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The Relationship between Capital and Liquidity Prudential Instruments

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THE RELATIONSHIP BETWEEN CAPITAL AND LIQUIDITY PRUDENTIAL INSTRUMENTS

Zlatuše Komárková, Martin Hodula, Lukáš Pfeifer[1]

The risks associated with credit and liquidity positions and asset and liability maturity mismatches are mitigated by applying capital ratio, leverage ratio, liquidity coverage ratio and net stable funding ratio requirements to banks. As a macroprudential authority, the Czech National Bank moreover responds to changes in systemic risk by changing the capital buffer requirements. This can induce a reaction by banks leading to a change in their balance-sheet structure, which, in turn, will affect their degree of fulfilment of all the requirements. This article analyses the relationship between the regulatory capital and liquidity instruments by studying banks' response to an increase in the countercyclical capital buffer rate and a subsequent economic downturn. The results reveal that it is vital for macroprudential authorities to look at the initial levels of the other required ratios before starting to change the countercyclical capital buffer rate if they are to maximise the effectiveness of the latter.

I. INTRODUCTION

The planned CRD V/CRR II regulatory package, which is expected to be implemented into national law during 2021, introduces a binding leverage ratio (LR) requirement in the capital regulation area and a net stable funding ratio (NSFR) requirement in the liquidity regulation area. Banks will be required to meet both these requirements together with the risk-weighted capital ratio (CR) requirement for credit risk and the liquidity coverage ratio (LCR) requirement already in force. Although the original regulatory objective of all four requirements was to increase banks' resilience to a specific type of risk, their interconnectedness means that their effect – especially on the real economy – will be more complex in reality.

The literature on the relationship between banks' capital (solvency) and liquidity is fairly extensive (ECB, 2018). It focuses primarily on the link between their leverage and liquidity over the cycle (Brunnermeier and Pedersen, 2009; Adrian and Shin, 2010; Huang and Ratnovski, 2011; Damar et al., 2013; BCBS, 2016), which is often mentioned in the context of the onset of the global financial crisis in 2007. In this regard, authors often note the complementarity of capital and liquidity instruments – capital regulation alone was not enough to mitigate the effects of the global financial crisis. Despite apparently being sufficiently capitalised at the time of the crisis, banks lost access to affordable liquidity and, just like manifestly undercapitalised banks, were gradually forced to sell off their illiquid assets, accumulate highly liquid assets and reduce their leverage, ultimately reining in the supply of credit to the real economy. Excessively high costs of funding, or loss of access to funding directly, are regarded as a fundamental channel of transmission of liquidity shocks to banks' capital (Puhr and Schmitz, 2014). Shock transmission also works in the opposite direction, as undercapitalised banks usually face liquidity risk in the form of high costs of funding. Several other empirical studies, focusing mainly on high-quality liquid assets, point to the complementarity of capital and liquidity regulation. Studies have shown that sufficient holdings of such assets reduce the overall credit risk in banks' balance sheets (Banerjee and Mio, 2015; Bonner, 2015; Duijm and Wierts, 2016). An abundant literature deals with the interaction of the weighted (CR) and unweighted (LR) capital requirements (Goel et al., 2017; Pfeifer et al., 2017; Mankart et al., 2018) but abstracts from the effect of liquidity requirements. Similarly, the literature also examines the relationship between the CR and LCR requirements but abstracts from the effect of the LR and the NSFR ones (Behn et al., 2019).

Cecchetti and Kashyap (2018) and Chami et al. (2017) investigate the relationship between the four requirements. The first study mechanistically explores the potential redundancy of the different sorts of requirements, while the second develops a dynamic model for bank holding companies and examines how various types of investments on the asset side interact. For a basic understanding of the interaction of the four requirements, it is useful to consult BCBS (2015), which analyses the relationships through the effect of three types of shocks to banks' balance sheets – credit, liquidity and funding (Table 1, BCBS 2015, p. 7). According to the findings of BCBS (2015), all three types of shocks should affect the constraining function of the NSFR and LR requirements, while only liquidity shocks should affect all the requirements.

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Table 1 Effects of selected types of shocks on the capital and liquidity regulatory requirements

Credit shock	Liquidity and collateral shock	Funding shock
Source:		
RWA migration	Change in share and/or prices of liquid balance-sheet assets	Change in liability maturities
Credit losses	Growth in balance sheet (e.g. due to binding credit lines) funding by short-term sources	Withdrawals of stable deposits
Impact:		
CR	CR	
LR	LR	LR
	LCR	LCR
NSFR	NSFR	NSFR

Source: BCBS, 2015, p. 7, Table 2, modified by the authors

This thematic article extends the issue of the interaction of capital and liquidity requirements by including a regulatory shock. Given their discretionary powers, it is vital for prudential authorities to study the effect of a change to one prudential instrument on the others if they are to maximise the effectiveness of their prudential tools and avoid an unintended negative knock-on effect on the supply of credit to the real economy. Studying the adjustment of banks to changes to a regulatory requirement is also useful for understanding the constraining effects of each requirement on banks operating under different business models. Lastly, it is also useful for ensuring that banks themselves, given their prudential interest in maintaining their capital and liquidity ratios optimally above the regulatory minimum (Behn et al., 2019), are not caught out by a change in the economic or regulatory conditions.

