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Liquidity regulation, bank capital ratio, and interbank rate

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ABSTRACT

We study the impact of the Basel III liquidity coverage ratio (LCR) on bank capital ratio and the interbank rate in a traditional banking model. We find that inappropriate parameters assigned to calculate High-Quality Liquid Assets (HQLAs) and Net Cash Flows (NCOs) would lower the equilibrium capital ratio especially when the required liquidity ratio is strengthened. In addition, these regulatory parameters may have macro-prudential effects to steer the interbank rate.

1. Introduction

One of the main objectives of the liquidity requirements proposed by Basel III (BCBS, 2013) is to reduce the need for central bank interventions when banks face distress (Monnet and Vari, 2023). However, their impact on bank capital ratios is less documented. In this paper, we extend the Poole (1968) model to analyze the impacts of strengthening the Basel-style liquidity requirement – represented by the liquidity coverage ratio (LCR) requirement – on the equilibrium capital ratio and the interbank rate. We find that sufficiently high liquidity weights on risk assets for calculating the stock of liquid assets would lower the capital ratio when the required liquidity ratio is stringent, implying an unintended consequence of raising liquidity requirements when inappropriate liquidity weights are assigned to risk assets. In a similar vein, low runoff rates assigned to liabilities to calculate bank expected cash outflows would also lead to lowered capital ratios. Thus, a strengthened capital requirement would be important to moderate these negative impacts, suggesting that improving the capital requirement proposed by current Basel III would be in the right direction. We also find that changes in these regulatory parameters can be employed to steer the interbank rates.

The contributions of this paper lie in three aspects. First, although there is a large body of Poole-style papers, such as Bech and Keister (2017) and Monnet and Vari (2023), very few investigate capital ratios. To achieve this objective, we endogenize the banks' equilibrium amounts of investment, liquid assets, and capital. Although Monnet and Vari (2023) relax the possibility of allowing banks' endogenous investment, their model excludes the existence of bank capital, as no capital is injected for the extra project invested. Second, we add to the literature on the debate on the costs and benefits of raising liquidity requirements. As an addition to related literature, e.g., Curfman and Kandrac (2022), we show that the parameters assigned for calculating High-Quality Liquid Assets (HQLAs) and Net Cash Outflows (NCOs) would also affect bank equilibrium capital ratios. Our results thus provide several timely policy implications for a more stable banking system given the current regulatory trends of raising liquidity requirements. Given that those parameters are ad-hoc factors suggested by BCBS (2013), we suggest they can be amended, if necessary, for better conduct of monetary policy (Bech and Keister, 2017).

2. The model

Our model is built following Poole (1968), and is a reduced form from recent variants, e.g., Bech and Keister (2017). The economy consists of a unit continuum of banks indexed by $i \in [0,1]$ and a central bank. There is a single time period divided into two stages. In the first stage, a representative bank i receives a given amount of deposits D, and can choose an amount K^i of capital, risk assets (including loans, securities, and other assets which yield returns to banks) N^i, risk-free liquid assets B^i, and interbank borrowing Δ^i (negative if it is an interbank lender) to maximize their profits. The bank's balance sheet can be

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written as: $N^i + B^i + \Delta^i = D + K^i$. In the second stage, the interbank market is closed, an amount of $\varepsilon^i \sim G$ of deposits is sent as a payment to another bank, where we assume $\mathrm{E}[\varepsilon^i] = 0$ and G is a continuous uniform distribution with bounded support, and the p.d.f. of which is denoted by g. The central bank can lend to banks, as a lender of last resort, at the amount of X^i, with a penalty rate. The balance sheet of a representative bank i at the second stage is summarized in Table 1.

