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Leverage Ratio and its Impact on the Resilience of the Banking Sector and Efficiency of Macroprudential Policy

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Abstract
Basel III responded to the financial crisis by redefining and expanding the capital requirements for risk-weighted assets and by proposing the introduction of a leverage ratio which sets a minimum level of capital for banks in relation to total exposures. The capital requirement is being increased primarily through the active use of macroprudential capital buffers. As a result, it was proposed that the leverage ratio requirement should also take into account the level of capital buffers and thus become a macroprudential policy tool. This article examines the relationship between capital and leverage ratios and discusses the options for, and effects of, introducing a macroprudential leverage ratio. We find that the capital and leverage ratios complement each other and that the introduction of a macroprudential leverage ratio could, under certain circumstances, enhance the effectiveness of a macroprudential policy.

1. Introduction

The general objective of capital regulation is to increase banks' resilience to unpredictable losses and to ensure that any losses they do incur are borne by their owners. This should ultimately curb risky behaviour by banks and hence reduce the likelihood of crises in the banking sector. Capital Requirements Directive (CRD IV) and Capital Requirements Regulation (CRR) extend capital regulation to include macroprudential capital buffers, application of which increases the banking sector's resilience to systemic risks. However, experience has shown that capital level based on risk-weighted assets may not be a sufficient guarantee of stability if the banking sector is excessively leveraged. Basel Committee on Banking Supervision (BCBS) therefore came up with the concept of the leverage ratio. It abstracts from the various credit risk levels of different asset classes and links Tier 1 capital to total exposures, comprising total assets plus selected off-balance-sheet items.

In late 2010, the BCBS recommended a methodology for calculating the leverage ratio.[1] The BCBS preliminarily set the minimum ratio (referred to here as the microprudential leverage ratio) at 3%, which limits the leverage of total

[1] The rules were later revised and are described in detail in BIS (2016a).

exposures to 33.3 times Tier 1 capital. European Banking Authority (EBAa, 2016) states, that the 3% level of calibration for the microprudential leverage ratio is appropriate for the EU banking sector. The microprudential leverage ratio is not a binding regulatory tool at the moment. However, the EU aims to make the leverage ratio a binding regulatory and supervisory tool as from 2018 (recitals 93–96 of the CRR).

There have also been proposals that the leverage ratio requirement should take into account the level of capital buffers and thus become a macroprudential policy tool. The European Systemic Risk Board (ESRB) mentions a macroprudential leverage ratio[2] as a possible instrument for preventing excessive credit growth and leverage in one of its recommendations (ESRB, 2013) and describes it in more detail in ESRB (2015).

This article deals with the relationship between the leverage and capital ratios and the role of the leverage ratio in capital regulation of the banking sector.[3] We begin by examining the nature of, and relationship between, the leverage and capital ratios. We then describe a possible setting of the macroprudential leverage ratio and its effect on the effectiveness of macroprudential policy. We go on to analyze the relationships between the two tools and selected financial indicators using data for groups of Czech banks in 2002–2015. We end by assessing the impact of the level of, and changes to, risk weights and macroeconomic conditions on the leverage and capital ratios. The key contribution of the study is to find out the possible complementary relationship between already exiting capital ratio and the newly proposed leverage ratio.

Table 1 Terms relating to capital regulation tools

Capital ratio	Ratio of capital to total risk exposures that bank actually holds (in %)
Minimum capital ratio	Ratio of regulatory minimum capital to total risk exposures (in %)
Macroprudential capital buffers	Add-ons to minimum capital ratio depending on evolution of systemic risk (in %)
Total capital ratio	Sum of minimum capital ratio and macroprudential capital buffers (in %)
Leverage ratio	Ratio of Tier 1 capital to total exposures that bank actually holds (in %)
Microprudential leverage ratio	Minimum prescribed leverage ratio (in %)
Macroprudential leverage ratio	Add-on to leverage ratio above its microprudential level depending on evolution of systemic risk (in %)
Total leverage ratio	Sum of microprudential and macroprudential leverage ratios (in %)
Capital requirement	Absolute amount of capital implied by total capital or leverage ratio (in CZK)
Capitalization	Absolute amount of capital that bank actually holds (in CZK)

Source: Compiled by authors.

[2] It has been introduced into national legislation for example in the UK (BoE, 2015).
[3] This article does not set out to recommend a calibration or form of legislation for the leverage ratio.

2. The relationship between the capital and leverage ratios

Neither the form nor the calibration of the leverage ratio as a binding regulatory tool has been set definitively yet. The examples given in this article therefore serve to illustrate the importance of the leverage ratio as a supplementary tool in capital regulation of the banking sector and are based on the preliminary form described in ESRB (2015). Table 1 summarizes the terms used in this article relating to the two capital regulation tools.[4]

2.1 The capital ratio and the leverage ratio

The **capital ratio** is a capital regulation tool that reflects the riskiness of assets. It is based on the capital requirement,[5] which is a function of the regulatory minimum capital ratio, the amount of assets and the risk weights of the relevant asset classes:

$$RWR = K^{RWR} \,/\, RWA, \tag{1}$$

$$RWA = RW \cdot TA, \tag{2}$$

which gives this formula for the capital requirement:

$$K^{RWR} = \left(RW \cdot TA\right) \cdot RWR, \tag{3}$$

where RWR is the total capital ratio (%), K^{RWR} is the capital requirement implied by the total capital ratio, RWA are risk-weighted assets, RW is the average risk weight across all asset classes and TA are total assets.