In current practice, the prudential authority changes the aggregate capital requirement only by changing the capital buffer rate. For this reason, we analyse the adjustment of Czech banks to a change in the countercyclical capital buffer (CCyB) rate. This is meant to demonstrate the various ways in which a change in the CR requirement can affect fulfilment of the LCR, NSFR and LR requirements via individual items of banks' (off-)balance sheets. Given the various adjustment strategies applied by banks in response to an increase in the capital requirement, we further test their actual resilience to a subsequent economic downturn (a credit shock; see Table 1). In other words, by simulating two different scenarios representing two different phases of the cycle, we analyse the effect that a specific way of meeting the increased capital buffer requirement in an upward phase of the cycle can have on banks' overall resilience during the subsequent downturn, assuming strict compliance with all four requirements across the cycle.

II. CAPITAL AND LIQUIDITY REQUIREMENTS

A CR requirement was already part of the Basel I regulatory framework in 1996. In 2006, Basel II introduced a risk-weighted requirement for credit risk, which more sensitively reflected the riskiness of exposures. In 2014, Basel III added a macroprudential capital buffer to the capital requirement. The CR is a function of the required minimum amount of capital, the amount of assets and the risk weights of the relevant asset classes. It can be written in simplified form as:

$$CR \leq \frac{Total\ capital}{Risk-weighted\ exposures} \approx 11.75\% \leq \frac{E}{\sum_n r_n^A A_n + \sum_o r_o^{OBSA} OBSA_o}, \quad (1)$$

where E is total capital, comprising the overall capital requirement and the capital surplus, A are risky assets, $OBSA$ are off-balance sheet assets and r_n^A, r_o^{OBSA} are risk weights.[2]

The main advantage of the risk-weighted capital requirement is that it takes into account asset riskiness in relation to the bank's business model. However, this gives rise to heterogeneity of risk weights[3] and hence also of the capital requirement across banks. CRD V/CRR II therefore introduces an LR requirement, which determines the minimum

[2] The value of 11.75% given in equation (1) refers to the overall capital requirement applicable in the Czech Republic as of 1 September 2019 excluding the systemic risk buffer and the Pillar 2 requirements (which are applied to only some institutions).

[3] The present regulatory framework allows risk weights – and hence asset riskiness – to be determined using either a standardised approach (STA) or an approach based on internal ratings (IRB). Banks applying the STA approach use risk weights laid down by law, while those using the IRB approach use internal models to determine them.

capital requirement regardless of the riskiness of banks' exposures.[4] The LR requirement is a function of Tier 1 capital and total exposures, comprising total assets plus selected off-balance sheet exposures. It can be expressed in simplified form as:

$$LR \leq \frac{Tier\ 1}{Total\ exposures} \approx 3\% \leq \frac{E}{R + A + OBSA}, \tag{2}$$

where R is a liquidity buffer composed of high-quality liquid assets.

The LCR requirement obliges a bank to hold a liquidity buffer which is adequate to cover its net liquidity outflows under stressed conditions over a period of 30 days. Net liquidity outflows equal liquidity outflows less liquidity inflows. The LCR requirement can be stated in simplified terms as:

$$LCR \leq \frac{Liquidity\ buffer}{Net\ liquidity\ outflow} \approx 100\% \leq \frac{\sum_j R_j v_j}{\sum_m l_m^D D_m - \sum_n bcA_n + \sum_o l_o^{OBSA} OBSA_o}, \tag{3}$$

where l_m^D and l_o^{OBSA} are the outflow rates, $\sum_j R_j = R$ denotes safe liquid assets,[5] v_j are weights reflecting the stressed conditions, $\sum_m D_m = D$ are less stable deposits, securities and liabilities maturing in less than one year, and $\sum_n bcA_n$ is the sum of expected liquidity inflows on risky assets ($\sum_n A_n = A$, b is the weight expressing the size of the expected inflows on risky assets and c is the cap on the size of the expected inflows, i.e. $1 - c$ is the deduction from the expected inflows[6]). It is apparent from equation (3) that the aim of the minimum required LCR of 100% is to maintain the weighted sum of the selected assets above that of the selected liabilities.

The NSFR requirement is designed mainly to ensure that banks' long-term and risky assets are adequately met with a diversity of stable funding instruments under both normal and stressed conditions. The NSFR can be expressed in simplified terms as:

$$NSFR \leq \frac{Available\ stable\ funding}{Required\ stable\ funding} \approx 100\% \leq \frac{\sum_k a_k^B B_k + \sum_m a_m^D D_m + E}{\sum_n f_n A_n + \sum_r f_r R_r}, \tag{4}$$

where a_k^B and a_m^D are the stable funding factors (on average, $a_m^D > a_k^B$), f_n and f_r are weights expressing the level of required stable funding used to cover the relevant assets (on average, $f_n > f_r$), $\sum_r R_r = R$ and $\sum_k B_k = B$ comprises stable deposits, securities and other liabilities maturing in more than one year. It is apparent from equation (4) that the aim of the required NSFR is to maintain the weighted sum of the selected liabilities above that of the selected assets. The principle of the NSFR requirement is the opposite of that of the LCR requirement (Cecchetti and Kashyap, 2018).

Czech banks have long been compliant with the binding CR and LCR requirements (see Charts 1 and 2). Most banks are compliant with the overall capital requirement, consisting of the minimum regulatory level in Pillar 1 (8%), the requirements based on the supervisory review of risks in Pillar 2 (1.8% on average for the sector) and capital buffers (5.9% on average for the sector), by a sufficient margin (FSR 2018/2019). The regulatory limit for the LCR has been 100% since 2018; at the end of 2018 the aggregate LCR for Czech banks stood at 189%. Almost all Czech banks were also compliant with the non-binding LR and NSFR requirements (see Charts 1 and 2). The expected minimum requirements are 3% for the LR and 100% for the NSFR.