2.1. The LCR requirement

The LCR requirement[1] on bank i is summarized as:

$$LCR^i = \frac{\tau_N N^i + B^i + \Delta^i + X^i - \varepsilon^i}{\theta_D(D - \varepsilon^i) + \theta_\Delta \Delta^i + \theta_X X^i} \geq \iota. \tag{1}$$

The numerator of (1) is the sum of banks' HQLAs, while the denominator is the sum of the NCOs, as defined by the LCR liquidity requirement. θ_D, θ_Δ and θ_X are the runoff rates on NCOs for deposits, interbank borrowing, and borrowing from the central banks, respectively, where a higher value means a higher fraction of cash outflows; τ_N is the liquidity weights (where $0 \leq \tau_N \leq 1$) on banks' investments[2] for the calculation of HQLAs, in which a higher weight indicates the use of a higher percentage of asset values as a source of liquidity; and ι is the required liquidity ratio. Let $E^i_{LCR} = \frac{\tau_N N^i + B^i + (1-\iota\theta_\Delta)\Delta^i - \iota\theta_D D}{1-\iota\theta_D}$ be the *excess liquidity* above the LCR requirement. Thus, the minimum amount bank i must borrow from the central bank to fulfill the requirement in (1) is given by:

$$X^i_{LCR} \equiv \max\left\{\frac{1-\iota\theta_D}{1-\iota\theta_X}\left(\varepsilon^i - E^i_{LCR}\right), 0\right\}, \tag{2}$$

where θ_D and θ_X are multiplied by ι (the required liquidity ratio). Therefore, the bank must borrow from the central bank if $\varepsilon^i > E^i_{LCR}$.

2.2. Optimal choices

Bank i will choose $\{K^i, N^i, \Delta^i\}$ to maximize its profit $\pi(\varepsilon^i)$, which is expressed as:

$$\pi(\varepsilon^i) = \tilde{r}_N N^i + \tilde{r}_B B^i - \tilde{r}_I \Delta^i - \tilde{r}_X X^i - \Psi_K. \tag{3}$$

Following Monnet and Vari (2023), we assume the return on investment $\tilde{r}_N = \frac{\overline{N}_{max} - N^i}{2A}$, where $\overline{N}_{max}$ represents the total investment demand when the interest rate is zero and A captures the sensitivity of the demand to interest rates. $\tilde{r}_B$ is the bond rate, $\tilde{r}_I$ is the interbank rate, while $\tilde{r}_X$ is the penalty rate on borrowing from the central bank. For tractability, we normalize the deposit rate (r_D) to zero; consequently, $\tilde{r}_N$, $\tilde{r}_B$, $\tilde{r}_I$ and $\tilde{r}_X$ are presented as the normalized spread between the respective rate and the deposit rate. $\Psi_K = \frac{\varphi_K}{2}(K^i)^2$ represents the equity issuance cost, which is introduced to trace the endogenous amount of K^i.

We can write the expected value of bank i as:

$$\mathbb{E}[\pi] = \tilde{r}_N N^i + \tilde{r}_B B^i - \tilde{r}_I \Delta^i - \tilde{r}_X \mathbb{E}\left[\max\left\{\frac{1-\iota\theta_D}{1-\iota\theta_X}\left(\varepsilon^i - E^i_{LCR}\right), 0\right\}\right] - \Psi_K. \tag{4}$$

Considering the distribution of ε^i, the function in (4) can be rewritten as:

$$\tilde{r}_N N^i + \tilde{r}_B B^i - \tilde{r}_I \Delta^i - \tilde{r}_X \frac{1-\iota\theta_D}{1-\iota\theta_X} \int_{E^i_{LCR}}^{\infty} \left(\varepsilon^i - E^i_{LCR}\right) dG(\varepsilon^i) - \frac{\varphi_K}{2}(K^i)^2. \tag{5}$$

Table 1
Balance Sheet of Bank i.

Assets	Liabilities
Investments: N^i	Deposits: $D - \varepsilon^i$
Liquid Assets: $K^i - N^i + D$	Net Interbank Borrowing: Δ^i
Reserve: $\Delta^i - \varepsilon^i + X^i$	Borrowing from Central Bank: X^i
	Equity: K^i

2.3. First-Order conditions (FOCs)

The FOC for investments N^i is:

$$\frac{\overline{N}_{max}}{2A} - \frac{N^i}{A} = \frac{\tilde{r}_X}{1-\iota\theta_X}\left[1 - G\left(E^i_{LCR}\right)\right]. \tag{6}$$

The FOC for capital K^i is:

$$\varphi_K K^i = \frac{\tilde{r}_X}{1-\iota\theta_X}\left[1 - G\left(E^i_{LCR}\right)\right]. \tag{7}$$