The main advantage of the capital ratio is that it takes into account the riskiness of assets. A bank that invests in higher-risk assets, which are generally associated with higher returns, should hold more capital than one that invests in less risky assets. CRD IV allows risk weights – and hence the riskiness of an asset – to be determined using either a standardized approach (STA) or an internal rating based approach (IRB). Banks applying the STA approach determine risk weights according to values laid down by law,[6] whereas those using the IRB approach determine them using internal models. The main risk characteristics which determine the risk weights

[4] These terms are for reference only and should not be taken as binding, as some of them have yet to be incorporated into legislation because the regulatory process is still ongoing.
[5]In this article we do not concern ourselves with the capital requirements for market risk and operational risk, which are based on other types of risks than credit risk. This is a simplification, as we work solely with the capital requirement for credit risk, which accounted for 87% of the total capital requirement as of 30 September 2015. We also use total risk exposures rather than risk-weighted exposures.
[6]Under the STA approach, the asset class, its external rating and any collateral are taken into account when determining the risk weight. As of the end of 2015, the STA approach was being used to determine risk weights for 29% of total exposures (FSR 2015/2016, pp. 46), so the IRB approach to determining credit risk was dominant.

in banks' IRB models are the probability of default of the credit exposure (PD) and the loss given default (LGD).[7]

The IRB approach is generally used to measure credit risk by large banks. Its advantages include greater sensitivity of the capital requirement to the risk structure of banks' assets. It tends to produce a lower risk weight for a given asset class than the STA approach.[8] Given the complexity of the IRB approach, therefore, concerns have been expressed about the risk of insufficiently strict models, or "model risk" (Leslé and Avramova, 2012). BIS (2016b) and EBA (2016b) show differences across banks in the RWA calculation, their consequences and propose legislative changes to the internal ratings-based approach. Aikman et al. (2014a) assert that financial systems are better characterized by existing uncertainty than by assessment of frequently unpredictable risk. For this reason, they believe that complex approaches should be complemented with simple yet comprehensive ones. The leverage ratio is an example of the latter.

The **leverage ratio** is a function of Tier 1 capital and total exposures, comprising total assets plus selected off-balance-sheet items:[9]

$$LR = K^{LR} / TE, \tag{4}$$

This gives the following capital requirement calculation:

$$K^{LR} = TE \cdot LR, \tag{5}$$

where LR is the total leverage ratio (%), K^{LR} is the capital requirement implied by the total leverage ratio and TE are total exposures[10] for the leverage ratio calculation.

The leverage ratio is therefore a (currently non-binding) capital regulation tool that does not reflect the riskiness of assets. Experience with the consequences of the recent financial crisis has shown that banks can record large losses even on assets that are generally regarded as low risk and have been assigned the highest rating (securitised assets and government bonds). Such assets have low risk weights and the capital requirement for them is therefore relatively low. Furthermore, a change in balance-sheet structure towards such assets allows banks to lower their capital requirements. However, the leverage ratio tool sets the capital requirement regardless of the riskiness of assets and thus defines the minimum absolute capital requirement. The risk of insufficient capital can therefore be mitigated by setting it at the right level. Introducing the microprudential leverage ratio implies setting the maximum

[7] Other variables enter the equation for the calculation of risk weights. For details, see Articles 153–154 of the CRR.

[8] This is true for Czech banks (FSR 2014/2015, pp. 42–45).

[9] Besides total assets, total exposures partially include the values of derivatives and add-ons for counterparty credit risk of repurchase transactions, securities or commodities lending or borrowing transactions, long settlement transactions and margin lending transactions. Other off-balance-sheet items are adjusted by the relevant coefficient. For details, see BIS (2016a) or ESRB (2016a).

[10] To better explain the role of the leverage ratio in capital regulation, we abstract from off-balance-sheet exposures and use a simplified leverage ratio defined as the ratio of Tier 1 capital to total assets. In other words, we assume that total assets equal total exposures.

leverage level. Juselius and Drehmann (2015) state that leverage, together with debt burden, are the main drivers of the financial cycle. The main objective of introducing the leverage ratio is therefore to increase banks' resilience to less likely losses due to credit risk and to reduce the probability and size of future financial crises. An improvement in financial stability thanks to the introduction of the leverage ratio is mentioned, for example, by Bair (2015) and Grill et al. (2015).

Table 2 summarizes the pros and cons of the capital and leverage ratios[11] and illustrates their **complementary relationship**, with the pros of one offsetting the cons of the other and vice versa. The leverage ratio to some extent mitigates the weaknesses of the capital ratio, such as modelling method complexity, model risk and procyclicality, which can lead to a lower capital requirement. Conversely, the capital ratio reduces the risk of funds being moved into riskier, higher-yield assets – a real risk if only the leverage ratio is in force.

Setting a risk-weight floor in the IRB approach – currently under discussion in ongoing preparations to revise the approaches to determining risk weights (BIS, 2016b) – would have a similar effect as introducing a microprudential leverage ratio. This option may be more appropriate where model risk or systemic risk is associated with a specific asset class or sector. However, if those risks cannot be ruled out for other asset classes and other sectors, it may be simpler and more effective to use a leverage ratio than set risk-weight floors for multiple asset classes (for details, see ESRB, 2015, pp. 23–25).

Table 2 Terms relating to capital regulation tools

Leverage ratio	Pros	(1) Increases resilience to less likely but highly correlated losses (2) Simple tool (3) Countercyclical
	Cons	(1) Increases risk of transfer of assets into riskier, higher-yield assets (2) Can be major regulatory change for banks specializing in low-risk assets
Capital ratio	Pros	(1) Reflects level of risk of assets and thus reduces incentive to allocate resources into riskier, higher-yield assets (2) Allows for more effective management of credit risk (IRB models)
	Cons	(1) Reliant on risk assessment of all types of assets – model risk (IRB models) (2) Low capitalisation for less risky assets (3) Complex and insufficiently comparable

Source: Compiled by authors.