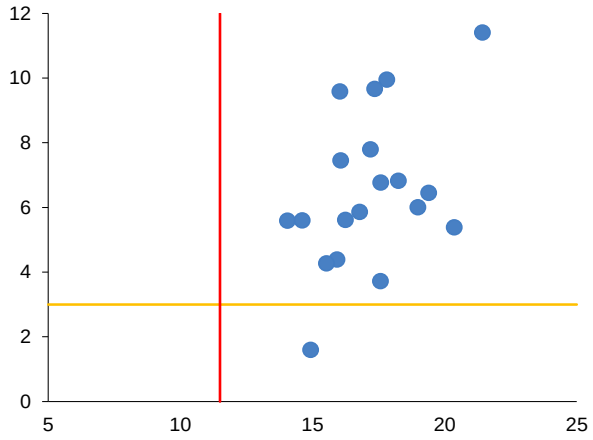
4 Another regulatory response is to set an output floor for total risk-weighted exposures in the IRB approach of 72.5% of the level implied by the application of the STA approach. Risk-weight heterogeneity should also be limited by the EBA (2017) guidelines, according to which banks should adequately include data covering a period of stress when calibrating the IRB parameters.

5 Cash, claims on the central bank, claims on central government and so on.

6 To prevent banks from relying exclusively on the expected inflows to meet their LCR requirements, and also to ensure a minimum level of liquid assets, the size of the inflows that can be recognised against the outflows is limited to 75% or 90% of the total expected outflows (EC, 2014, Article 33, Cap on Inflows).

Chart 1 Capital and leverage ratios of Czech banks

(%, x-axis: capital ratio; y-axis: leverage ratio)

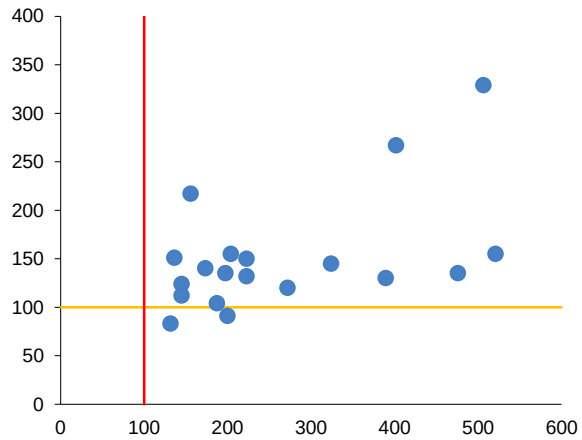


Source: CNB

Note: The vertical line expresses the capital ratio requirement (11.75%) excluding the systemic risk buffer and the Pillar 2 requirement. The horizontal line represents the leverage ratio requirement applicable on the implementation of CRD V/CRR II. Data for 19 Czech banks as of 2018 Q3.

Chart 2 Net stable funding and liquidity coverage ratios of Czech banks

(%, x-axis: LCR; y-axis: NSFR)



Source: CNB

Note: The vertical line expresses the LCR requirement (100%) and the horizontal line represents the NSFR requirement applicable on the implementation of CRD V/CRR II. Data for 19 Czech banks as of 2018 Q3.

III. ANALYSIS OF THE INTERACTION OF BANK CAPITAL AND LIQUIDITY POSITIONS

For our simulation exercise, we used the stylised balance sheets of 19 Czech banks, divided into four groups: large, medium-sized and small banks, and building societies (see Table 2).[7]

Table 2 Stylised bank balance sheets

Assets	Liabilities
Safe liquid assets (zero risk weight) $R_1, R_2, \dots, R_j$	Less stable deposits, liabilities and securities maturing in less than one year $D_1, D_2, \dots, D_m$
Risky assets (non-zero risk weight) $A_1, A_2, \dots, A_n$	Stable deposits, securities and liabilities maturing in more than one year $B_1, B_2, \dots, B_k$
Off-balance sheet assets $OBSA_1, OBSA_2, \dots, OBSA_o$	Equity E
Other assets $OA_1, OA_2, \dots, OA_o$	

Source: Cecchetti and Kashyap (2018), modified by the authors

We simplified equations (1)–(4) defined above[8] (Cecchetti and Kashyap, 2018). The capital and liquidity requirements take on the following form of a system of non-linear equations:

CR $$\boldsymbol{A} \leq \frac{1}{\alpha(\phi + \kappa\theta)} \quad (5)$$

[7] The division of banks into large, medium-sized and small banks and building societies is in line with current CNB methodology. Banks are differentiated in terms of total assets. Large banks have total assets of over CZK 250 billion, medium-sized banks total assets of over CZK 50 billion and up to CZK 250 billion and small banks total assets of less than CZK 50 billion. This breakdown was supported by an analysis we conducted of the similarity of Czech banks' balance sheets using the cosine similarity method of Blocher (2011). Cosine similarity expresses the similarity of two vectors by calculating the cosine of the angle between them. Formally: $similarity(a,b) = cos(\vartheta) = \frac{a.b}{\|a\|\|b\|} = \frac{\sum a_i b_i}{\sqrt{\sum a_i^2 \times b_i^2}}$.

[8] The series of algebraic modifications and simplifications of equations (1)–(4) is described in detail in the Technical Appendix.