The FOC for interbank volume Δ^i is:

$$\tilde{r}_I = \tilde{r}_X \frac{1-\iota\theta_\Delta}{1-\iota\theta_X}\left[1 - G\left(E^i_{LCR}\right)\right]. \tag{8}$$

2.4. Aggregation

Given that $\int_0^1 \Delta^i = 0$, we can rewrite (6), (7), and (8) as:

$$\frac{\overline{N}_{max}}{2A} - \frac{N^*}{A} = \frac{\tilde{r}_X}{1-\iota\theta_X}\left[1 - G(E_{LCR})\right]. \tag{9}$$

$$\varphi_K K^* = \frac{\tilde{r}_X}{1-\iota\theta_X}\left[1 - G(E_{LCR})\right]. \tag{10}$$

$$\tilde{r}^*_I = \tilde{r}_X \frac{1-\iota\theta_\Delta}{1-\iota\theta_X}\left[1 - G(E_{LCR})\right]. \tag{11}$$

where $E_{LCR} = \frac{\tau_N N^* + B^* - \iota\theta_D D}{1-\iota\theta_D}$, and variables with superscript $(*)$ are their total value after aggregation.

3. Results

3.1. Impact of hqla weights on capital ratios

From (9), we can obtain:

$$\frac{\partial N^*}{\partial \iota} = \frac{A V_X (1-\iota\theta_X)(1-\iota\theta_D)}{g\tau_N \tilde{r}_X - (1-\iota\theta_X)(1-\iota\theta_D)}. \tag{12}$$

Similarly, from (10), we can obtain:

$$\frac{\partial K^*}{\partial \iota} = \frac{1}{\varphi_K}\left\{\frac{g\tilde{r}_X\theta_D(D - B^*)}{(1-\iota\theta_X)(1-\iota\theta_D)^2} + \frac{\tilde{r}_X\theta_X}{(1-\iota\theta_X)^2}\left[1 - G(E_{LCR})\right]\right\}. \tag{13}$$

Let $V_X = \frac{g\tilde{r}_X\theta_D(D-B^*)}{(1-\iota\theta_X)(1-\iota\theta_D)^2} + \frac{\tilde{r}_X\theta_X}{(1-\iota\theta_X)^2}\left[1 - G(E_{LCR})\right] > 0$ so that (13) can be rewritten as:

$$\frac{\partial K^*}{\partial \iota} = \frac{V_X}{\varphi_K}. \tag{14}$$

[1] Since we are focusing on the impacts of strengthening liquidity requirements, we remove reserve requirements from our analysis by assuming reserve equal to 0.

[2] In addition to related literature, the introduction of liquidity weights on bank investments follows BCBS (2013) and recent literature, such as Walther (2016), in which bank (illiquid) investment projects receive 'liquidity weights' for calculation of HQLAs. τ_N can be seen as assigned liquidity weights as set in Annex 4 of BCBS (2013) and the fraction of matured loans, which can be seen as liquid assets to banks (De Nicolò *et al.*, 2014).

Capital ratio refers to the capital held by banks as a function of risk assets. It is then calculated as $k^* = \frac{K^*}{N^*}$. We use this *risk-based* measure (similar to Basel III; BCBS, 2011) given that we only focus on risk assets N^*, instead of total assets, i.e., $B^* + N^*$. Thus, $\frac{\partial k^*}{\partial \iota} = \frac{\frac{\partial K^*}{\partial \iota}N^* - \frac{\partial N^*}{\partial \iota}K^*}{(N^*)^2}$. Using (12) and (14), we obtain:

$$\frac{\partial k^*}{\partial \iota} = \left[N^* - \frac{A\varphi_K(1-\iota\theta_X)(1-\iota\theta_D)K^*}{g\tau_N\widetilde{r}_X - (1-\iota\theta_X)(1-\iota\theta_D)}\right]\frac{V_X}{\varphi_K(N^*)^2} \gtrless 0. \tag{15}$$

From (15), one can see the sign of $\frac{\partial k^*}{\partial \iota}$ depends on the value of τ_N. We thus have the following proposition.