2.2 The constraining effect of the capital and leverage Ratios

The complementary relationship between the two tools suggests that they have different effects on a banks' capital requirement (see Table 3). To illustrate those different effects, we chose the same settings of the two tools as in ESRB

[11] For details on the costs and benefits of introducing the leverage ratio, see Fender and Lewrick (2015).

(2015), i.e. a total capital ratio expressed in terms of Tier 1 capital[12] of 8.5% (a minimum requirement of 6% plus a 2.5% capital conservation buffer[13]) and a microprudential leverage ratio of 3%. We then chose individual asset classes and corresponding regulatory risk weights based on the STA approach. The different effects of the leverage and capital ratios are clear from the last two columns of the table. A focus by banks on riskier assets is associated with a higher capital requirement based on the total capital ratio, whereas a focus on less risky assets is associated with a higher requirement based on the microprudential leverage ratio.

Table 3 Minimum capital requirement given a microprudential leverage ratio of 3% and a risk-weighted capital requirement of 8.5%

Asset class (100)	*STA regulatory risk weights of banks (in %)*	**Capital**	
		Leverage ratio requirement	*Risk-weighted requirement*
Central governments	0	3.0	0.0
Financial institutions	20	3.0	1.7
Retail – mortgage loans	**35**	**3.0**	**3.0**
Retail – consumer loans	75	3.0	6.4
Corporate sector	100	3.0	8.5

Notes: As an example, we chose an exposure of CZK 100,000 and assumed a microprudential leverage ratio of 3% and a minimum capital ratio of 8.5%. Using the formula for computing capital requirements, we calculated the capital requirements based on the leverage and capital ratios (last two columns, in CZK thousands).
Source: Authors' calculations.

It can be seen in Table 3 that, given relevant settings of the two tools, the microprudential leverage ratio (3%) leads to the same capital requirement (CZK 3,000) as the total capital ratio (8.5%) at an average risk weight of 35%. With the said settings of the two tools, a risk weight of 35% therefore represents the critical average risk weight (CARW), which we obtain by dividing the total leverage ratio by the total capital ratio (3/8.5).[14] The CARW is therefore the average risk weight at which the bank is equally constrained by the two capital regulation tools, or at which the bank must maintain the same capital requirement to comply with both tools.

$$CARW = LR / RWR \, , \tag{6}$$

It also holds that

[12] The leverage ratio is also expressed in terms of Tier 1 capital for now.
[13] Although the capital conservation buffer is commonly classed as a macroprudential tool, it is in essence a newly defined element of the traditional microprudential capital requirements.
[14] If we did not abstract from off-balance-sheet items for the leverage ratio, the equation would be: CARW = (LR/RWR)·(TE/TA).

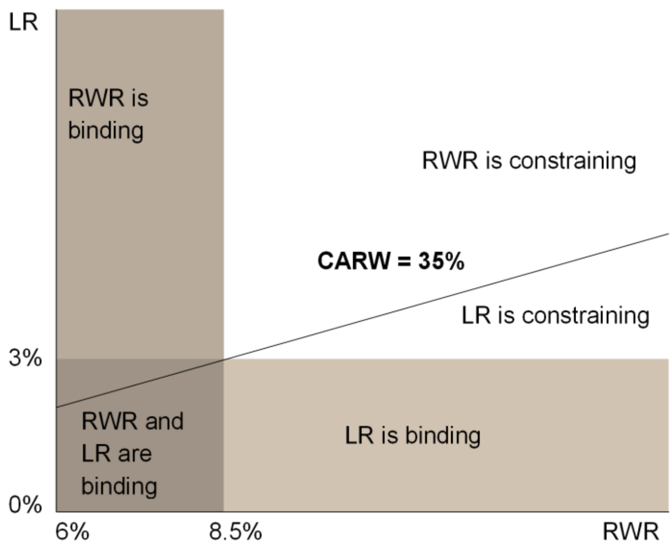
$$K^{LR} = K^{RWR}, \quad \text{if } CARW = RW \tag{7}$$

$$K^{LR} > K^{RWR}, \quad \text{if } CARW > RW \tag{8}$$

$$K^{LR} < K^{RWR}, \quad \text{if } CARW < RW \tag{9}$$

So, if both tools apply, banks will be constrained by at least one of them at any given moment in time, depending on which capital requirement is higher: that based on the leverage ratio or that based on the capital ratio. The constraining effect of the specific capital regulation tool depends, in addition to its setting, on banks' business model or risk weights. Given the above settings of the two tools, if a bank has an average risk weight above 35%, it will be constrained by the capital ratio. Conversely, if the risk weight is below 35%, the leverage ratio will be constraining (see Figure 1). The CARW level therefore determines the constraining effect of the two tools.

Figure 1 Constraining effect of the leverage and capital rations given a constant CARW



Notes: LR denotes the total leverage ratio and RWR the total capital ratio. If the LR is identified as constraining, the bank must hold more capital under the leverage ratio requirement. If the RWR is constraining, it must hold more capital based on the regulatory capital ratio. The area denoted as binding is the area associated with a breach of the regulatory requirement in our illustrative example.
Source: Fender and Lewrick (2015), compiled by authors.