LR $$\boldsymbol{R} + (1+\theta)\boldsymbol{A} \leq \frac{1}{\beta} \quad (6)$$

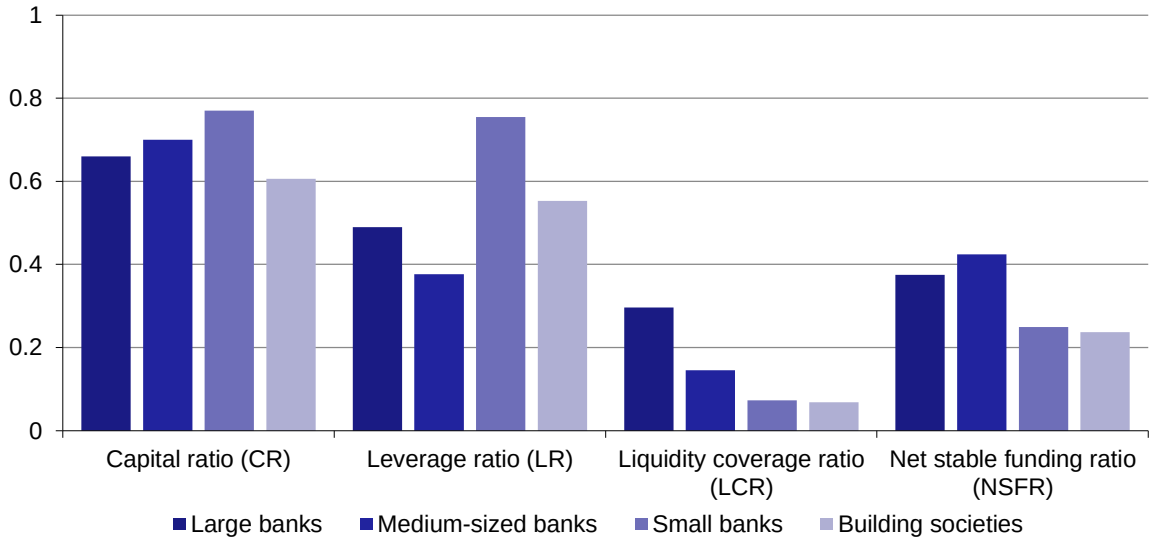
LCR $$\boldsymbol{D} \leq \frac{1}{\gamma}\boldsymbol{R} - \frac{\omega\theta}{\gamma}\boldsymbol{A} \quad (7)$$

NSFR $$\boldsymbol{D} \leq \boldsymbol{R} + \left(\frac{\beta - \eta^B}{\eta^D - \eta^B}\right)\boldsymbol{A} - \left(\frac{1-\eta^B}{\eta^D - \eta^B}\right) \quad (8)$$

where items in bold are taken relative to the amount of equity, i.e. divided by E, α is the required capital ratio, β is the required LR, κ are risk-weighted off-balance sheet items ($\sum_o r_o^O OBSA_o \approx \kappa OBSA$) and ϕ, θ are the shares of risk-weighted assets and off-balance sheet items in the balance-sheet total. Further, for γ and ω it holds that $\sum_m l_m^D D_m \approx \gamma D$ and $\sum_o l_o^O OBSA_o \approx \omega OBSA$, and for η^B, η^D it holds that $\sum_k a_k^B B_k \approx \eta^B B$, $\sum_m a_m^D D_m \approx \eta^D D$.

As banks' strategies for adjusting to regulatory changes and other economic shocks depend on their initial balance-sheet conditions (Behn et al., 2019), we started by computing the relative initial constraints imposed on the groups of banks by each capital and liquidity requirement (see Chart 3). A simple comparison across the requirements reveals that domestic banks are constrained more by the capital requirements than by the liquidity requirements. Their short-term liquidity position, made up of a relatively high proportion of liquid assets or stable funding, can be considered very strong. Czech banks are least constrained by the LCR requirement. A comparison across the groups of banks shows that small banks are most constrained by the CR and LR requirements, large banks by the LCR requirement and medium-sized banks by the NSFR requirement. For small banks, in addition to a high constraint by the LR requirement we observe a very low constraint by the LCR requirement. To some extent, this is an unintended consequence of the spillover of the effect of capital regulation to bank liquidity, while banks with relatively large amounts of high-quality liquid assets or a large off-balance sheet are conversely constrained to a greater extent by the LR requirement (for more details, see Pfeifer et al., 2017). The LR requirement thus to some extent prevents banks from increasing their balance-sheet totals using only liquid assets funded from external sources, especially those with low stability. According to the results, building societies are least constrained by the two liquidity requirements. This is due to their specific business model, which involves a high proportion of liabilities maturing in more than one month.

Chart 3 Relative constraints imposed on banks by the capital and liquidity requirements



Source: CNB, authors' calculations.
Note: The figures on the vertical axis indicate to what extent the bank is constrained by the requirement. A figure of less than one means the bank or group of banks is compliant with the regulatory requirement. The lower is the value, the less the bank is constrained by the requirement. Banks were aggregated into groups according to the size of their total assets. The figure for the group was calculated as a weighted average for the individual banks. Data as of 31 December 2018.

In the simulation exercises, we assume that banks try to maintain all four ratios at optimum levels.[9] With regard to the phase of the financial cycle, we consider two scenarios that could lead to the ratios diverging in either direction from their optimum level determined by the bank. In Scenario 1, we assume an upward phase of the financial cycle and a related one-off increase in the CCyB rate. In Scenario 2, we consider the opposite phase of the cycle at a time of recession or stress. A bank is likely to respond to the changes (shocks) defined in the scenarios depending on the initial levels of its ratios, and this in turn will cause its balance-sheet structure to change. In simplified terms, this means that the values of the variables entering the calculations of the ratios given in equations (1)–(4)/(5)–(8) will change. For both scenarios, we assume three possible adjustment options (see Table 3). In Scenario 1 we assume that the size of the balance sheet stays constant, while in Scenario 2 we assume that it shrinks.