Proposition 1. There exists a threshold $\overline{\tau}_N = \frac{(1-\iota\theta_X)(1-\iota\theta_D)\left(1+\frac{A\varphi_K K^*}{N^*}\right)}{g\widetilde{r}_X}$, such that $\frac{\partial k^*}{\partial \iota}\left\{\begin{matrix} > \\ = \\ < \end{matrix}\right\}0$ as $\tau_N\left\{\begin{matrix} < \\ = \\ > \end{matrix}\right\}\overline{\tau}_N$.

Proposition 1 is derived directly from (15). The takeaway from Proposition 1 is that there are two competing effects on an equilibrium capital ratio k^*, with the strengthening of LCR liquidity requirement (i.e., a higher ratio ι). On the one hand, a higher required liquidity ratio would raise banks' liquid asset holdings, as only raising liquid assets can satisfy the increased liquidity ratio required, which lowers bank investment in risk assets and therefore raises the capital ratio per unit of investment. On the other hand, a stringent liquidity requirement lowers the equilibrium capital ratio when the weights on bank risk assets are relatively high so that they are considered more liquid, which means holding a higher amount of risk assets qualifies banks to satisfy the required liquidity ratio by means of higher HQLAs. In this case, banks could, in practice, react by lowering their capital ratios as recent studies such as Fang et al. (2022), Berger et al. (2023) and Dursun-de Neef et al. (2023) show that banks across the globe have recently held higher capital ratios than the minimum required ratio. Consequently, a capital requirement is essential in this case to set a floor on bank capital, implying that the current trend of increasing capital requirement by the current Basel III is on the right track. Which of the effects dominates depends on the liquidity weights assigned: when the assigned liquidity weights are high (low), i.e., when τ_N is high (low), the second (first) effect dominates, and thus a strengthened liquidity requirement would lower (raise) banks' capital ratio.[3]

Since we cannot compare these two effects analytically, the results above are graphically presented in Fig. 1. Panel A shows the results for equilibrium capital ratios. When the liquidity weights are low ($\tau_N = 0.1$), raising the required liquidity ratio ι would raise the equilibrium capital ratio. However, this effect is reversed when the weights are higher (i.e., when $\tau_N \geq 0.2$). Panel B indicates that the benefit of lower liquidity weights (i.e., heavier haircuts) comes at the cost of lower investment, and the effect is more pronounced when ι increases. The upward slope of investment (when $\tau_N \geq 0.2$) is akin to the results of Curfman and Kandrac (2022), who showed a positive relationship between liquidity securities holdings and required liquidity ratios. In other words, a higher τ_N value raises the amount of bank investment (and lowers the capital ratio). This effect is more pronounced when the required liquidity ratio is raised, suggesting that inappropriately high liquidity weights for the HQLAs calculation would introduce a more fragile banking system.

3.2. *Impact of NCO runoff rates on capital ratios*

Regarding the impacts of runoff rates θ_X and θ_D on capital ratios, we have the following proposition:

Proposition 2. For a given value of τ_N, $\frac{\partial^2 k^*}{\partial \iota \partial \theta_X} > 0$ and $\frac{\partial^2 k^*}{\partial \iota \partial \theta_D} > 0$.

The proof of Proposition 2 is provided in the Appendix. Proposition 2 suggests that a higher value of θ_X or θ_D would lead to a higher capital ratio. The reason is intuitive, as a higher runoff rate on NCOs forces banks to raise their asset liquidity to satisfy the LCR requirement, e.g., lowering risk investments and raising liquid assets, which would accordingly lead to an increase in their capital ratios per unit of risk investment. This result implies that the runoff rate to calculate NCOs could also affect banks' equilibrium capital ratios. Moreover, as shown in the Appendix, we also find that these parameters could also affect interbank rates.

4. Conclusion

In this paper, we extend a traditional model on the interbank market to investigate the impacts of a liquidity requirement (the LCR requirement) on the equilibrium bank capital ratio and the interbank rate. We find that inappropriate values of regulatory parameters for calculating HQLAs and NCOs could lower the equilibrium banks' capital ratio when the liquidity requirement is stringent. Our results call for a cautious implementation of these regulatory parameters and stress the importance of capital requirements as a supplement for liquidity requirements. We also show that these regulatory parameters can affect interbank rates.