If changes in the settings of the two tools are equal in percentage terms, the CARW level will not change (see Figure 1 and the CARW expressed as a line). If they change differently, the CARW will also change. An increase in the total capital ratio – for example in the form of the introduction of, or an increase in, macroprudential capital buffers – would lead to a decrease in the CARW and hence also in the constraining effect of the leverage ratio. Therefore, it has been proposed that the leverage ratio requirement should take into account the level of capital buffers and thus become a macroprudential policy tool.

3. The macroprudential leverage ratio

Macroprudential capital buffers usually fulfil two macroprudential policy objectives: to prevent misaligned incentives for financial institutions (structural dimension of systemic risk) and to prevent excessive credit growth and leverage (cyclical dimension of systemic risk). In this section, we will look at possible ways of linking them to the macroprudential leverage ratio and its objective. We will therefore assume that the microprudential leverage ratio is in force as a capital regulation tool.

3.1 The structural and countercyclical macroprudential leverage ratios

To mitigate the structural dimension of systemic risk, CRD IV allows the application of a broadly defined systemic risk buffer (SRB). This buffer is currently usually applied to systemically important institutions and has the same objective as those for global and other systemically important institutions (G-SIIs and O-SIIs respectively).[15] These buffers are meant to increase the resilience of systemically important institutions, whose failure could impair the stability of the entire financial system. ESRB (2015) describes the option of linking the above buffers to a "structural macroprudential leverage ratio", the application of which would simultaneously increase the total leverage ratio.

In periods of excessive credit growth and leverage, which are associated with an elevated risk of future losses, CRD IV provides the application of a countercyclical capital buffer (CCyB).[16] The objective of the CCyB is to reduce the risk of excessive credit growth and the effect of the cycle on capital requirements. In booms, the risk weights of IRB banks[17] can move procyclically (Aikman et al., 2014b) due to procyclicality in the components used to calculate them, as PD and LGD (see section 2 of this article) are derived from measures[18] that tend to be lower in booms and higher in recessions. Given the recurring expansion and contraction phases of the economic and financial cycle, the economy can be expected to slow after a period of strong growth.[19] The CCyB is therefore applied during a boom so it can later be released during a contraction. This should lead to greater resilience of banks and lower amplitude of the credit cycle. ESRB (2015) describes the option of linking the CCyB to a "countercyclical macroprudential leverage ratio". Brei and

[15]SRB is governed by Article 133 of the CRD and the G-SII and O-SII buffers by Article 131 of the CRD.
[16]CCyB is governed by Article 136 of the CRD.
[17]At the moment, procyclical movement in the components of risk weights can pose a risk to IRB banks. If risk triggers are introduced in the STA approach (BIS, 2015) a similar risk could apply to STA banks.
[18]PD is derived from the ratio of NPLs to total loans in the investment portfolio and LGD from the rate of recovery of a given NPL.
[19]In a contraction phase of the financial cycle, by contrast, PD, LGD and hence also risk weights tend to be overestimated even though they are often falling due to investments being moved into less risky assets. This could constrain lending activity and hinder economic recovery.

Gambacorta (2014) find that the leverage ratio is a more countercyclical capital regulation tool than the capital ratio.

3.2 The setting of the macroprudential leverage ratio

(i) The impact of (non-)introduction of the macroprudential leverage ratio

In section 2 we followed the lead of the ESRB (2015) by using a CARW of 35%. However, the CARW can vary depending on the settings of the total leverage and capital ratios (see Table 4). The CARW is lowered among other things by the introduction of a macroprudential capital buffers without simultaneous introduction of a macroprudential leverage ratio. This lowers the risk weight indicating the minimum absolute capital requirement and reduces the constraining effect of the leverage ratio.

If, for example, the SRB is introduced for systemically important institutions and the structural macroprudential leverage ratio is not simultaneously activated, the CARW for those institutions will decrease, because the total capital ratio will rise while the total leverage ratio will remain unchanged. The CARW will thus be lower and the leverage ratio less constraining for systemically important institutions than for the rest of the sector. Conversely, if the structural macroprudential leverage ratio is introduced simultaneously, the total leverage ratio will be higher and the maximum leverage level lower for systemically important institutions than for the rest of the sector.

Table 4 Effects of the setting of the total capital ratio on the CARW (%)

Items included in total capital ratio	Total capital ratio	Microprudential leverage ratio	CARW
Minimum capital ratio (MCP)	6.0	3.0	50
MCP+CCoB	8.5	3.0	35
MCP+CCoB+CCyB	11.0	3.0	27
MCP+ CCoB+CCyB+SRB	14	3.0	21

Notes: MCP = Minimum capita ratio (Tier 1), Tier 1 = the highest quality of regulatory capital; CCoB = capital conservation buffer; CCyB = countercyclical capital buffer; SRB = systemic risk buffer.
Source: Compiled by authors.

If the countercyclical macroprudential leverage ratio is not activated at the same time as the CCyB, the constraining effect of the leverage ratio will decrease during an expansion phase of the financial cycle. The risk weight indicating the minimum absolute capital requirement will fall as the CARW decreases. Conversely, if the countercyclical macroprudential leverage ratio is simultaneously applied, the maximum leverage level will fall in an expansion phase of the financial cycle.