Table 3 Assumed reactions of banks after the scenarios are applied

Scenario	Variant	Description of scenario	Explanation of scenario
Scenario 1 ↑CCyB rate	A	↓B and ↑E	Increase in equity and simultaneous decrease in liabilities maturing in more than one year
	B	↓D and ↑E	Increase in equity and simultaneous decrease in liabilities maturing in less than one year
	C	↓A and ↑R	Decrease in risky assets and simultaneous increase in risk-free assets
Scenario 2 ↑loss-category assets	A	↓A, ↓E and ↑RW (prior increase in equity)	Decrease in risky assets and equity and simultaneous increase in asset riskiness
	B	↓A, ↓E and ↑RW (prior decrease in asset riskiness)	
	C	↓A, ↓E and ↑RW (no prior increase in CCyB rate)	

Note: E is total equity, R are safe liquid assets, A are risky assets, B are stable deposits, securities and other liabilities maturing in more than one year, D are less stable deposits, securities and liabilities maturing in less than one year, and RW are risk weights.

III.1 SCENARIO 1: AN INCREASE IN THE CCYB RATE IN AN UPWARD PHASE OF THE FINANCIAL CYCLE

Scenario 1 is the situation where the prudential authority raises the capital requirement by increasing the CCyB rate by 1.25 pp. Given that a non-zero CCyB rate of 1.25% was applicable in the Czech Republic as of the date of our analysis, i.e. 31 December 2018, we simulate an increase in the CCyB rate to its maximum value of 2.5%.[10]

The bank's response to the rate hike depends primarily on the initial size of its voluntary capital buffer. If it holds a sufficient capital surplus, i.e. if its actual capital ratio is at least equal to the new required ratio, there is no need at all from the regulatory perspective for it to respond to the tighter capital requirement by changing its balance-sheet structure. However, if it has no voluntary capital buffer, if the buffer it does hold is not large enough, or if it regards it as optimal to keep the buffer at a particular level, it will probably choose one of the following potential adjustment options while keeping its balance-sheet size constant: (a) increase its capital ratio by issuing new equity or accumulating equity through retention of earnings (E), and simultaneously repay its liabilities (Scenario 1, options A and B) and/or (b) reduce the share of the credit portfolio in favour of holding more risk-free liquid assets (Scenario 1, option C).[11]

All these options lead to a rise in the capital ratio, because the change in the constraint imposed by the capital requirement will always be positive. All three responses could also affect the levels of the other requirements (LR, LCR, NSFR), leading them to diverge temporarily from their optimum levels. In this simulation exercise, we monitor the direction, not the magnitude, of the change in the constraints imposed by the individual requirements. Put simply, we examine whether a change in the CCyB rate leads to a higher or lower constraint for each requirement. Chart 4 illustrates the results.

[9] Each bank has its own optimum level for each ratio. For various reasons, the optimum level is higher than the regulatory minimum (see, for example, Behn et al., 2019, Brunnermeier and Sannikov, 2014, and Valencia, 2014).

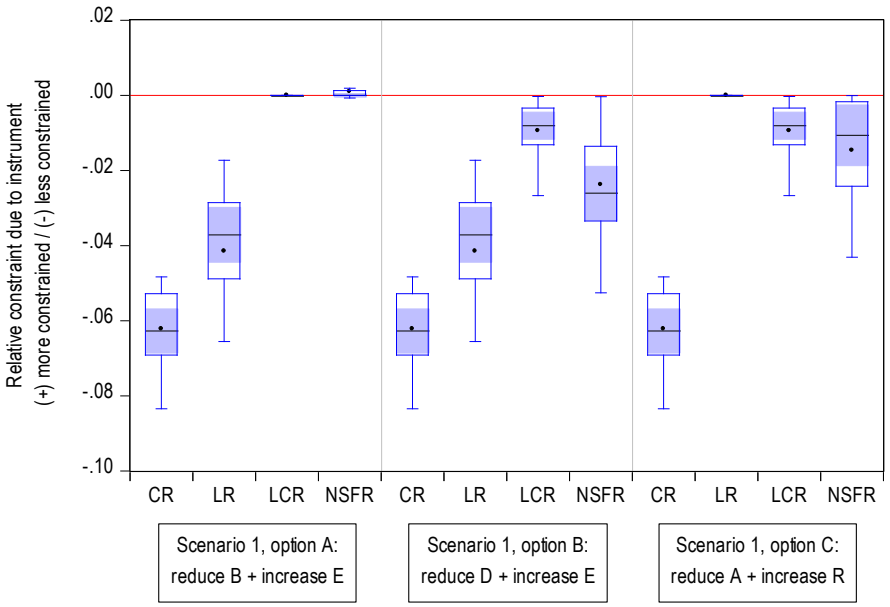
[10] In exceptional cases, the competent macroprudential authority may set the CCyB rate higher than 2.5%.

[11] The bank could also opt to intentionally reduce the risk weights on its exposures, which would simultaneously relax the constraint imposed by the increased capital requirement. As the bank's risk weights are subject to strict supervisory oversight, we do not regard this option as realistic. The bank may also choose a combination of options.