Data availability

Data will be made available on request.

Appendix

Proof of Proposition 2

Copying (15) below:

$$\frac{\partial k^*}{\partial \iota} = \left[N^* - \frac{A\varphi_K(1-\iota\theta_X)(1-\iota\theta_D)K^*}{g\tau_N\widetilde{r}_X - (1-\iota\theta_X)(1-\iota\theta_D)}\right]\frac{V_X}{\varphi_K(N^*)^2}.$$

One can see that the sign of $\frac{\partial k^*}{\partial \iota}$ depends on the sign in the bracket, and thus the problem can be reduced to:

[3] The different treatment of certain types of bank assets between capital and liquidity regulations confirms the practical importance of our model. For example, corporate debt rated between A+ and BBB- has a liquidity weight of 50 % (BCBS, 2013, Annex 4; BCBS, 2019, Paragraph 99.1). However, in the standardized capital regulation, corporate debt rated A+ to A- has a risk weight of 50 %, while those rated between BBB+ and BBB- have a weight of 75 % (BCBS, 2022, Paragraphs 20.41 and 20.43). This fact implies that corporate debt securities rated between BBB+ and BBB- are treated better in liquidity regulation than in the capital requirement. Thus, if well-capitalized banks choose to sell A+ securities to invest the same amount in BBB- securities (e.g., due to the higher expected profitability of the latter), their minimum regulatory capital would increase while there would be no change in their regulatory liquidity ratio.

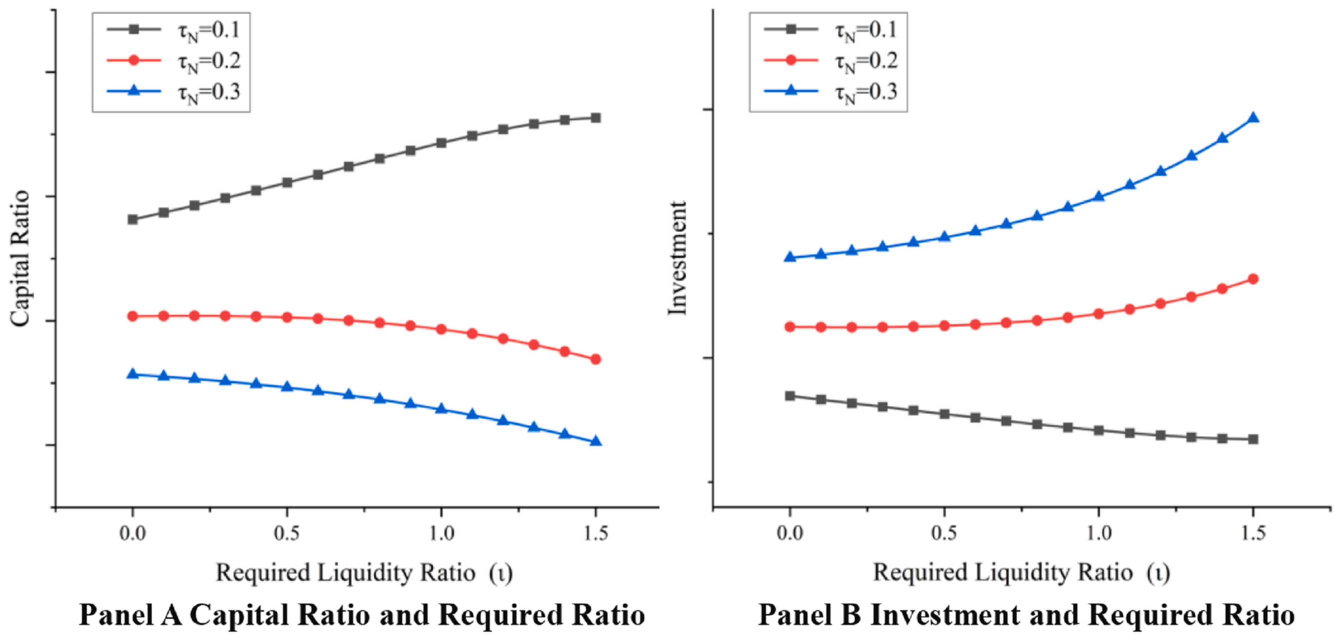

Fig. 1. Capital Ratio, Investment and Required Liquidity Ratio.
The parameters for constructing Fig. 1 are: $\theta_\Delta = 0.6$, $\theta_D = 0.3$, $\theta_X = 0.2$, $D = 0.07$, $\overline{N}_{max} = 0.2$, $A = 3$, $\varphi_K = 10$, $G \sim U[-1, 1]$.