A rise in the macroprudential capital buffers without a corresponding increase in the macroprudential leverage ratio therefore always leads to a fall in the CARW and a decrease in the constraining effect of the leverage ratio. If, despite the fall in the CARW, the average risk weight remains lower than the CARW for some banks, an increase in the macroprudential capital buffers will not have a constraining effect on those banks. The capital requirement based on the microprudential leverage ratio would remain higher than the capital requirement based on the total capital ratio (see section 2.2). These banks would thus continue to be constrained by the microprudential leverage ratio, and their capital requirement would not take into account the increase in systemic risk. The introduction of the macroprudential leverage ratio could therefore have a positive effect on the attainment of macroprudential policy objectives, especially in a situation where systemic risk is rising and the risk weights of banks with significant market shares are below the CARW. This is because the macroprudential leverage ratio has a similar objective as the macroprudential capital buffers, the only difference being that it constrains banks with risk weights below the CARW, on which macroprudential capital buffers do not have a constraining effect.

According to ESRB (2015), for the purposes of setting the macroprudential leverage ratio it is possible to make some changes to it in line with the evolution of systemic risk or to apply a fixed rule that automatically keeps the CARW constant over time, which implies a constant constraining effect of the two capital regulation tools. In other words, they can use a fixed rule to ensure that the risk weight indicating the minimum capital requirement does not change.

We will not deal any further with minor adjustments to the macroprudential leverage ratio, as they can differ from case to case. We will concentrate on clarifying how the fixed rule is applied.

(ii) The setting of the macroprudential leverage ratio using the fixed rule with an initial CARW of 35%

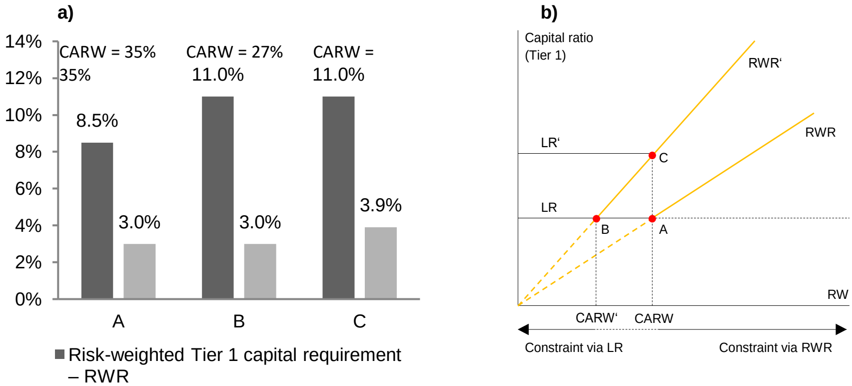
We start with the example of setting the countercyclical macroprudential leverage ratio[20] using a fixed rule keeping the CARW constant at 35%. Then we look at the effect of a different initial CARW on the macroprudential leverage ratio when the fixed rule is applied.

Figures 2a and 2b depict three different scenarios, all of them continuing to assume a microprudential leverage ratio of 3% and a total capital ratio of 8.5%. In the initial scenario A, macroprudential buffers are not added to the total capital ratio and the CARW is therefore 35% (3/8.5). In scenarios B and C, the maximum CCyB of 2.5% is introduced. However, these scenarios differ in the introduction of the countercyclical macroprudential leverage ratio. In scenario B, the macroprudential leverage ratio is not introduced and the total leverage ratio remains at 3%. The CARW therefore falls to 27% (moving from point A to point B in Figure 2b). With this shift, the constraining effect of the capital ratio increases at the expense of that of the leverage ratio. In scenario C, the 2.5% CCyB is incorporated into the total leverage ratio so that the CARW stays constant at 35% (the fixed rule mentioned above). The total leverage ratio therefore rises to 3.9%, while the countercyclical macroprudential leverage ratio is 0.9% (point C in Figure 2b). As the CARW is kept constant, the constraining effect of the two capital regulation tools remains the same as before the introduction of the CCyB. By definition, however, the minimum capital

[20] The situation is more complicated for the structural macroprudential leverage ratio, as it only applies to certain institutions.

requirement increases and conversely the maximum possible leverage for banks decreases as the total leverage ratio rises.

Figure 2 Effect of introducing a macroprudential leverage ratio on the CARW and the constraining effect of the two capital regulation tools



Source: Authors' calculations.

(iii) The effect of the CARW level on the macroprudential leverage ratio when the fixed rule is applied

When the fixed rule is applied, the initial CARW level has an effect on the macroprudential leverage ratio in addition to the setting of the constraining effect of the two tools, as it holds that:

$$\Delta LR = CARW \cdot \Delta RWR \,, \qquad (10)$$

where ΔLR is the change in the total leverage ratio and $\Delta RWRa$ is the change in the total capital ratio.

Table 5 Effects of the minimum capital requirement level on the CARW and the macroprudential leverage ratio

Items included in total capital ratio	Total capital ratio	Microprudential leverage ratio	ARW	Macroprudential leverage ratio		
				CCyB = 2.5 %	SRB = 3 %	CCoB = 2.5%
MCP	6.0	3.0	50	1.3	1.5	1.3
MCP+CCoB	8.5	3.0	35	0.9	1.1	-