Chart 4 shows that if the bank chooses to increase its equity (E) by repaying its liabilities (D and B), not only will the constraint imposed by the CR requirement decrease, but so will that imposed by the LR requirement. In the case of the LCR and NSFR requirements, the effect of option 1B is unambiguous. As is also clear from equations (3)/(7) and (4)/(8), the repayment of unstable short-term liabilities (D) will reduce the constraint imposed by both liquidity requirements. The repayment of stable deposits and long-term securities and other liabilities (option 1A) will leave the LCR requirement – and essentially also the NSFR requirement – unchanged. Achieving a higher CR by changing the asset structure towards an increase in the proportion of high-quality liquid assets in the balance sheet (option 1C) will reduce the constraints imposed by both the CR requirement and the LCR and NSFR requirements. The constraint imposed by the LR requirement is not affected by this change. By changing their asset structures towards less risky exposures, banks can therefore reduce the constraints imposed by the CR, LCR and NSFR requirements, but not that imposed by the LR requirement. The latter thus serves as a prudential safeguard in the case not only of the CR requirement, but also of the liquidity requirements.[12]

The bank can reduce the constraints imposed by all the requirements by substituting unstable short-term liabilities with equity (option 1B). However, this option may be only seemingly optimal for the bank – or only optimal in the short term – if the originally unstable liabilities are used to finance risk-free assets with low rates of return. An increase in the ratio of equity to liabilities will probably in time lead to the asset structure changing (Behn et al., 2019) from less profitable assets (government bonds) to more profitable ones (customer loans) and to the LCR and NSFR decreasing again. This is corroborated by studies analysing the impact of an increase in capital buffers on bank lending. These studies find that an increase in the capital buffer can have a negative impact on bank lending in the short term but a positive impact in the medium to long term (see, for example, Gambacorta and Shin, 2016). Further, Behn et al. (2019) and Kolcunová and Malovaná (2019) state that banks operating close to the minimum required CR choose the less favourable option from the regulator's perspective, namely a reduction in lending (option 1C). How the bank ultimately chooses to increase its capital ratio thus depends both on the future costs and benefits of the chosen option and on its initial CR.[13] The change in balance-sheet structure described in all the options above substantially changes the bank's resilience to a potential shock affecting lending to the real economy, as discussed in Scenario 2.

Chart 4 Changes in the constraints imposed on banks by the capital and liquidity requirements in response to an increase in the CCyB rate



Source: CNB, authors' calculations.

Note: E is total equity, R are risk-free assets, A are risky assets, B are stable deposits, securities and other liabilities maturing in more than one year, and D are less stable deposits, securities and liabilities maturing in less than one year. The values on the vertical axis indicate whether the bank is more (+) or less (-) constrained by the requirement. The simulation was conducted using data for 2018 Q3 for each bank in the sample (n=19). The results are reported using a box-plot diagram where the horizontal line represents the median and the blue area the 95% confidence interval.

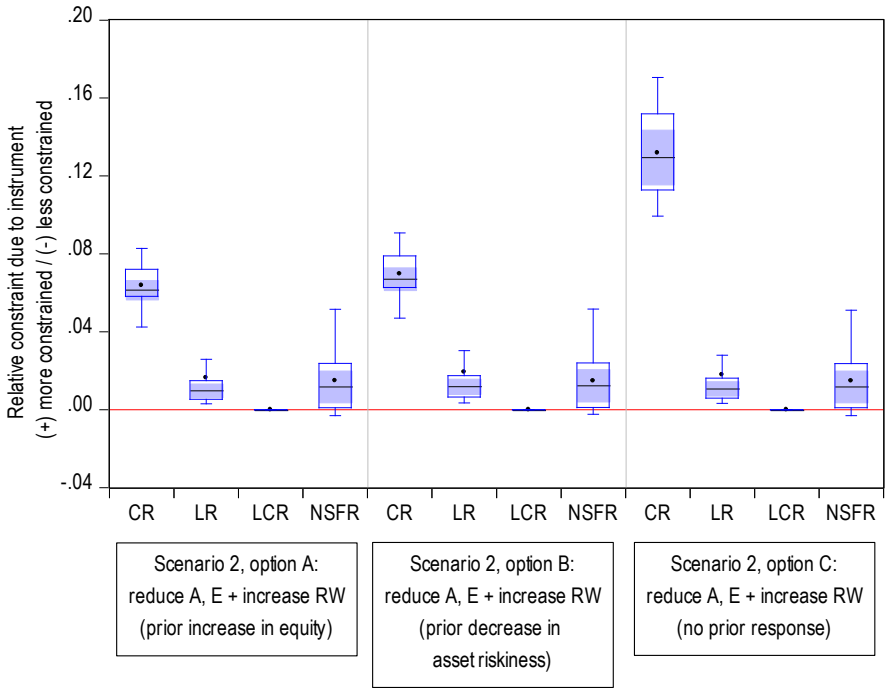
[12] The LR requirement to some extent affects the concentration of sovereign exposures in banks' balance sheets, to which a zero or near-zero risk weight is applied under the European regulations. Increasing the balance sheet solely by purchasing government bonds in return for short-term liabilities would reduce the bank's leverage ratio. To maintain the LR, the bank would have to use its equity to finance the increase in sovereign exposures. Given the low returns on such exposures, this would probably be an inefficient strategy for the bank.

[13] The optimum choice is included in the analyses conducted by the CNB's Financial Stability Department. For reasons of space, however, this issue is not covered in this article.