$$\frac{\partial^2 k^*}{\partial\iota\partial\theta_X} = \frac{A\varphi_K K^* g\tau_N \widetilde{r}_X \iota(1-\iota\theta_D)}{[g\tau_N\widetilde{r}_X - (1-\iota\theta_X)(1-\iota\theta_D)]^2} > 0,$$

$$\frac{\partial^2 k^*}{\partial\iota\partial\theta_D} = \frac{A\varphi_K K^* g\tau_N \widetilde{r}_X \iota(1-\iota\theta_X)}{[g\tau_N\widetilde{r}_X - (1-\iota\theta_X)(1-\iota\theta_D)]^2} > 0.$$

Impact of HQLA and NCO Parameters on Interbank Rates

Partially differentiating (11), we find that:

$$\frac{\partial\widetilde{r}_I^*}{\partial\iota} = \widetilde{r}_X \frac{g\theta_D(1-\iota\theta_\Delta)(D-\tau_N N^* - B^*)}{(1-\iota\theta_X)(1-\iota\theta_D)^2} - \widetilde{r}_X[1-G(E_{LCR})]\frac{\theta_\Delta - \theta_X}{(1-\iota\theta_X)^2} \gtrless 0.$$

Although the sign of $\frac{\partial\widetilde{r}_I^*}{\partial\iota}$ is undetermined, we have:

$$\frac{\partial^2\widetilde{r}_I^*}{\partial\iota\partial\tau_N} = -\frac{g\widetilde{r}_X(1-\iota\theta_\Delta)N^*}{(1-\iota\theta_D)(1-\iota\theta_X)} < 0,$$

$$\frac{\partial^2\widetilde{r}_I^*}{\partial\iota\partial\theta_\Delta} = -\frac{\iota g\theta_D\widetilde{r}_X(D-\theta_N N^* - B^*)}{(1-\iota\theta_X)(1-\iota\theta_D)^2} - \frac{\widetilde{r}_X}{(1-\iota\theta_X)^2}[1-G(E_{LCR})] < 0,$$

$$\frac{\partial^2\widetilde{r}_I^*}{\partial\iota\partial\theta_X} = \frac{g\theta_D\theta_X\widetilde{r}_X(1-\iota\theta_\Delta)(D-\theta_N N^* - B^*)}{(1-\iota\theta_X)^2(1-\iota\theta_D)^2} + \widetilde{r}_X[1-G(E_{LCR})]\frac{1+\iota(\theta_X - 2\theta_\Delta)}{(1-\iota\theta_X)^3} > 0,$$

$$\frac{\partial^2\widetilde{r}_I^*}{\partial\iota\partial\theta_D} = \frac{g\widetilde{r}_X(D-\tau_N N^* - B^*)}{(1-\iota\theta_X)^2(1-\iota\theta_D)^2}\left[\frac{(1-\iota\theta_\Delta)(1-\iota\theta_X)(1+\iota\theta_D)}{1-\iota\theta_D} - \iota(\theta_\Delta - \theta_X)\right] \gtrless 0.$$

The takeaway is that, to lower the interbank rate, the government can choose to raise τ_N (making investment more eligible to be added to the stock of liquid assets); to raise θ_Δ (making interbank borrowing less eligible to satisfy the requirement); to lower θ_X (making borrowing from the central bank a more preferred alternative to interbank borrowing). However, it would be less effective to adjust θ_D, as changes in θ_D would affect all banks unanimously, irrespective of their interbank position, thus leaving the impacts on interbank rate undetermined. These results thus suggest that the regulatory parameters can affect interbank rates as well.

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