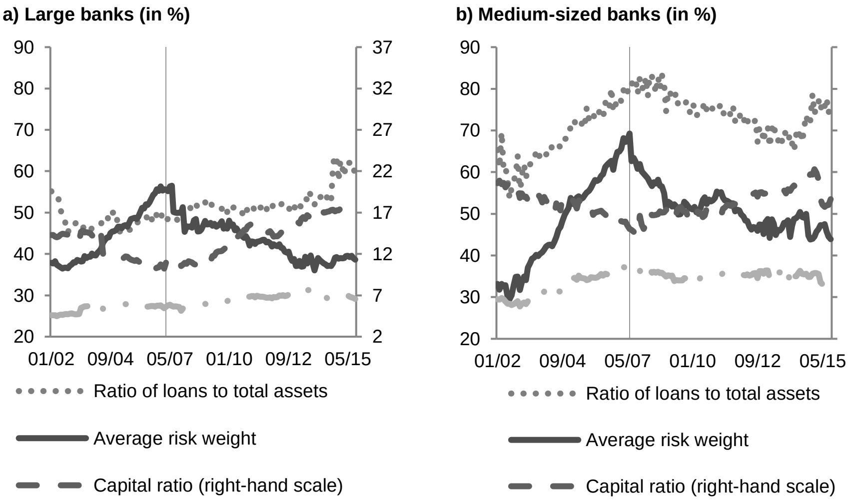
Notes: MCP = Minimum capital ratio (Tier 1), Tier 1 = the highest quality of regulatory capital, CCoB = capital conservation buffer, CCyB = countercyclical capital buffer, SRB = systemic risk buffer. The macroprudential leverage ratio, given in the final three columns of the table, is computed as the CARW multiplied by the relevant macroprudential capital buffer.
Source: Compiled by authors.

The initial CARW can be in our example 35% or 50% (see Table 5), which, for example, given the introduction of the maximum CCyB and keeping the CARW constant, leads to a macroprudential leverage ratio in the range of 0.9%–1.3%.

4. Empirical analysis[21]

In this section, we first illustrate the relationship between the two capital tools and selected financial indicators for medium-sized and large banks[22] in the Czech Republic in the period 2002–2015. Some banks started to migrate to the IRB approach to measuring credit risk in the second half of 2007 (shown by a vertical line in Figures 3a and 3b). Given the significant role of risk weights, we then use a simple vector autoregression model (VAR) followed by an impulse response analysis to assess the different impacts of the changes of risk weights on the leverage and capital ratios. Then we assess the impacts of the changes of macroeconomic conditions on both capital tools.

Figure 3 Indicators relating to capital regulation – large and medium-sized banks



Notes: The vertical line denotes the start of gradual migration to the IRB approach to measuring credit risk, which concerned all large banks and some medium-sized banks and building societies (in the majority of their portfolios). All small banks, however, still use the STA approach.
Source: CNB.

The data are not available in a long enough time series for us to compute the denominator of the leverage ratio. In what follows, therefore, we use a simplified leverage ratio calculated as the simple ratio of Tier 1 capital to total assets (instead of total exposures), i. e. excluding off-balance-sheet items. Czech banks are currently characterized by a relatively conservative business model focusing on lending to non-financial corporations and providing loans for house purchase. The Czech banking sector's off-balance sheet is therefore relatively small, justifying the above simplification. Risk weights are calculated as the ratio of risk-weighted assets to total

[21] We use internal data for Czech banking sector provided by Czech National bank.
[22] We divide banks into large banks, medium-sized banks, small banks and building societies in accordance with the methodology in force at the end of 2015. We therefore classify banks by size according to their total assets. Large banks have total assets of over CZK 250 billion, medium-sized banks total assets of CZK 50–250 billion and small banks total assets of less than CZK 50 billion.

assets. Output gap is calculated by purely statistical Hodrick-Prescott filter with $\lambda = 1600$. Real interest rate is the 3M PRIBOR deflated by GDP deflator, which is also used for calculation of real exchange rate. For the sake of simplicity and up-to-date data availability we use CZK/EUR due to prevailing eurozone export exposition of Czech economy. Further the trend values are extracted by Hodrick-Prescott filter and the gap is used for capturing change in monetary conditions. Data are in quarterly frequencies. Financial indicators are downloaded from CNB internal data stock and from CNB and Eurostat official database.

Figures 3a and 3b illustrate the evolution of the leverage and capital ratios, risk weights and ratio of loans to total assets on the example of medium-sized and large banks. The risk weights are affected by the asset structure, which changes over time as a result of change not only in the ratio of loans to total assets, but also in the credit portfolio structure. However, the financial indicators used in the figures do not capture change in the credit portfolio structure. In the case of the IRB approach, the risk weights are also affected by the cyclicality of the components used to calculate them (especially PD; see sections 2.1 and 3.1 of this article). It is apparent from Figures 3a and 3b that the risk weights started falling simultaneously with the switch to the IRB approach. In the case of medium-sized banks, this change and the subsequent decline can be partly explained by a fall in the ratio of loans to total assets and a rise in the ratio of less risky mortgage loans to total loans. The ratio of loans for property purchase to total loans has increased by 17.0 pp in medium-sized banks and 9.7 pp in large banks since 2007. The ratio of loans to total assets in large banks has meanwhile tended to rise. The fall in risk weights can be therefore explained solely by a change in asset structure, so migration to the IRB approach also played a role (see Figures 3a and 3b).

4.1 The effect of the risk weight on the relationship between the capital and leverage ratios

In section 2.2 we stated that the CARW level determines the intensity of effect of the individual capital regulation tools in the banking sector. By comparing the CARW and the average risk weights, we can determine which of the capital regulation tools has a constraining effect on a specific bank.