III.2 SCENARIO 2: COVERAGE OF LOAN LOSSES BY EQUITY IN A DOWNWARD PHASE OF THE FINANCIAL CYCLE

In Scenario 2, we simulate the situation where the bank is exposed to a recession, while taking into account the prior option chosen by the bank in response to the increase in the CCyB rate in Scenario 1. Scenario 2 assumes a deterioration in the credit portfolio (10% growth in provisions and risk weights) and growth in loss-category assets (also 10%). We also assume zero profits – the growth in losses reduces the bank's profitability and hence its ability to accumulate earnings. The bank uses its equity (E) to cover the losses. According to equation (1)/(5), all three variables change – equity (E) and risky assets (A) decrease, while risk weights (RW) increase. This leads to a decline in the CR. Ceteris paribus, the rise in risk weights increases the capital requirement in absolute terms.

Chart 5 Changes in the constraints imposed on banks by the capital and liquidity requirements in response to the coverage of loan losses by equity



Source: CNB, authors' calculations.

Note: E is total equity, A are risky assets and RW are risk weights. The values on the vertical axis indicate whether the bank is more (+) or less (-) constrained by the requirement. The simulation was conducted using data for 2018 Q3 for each bank in the sample (n=19). The results are reported using a box-plot diagram where the horizontal line represents the median and the blue area the 95% confidence interval.

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The results of this simulation exercise (see Chart 5) show that during the recession the bank is less constrained by the CR requirement if it previously responded to the increase in the CCyB rate by increasing its equity (option 2A). It is constrained rather more if it responded to the rise in the CCyB rate by changing its balance-sheet structure towards risk-free liquid assets (option 2B). Not surprisingly, the bank is most constrained by the CR requirement if the capital requirement was not raised through an increase in the CCyB rate before the period of stress (option 2C).

According to the equations defined above, the coverage of losses by equity should also affect compliance with the LR, LCR and NSFR requirements. In our simulation exercise, growth in the constraints imposed by the LR and NSFR requirements is apparent in all three options (see Chart 5). In the case of the LCR requirement, the effect is ambiguous, as it depends largely on the size of the actual liquidity inflow generated on the loss-category assets included in the denominator of the LCR. A decline in liquidity inflows will cause the net outflow of liquidity to rise. With a constant liquidity buffer, this should lead to an overall decrease in the LCR. However, if the decline in liquidity inflows on loss-category assets is smaller in reality than the regulatory deduction from the expected inflow (equation 3, c, or $1-c$),[14] the constraint imposed by the LCR requirement will not increase. This is the case in our simulation (see Chart 5).

[14] Put simply, our simulated decline in the liquidity inflow was less than 25% of the total expected outflow. The simulated stress should therefore have no effect on the LCR.

In the phase of the financial cycle when the bank is not generating sufficient profits and is using equity to cover its loan losses, the macroprudential authority usually starts the process of lowering the CCyB rate (for details on the release of the CCyB in the Czech Republic, see, for example, CNB, 2020). The authority's primary objective is to reduce the CR requirement in order to maintain a stable flow of credit to the real economy. Put simply, the constraint imposed by the CR requirement would decrease in Chart 5. However, releasing the CCyB will not reduce the constraints imposed by the LR and NSFR requirements. Where a bank under stress is nearing the minimum required levels of these ratios, it will again choose between several options for changing its balance-sheet structure in an attempt to get them back to their optimum levels. In a recession, besides resorting to fire sales or changing its funding sources, it can choose to reduce lending as one of the options. The chosen option thus to some extent influences the effectiveness of the CCyB as a macroprudential instrument.

It is therefore vital for (micro- and macro-) prudential authorities to continuously monitor banks' responses to the change in conditions and to assess the impact of those responses in relation to the levels of all the regulatory requirements.

IV. CONCLUSION

The increasingly complex regulation of the banking sector is increasing the importance of analysing the interactions of regulatory instruments. In this article, we describe the potential interactions of the capital ratio (CR), leverage ratio (LR), liquidity coverage ratio (LCR) and net stable funding ratio (NSFR) requirements. To determine the constraining role of each regulatory instrument, we apply algebraic simplification of their equations à la Cecchetti and Kashyap (2018). We then conduct a simulation of two scenarios at the individual bank balance-sheet level. Specifically, we consider a one-off increase in the countercyclical capital buffer (CCyB) rate as Scenario 1 and a deterioration in the credit portfolio as Scenario 2. This simulation exercise allows us to assess how an external shock, and banks' subsequent response to it, affect compliance with the four regulatory instruments. Banks' response, i.e. their adjustment to our chosen scenario, takes place through a change in the structure of their balance sheets. Table 4 summarises the results.

Table 4 Change in the constraints imposed by the requirements after a CCyB rate increase

Change in relative constraint on bank due to requirement	Scenario 1			Scenario 2		
	(A)	(B)	(C)	(A)	(B)	(C)
	↓B and ↑E	↓D and ↑E	↓A and ↑R	↓A, ↓E and ↑RW (prior increase in E)	↓A, ↓E and ↑RW (prior decrease in A)	↓A, ↓E and ↑RW (no prior increase in CCyB rate)
CR						
LR						
LCR						
NSFR						

Change in constraint on bank due to regulatory instrument
Less constrained — More constrained

In Scenario 1, banks' response to an increase in the CCyB rate will lead – via an increase in equity – to growth in both the CR and the LR (Table 4, Scenario 1, options A and B) and, given simultaneous repayment of short-term and unstable liabilities, to substantial growth in the LCR and the NSFR. The constraining role of all four requirements will therefore decline. An increase in the CR in the form of a change in asset structure towards less risky assets will also lead to growth in the LCR and the NSFR. The LR requirement, though, will not be affected by the change in balance-sheet structure and can thus serve as a prudential safeguard in the case not only of the CR requirement, but also of the liquidity requirements. On the other hand, if the leverage ratio requirement is higher than the capital ratio requirement, the bank need not respond to the increase in the CCyB rate at all.

