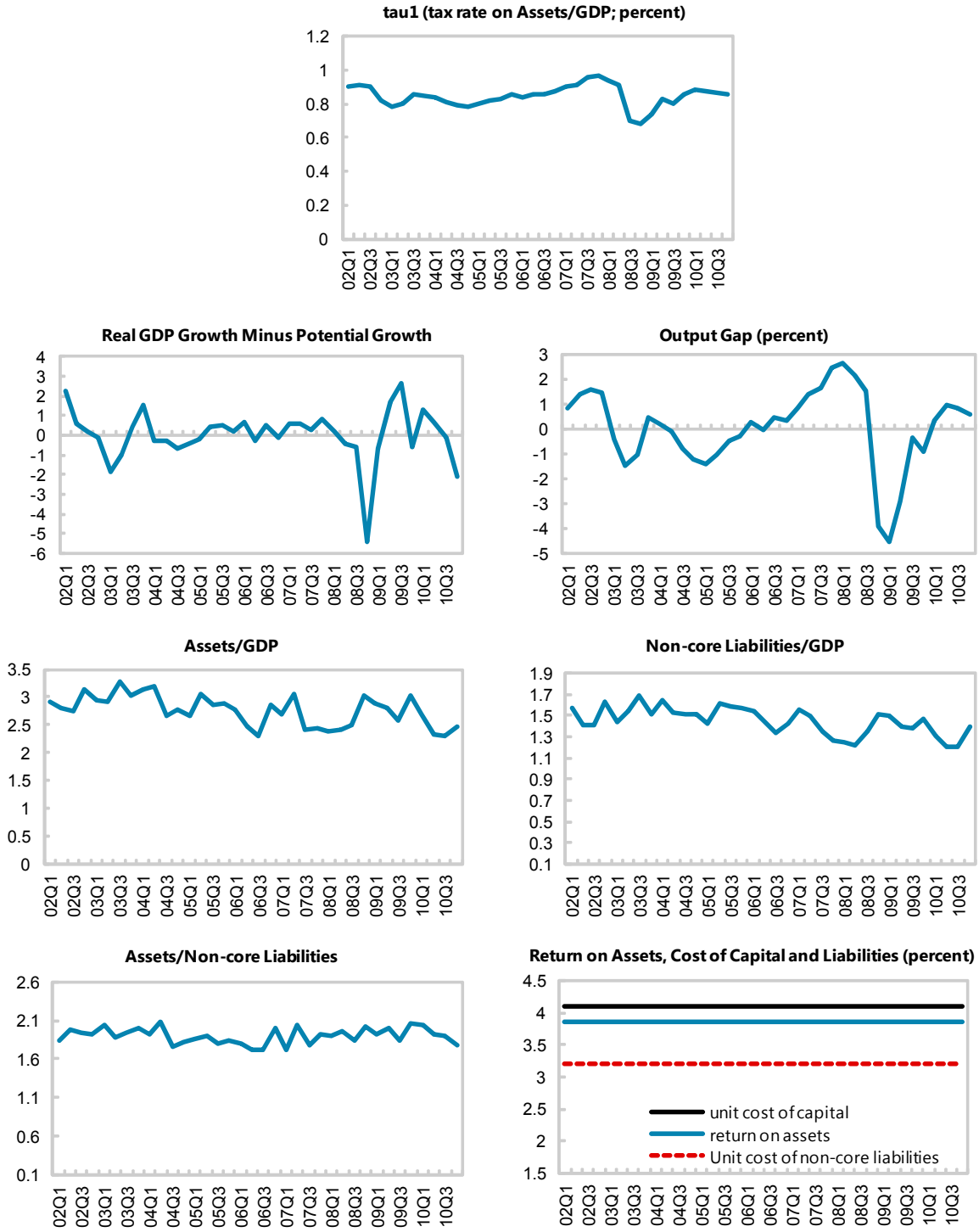
Source: Authors' simulations.
1/ Main Model. Bold solid black is the baseline, where MaPPs respond both to GDP level and growth. Solid blue is for when MaPPs only respond to GDP level, and dotted red is when they respond only to growth.

Figure 2. Korea: Simulations versus Actual Data, 2002-2010



Source: Korean authorities and authors' simulations.

Figure 3. Korea: Macroprudential Model Simulations, 2002-2010 /1



Source: Authors' simulations.
1/ Model with variable capital and MaPP tax only on Assets/GDP.

Table 1. Baseline Parameter Values

α1	α2	α3	β1	β2	β3
0.6	3.0	3.0	1.9	1.0	1.0

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