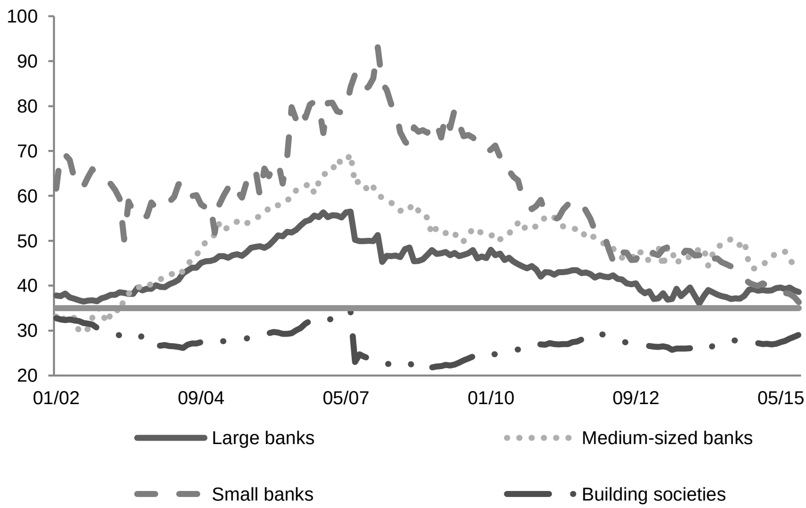
For the purposes of explaining the relationship between the leverage and capital ratios, we have so far worked with a CARW of 35%, as in ESRB (2015). At this CARW level, the leverage ratio would represent a constraint for building societies in the Czech Republic, as for this type of bank the capital requirement based on the leverage ratio would be higher than that based on the capital ratio over the entire period under review (see Figure 4). However, a substantial decline in risk weights is visible for all the other types of banks in recent years as well. Risk weights have declined especially in case of small banks, because there has been most significant change in the balance-sheet structures towards less risky assets (share of loans to total assets declined from 92 % in 2007 to 52 % in 2015 - CNB, internal data).

Table 6 Data statistics

Variables	Mnemonics	Mean	Std. Dev.	Jarque-Bera	ADF
output gap CZ	og	-0,27934	2,05645	22,248***	-2,97542**
output gap EA	og_ea	-0,11340	1,33848	10,132***	-3,77231**
real exchange rate gap	rer	-0,35725	2,84042	68,082***	-3,14279**
real interest rate gap	rir	0,00386	0,01256	201,747***	-4,57140***
capital ratio - large banks	cap_ratio	0,01533	0,32824	1389,225***	-12,0543***
leverage ratio - large banks	lev_ratio	0,01212	0,15027	453,946***	-13,3330***
risk weighted assets to assets - large banks	rwa_ta	0,00474	1,04098	1439,246***	-3,58833***
loans to assets - large banks	credit_ta	0,03319	1,33627	1299,416***	-15,3263***
capital ratio - medium-sized banks	cap_ratio	-0,01155	0,53153	195,600***	-14,9643***
leverage ratio - medium-sized banks	lev_ratio	0,00808	0,37060	979,281***	-17,2888**
risk weighted assets to assets - medium-sized banks	rwa_ta	0,06585	1,47106	10362,34***	-5,89309***
loans to assets - medium-siezed banks	credit_ta	0,06203	2,63779	19,206***	-16,7847***
capital ratio - building societies	cap_ratio	0,00458	0,38016	2977,645***	-14,2088***
leverage ratio - building societies	lev_ratio	0,00262	0,06987	76,883***	-6,01085**
risk weighted assets to assets - building societies	rwa_ta	-0,02281	0,97733	77771,08***	-15,0589***
loans to assets - building societies	credit_ta	0,12081	1,19439	1926,194***	-12,4063***

Source: CNB, data on Eurozone GDP were obtained from Eurostat.

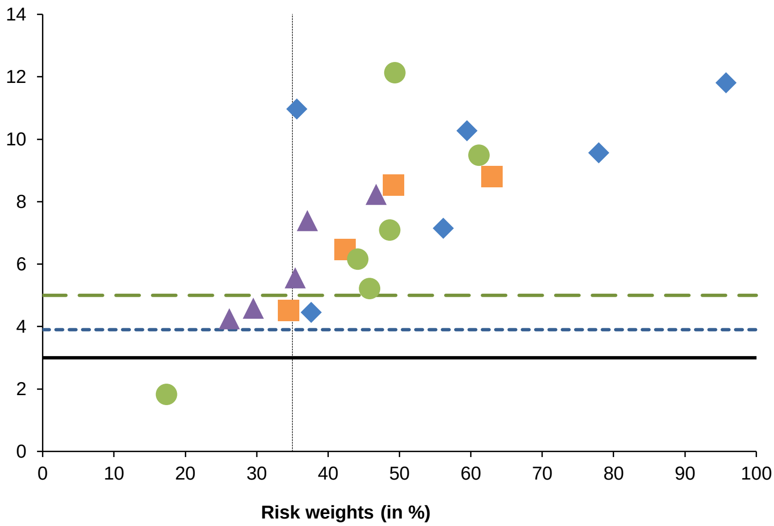
Figure 4 Risk weights for bank types in the Czech Republic (in %)



Notes: The average risk weight is calculated as the ratio of risk-weighted assets to total assets. The thick horizontal line denotes a CARW of 35%.
Source: CNB.

Figure 5 depicts the risk weights and leverage ratios for specific banks. One bank would currently be non-compliant with a microprudential leverage ratio of 3%. If we were to take into account the setting of the macroprudential leverage ratio in the scenario highlighted in Table 5 (as also used by ESRB, 2015), i.e. a maximum countercyclical component of 0.9% and a structural component of 1.1%, another one bank would be non-compliant with the maximum total leverage ratio. For those two institutions and another two building societies, the leverage ratio would be constraining, as their risk weight is below 35%.

Figure 5 Leverage ratios and risk weights across banks as of 30 September 2015 (y-axis: leverage ratio in %)



Notes: In this case, the leverage ratio calculation includes the effect of the off-balance sheet. Squared dots depict systemically important banks, round dots small banks and diamond dots medium-sized banks and triangle dots building societies. The vertical line illustrates a CARW of 35%. The solid black horizontal line illustrates a microprudential leverage ratio of 3%, the dotted line additionally a cyclical macroprudential leverage ratio of 0.9% and the interrupted line additionally a structural macroprudential leverage ratio for systemically important institutions of 1.1%.
Source: CNB.