In Scenario 2, we simulate a situation of credit risk materialisation. However, we also take into account the bank's prior response to the increase in the CCyB rate in Scenario 1. We generally report a positive effect of a previous increase in the CCyB rate on the sector's capital resilience during a recession (Table 4, Scenario 2, options A and B), especially if the bank responds to the increase in the CCyB rate by increasing its equity. The downward phase of the financial cycle is usually associated with the process of releasing the CCyB, when the constraint on the bank due to the CR requirement will decrease. However, the constraints imposed by the LR and NSFR requirements will not decrease and may even

increase. The effectiveness of the CCyB as a countercyclical instrument thus depends to some extent on banks' LR and NSFR levels at the time of the potential change in the CCyB rate. Where the LR and NSFR are close to their minimum required levels, the bank could also reduce the constraints imposed on it by the requirements by choosing to rein in its supply of credit to the real economy. However, this choice is undesirable in a downward phase of the cycle. For the instruments to have the maximum effect, it is therefore vital for prudential authorities to monitor and assess banks' potential responses to regulatory and economic shocks across the phases of the financial cycle.

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TECHNICAL APPENDIX

To derive the equations describing the individual regulatory instruments, the balance sheet in Table 2 is further simplified using aggregated notation of selected items.

I. $A = \sum_n A_n$, the sum of risky assets,

II. $R = \sum_j R_j$, the sum of safe liquid assets,

III. $OBSA = \sum_o OBSA_o$, the sum of off-balance sheet assets,

IV. $D = \sum_m D_m$, the sum of less stable deposits, securities and other liabilities maturing in less than one year,

V. $B = \sum_k B_k$, the sum of stable deposits, securities and other liabilities maturing in more than one year.

We now rewrite the equations relating to the capital and liquidity regulation tools using the balance-sheet items defined above. The capital requirement says that equity (E) must be greater than or equal to a weighted average of the on-balance sheet risky assets (A) and off-balance sheet assets $(OBSA)$. The weights reflect the riskiness of each item. Formally:

$$E \geq \alpha \left[\sum_n r_n^A A_n + \sum_o r_o^O OBSA_o \right], \tag{A1}$$

where α is the capital requirement and r_n^A, r_o^O are the risk weights.

Unlike the capital requirement, the leverage ratio takes into account total assets $(R + A + OBSA)$, against which it compares the amount of equity:

$$E \geq \beta [R + A + OBSA], \tag{A2}$$

where β is the leverage ratio requirement.

Turning to the liquidity requirements, the liquidity coverage ratio requires a bank to hold high-quality liquid assets (R) to cover net liquidity outflows over a period of 30 days. The requirement applies both to the liability side and to off-balance sheet items on the asset side:

$$R \geq \left[\sum_m l_m^D D_m + \sum_o l_o^O OBSA_o \right], \tag{A3}$$

where l_m^D and l_o^O are the run-off rates on deposits and off-balance sheet items.

Finally, the net stable funding ratio states that available stable funding must be greater than or equal to required stable funding:

$$\sum_k a_k^B B_k + \sum_m a_m^D D_m + E \geq \sum_n f_n A_n, \tag{A4}$$

where a_k^B and a_m^D are the weights used to compute available stable funding and f_n are the weights used to compute required stable funding.

This notation can be simplified further:

CR: $E \geq \alpha [L + \kappa OBSA]$, where $\sum_o r_o^O OBSA_o \approx \kappa OBSA$.

LR: $E \geq \beta [R + A + OBSA]$

LCR: $R \geq \gamma D + \omega OBSA$, where $\sum_m l_m^D D_m \approx \gamma D$ a $\sum_o l_o^O OBSA_o \approx \omega OBSA$.

NSFR: $\eta^B B + \eta^D D + E \geq \tau A$, where $\sum_k a_k^B B_k \approx \eta^B B$, $\sum_m a_m^D D_m \approx \eta^D D$ a $\sum_n f_n A_n \approx \tau A$.

At the same time: $R + A = B + D + E$, i.e. assets equal liabilities.

At this point, we have four asset categories and three liability categories, so we need to address the problem of dimensionality. Cecchetti and Kashyap (2018) further assume that risk-weighted assets (L) and off-balance sheet assets (OBSA) are proportional to the level of on-balance sheet risky assets (A), i.e. they can be expressed as shares of total assets: $L = \phi A$ and $OBSA = \theta A$. We must simultaneously assume that these shares in total assets do not change much over time.

The notation can now be simplified even more:

CR: $E \geq \alpha(\phi + \kappa\theta)A$,

LR: $E \geq \beta[R + (1 + \theta)A]$,

LCR: $R \geq \gamma D + \omega\theta A$,

NSFR: $\eta^B B + \eta^D D + E \geq \tau A$.

In the final step, we can express all the on-balance sheet items relative to equity (E) and use the balance-sheet identity to eliminate some items (such as B):

CR: $\boldsymbol{A} \leq \frac{1}{\alpha(\phi+\kappa\theta)}$,

LR: $\boldsymbol{R} + (1 + \theta)\boldsymbol{A} \leq \frac{1}{\beta}$,

LCR: $\boldsymbol{D} \leq \frac{1}{\gamma}\boldsymbol{R} - \frac{\omega\theta}{\gamma}\boldsymbol{A}$,

NSFR: $\boldsymbol{D} \leq \boldsymbol{R} + \left(\frac{\beta-\eta^B}{\eta^D-\eta^B}\right)\boldsymbol{A} - \left(\frac{1-\eta^B}{\eta^D-\eta^B}\right)$.

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