4.2 Vector Autoregression Model (VAR)

A simple VAR model is used to analyse the effect of a change in the risk weight on the leverage ratio and to compare it with the effect of a change in risk weights on the capital ratio.[23] Following Lutkepohl (2005), let's assume an underlying structural model of an economy in the form:

$$\mathbf{A}\mathbf{y}_t = \mathbf{A}_1^*\mathbf{y}_{t-1} + \ldots \mathbf{A}_p^*\mathbf{y}_{t-p} + \boldsymbol{\varepsilon}_t \,, \tag{11}$$

[23] The number of lags was chosen so that the residuals were not correlated. No additional structural constraints were added to the models. All time series were seasonally adjusted and detrended. The VAR model does not display autocorrelation of residuals.

where y is a vector of K endogenous variables, $\boldsymbol{\varepsilon}$ is a vector of structural innovations and A and A^* are $K \times K$ matrices of coefficients. We do not consider exogenous variables for the sake of simplicity, however, we do use them in the actual estimations. The variance covariance matrix of the structural innovations is assumed to be orthonormal. The underlying model is unknown. What is being estimated is the reduced form of previous equation:

$$\mathbf{Ay}_t = \mathbf{A}_1\mathbf{y}_{t-1} + ...\mathbf{A}_p\mathbf{y}_{t-p} + u_t \, , \tag{12}$$

where A are $K \times K$ matrices of coefficients and u is a vector of innovations, which are not autocorrelated. The VAR must be stationary. The shocks contained in vector **u** have no direct interpretation. However, from Ay_t and y_t it follows:

$$\mathbf{A}_j = \mathbf{A}^{-1}\mathbf{A}_j^*, \tag{13}$$

$$\Sigma_\varepsilon = \mathbf{A}\Sigma_u\mathbf{A}' \, , \tag{14}$$

where Σ denotes a variance covariance matrix. Therefore, constraining the coefficients of matrix A yields a decomposition of the variance covariance matrix of the innovations of the reduced form system so that they can be related to the structural innovations. The coefficients of matrix A describe the contemporaneous relations between the endogenous variables. This is the so-called A-model. Regarding the assumption of orthonormal variance covariance matrix of structural innovations in Ay_t, the matrix equation contains $K(K-1)/2$ independent equations. To obtain a unique solution for the K^2 coefficients of matrix A, one needs to impose another $K(K+1)/2$ restrictions on A. Diagonal elements of matrix A are typically restricted to 1. This means that another $K(K-1)/2$ restrictions are needed.

Table 7 Structure of VAR models

		VAR1 - large	VAR2 - medium	VAR3 - building	VAR4 - large	VAR5 - medium	VAR6 - building
endogenous variables		cap_ratio	cap_ratio	cap_ratio	lev_ratio	lev_ratio	lev_ratio
		lev_ratio	lev_ratio	lev_ratio	rwa_ta	rwa_ta	rwa_ta
		rwa_ta	rwa_ta	rwa_ta	og	og	og
		credit_ta	credit_ta	credit_ta	rir	rir	rir
		-	-	-	rer	rer	rer
exogenous variables		og_ea	og_ea	og_ea	og_ea	og_ea	og_ea
observations		50	50	50	50	50	50
lags		2	2	2	2	2	2
LM test for autocorrelation (1 - 5 lags)		32.39068	37.12116	19.95274	36.55065	29,714	28,934
		41.08340*	30.26335	19.83137	22.81781	29,156	25,374
		24.31843	35.60701	23.13772	40.15510**	35,005*	33,233
		32.60556	36.31026	19.81016	37.14035*	44,855***	44,228**
		31.13786	26.30777	25.66992	19.28306	30,440	21,880
Jarque-Bera		328.6582	122.8469	29.79896	3.789390	4,236	44,246***
White		254.7618	288.6576	251.4562	358.2308	355,102	334,924

Notes: LM statistic is based on Lagrange multiplier test for autocorrelation under the null of no autocorrelation up to the given lag. Jarque-Bera is the Jarque-Bera statistic under the null of multivariate normal distribution (Cholesky decomposition used). White is the White statistic under the null of no heteroskedasticity. LR test statistic is based on comparison of log likelihood of the unrestricted model (null hypothesis) and restricted model (alternative hypothesis). (*, **, *** denote rejection of the null at 10 %, 5 % and 1 % level of significance, respectively). cap_ratio = capital ratio; lev_ratio = leverage ratio; rwa_ta = risk weighted assets to assets; credit_ta = loans to assets; rir = real interest rate gap; rer = real exchange rate gap; og = output gap CZ; og_ea = output gap EA.

Source: Compiled by authors.

The relationship between the variables is illustrated using impulse response functions (IRFs), which express the response generated by an unexpected shock (impulse) to the current value and future values of the explained variables. We conducted a simulation with an analytical (asymptomatic) standard deviation response to obtain the responses to a shock to the endogenous variables in the 5% and 32% significance interval with a decomposition method based on generalised impulses, as described in more detail in Pesaran and Shin (1998). We constructed an orthogonal set of innovation independent of the variables' ordering in VAR model. The IRFs are then computed by applying a variable specific Cholesky factor.

The analysis was conducted separately for each bank (without small banks)[24] type using the leverage and capital ratios, risk weights and ratio of loans and receivables to total assets (endogenous variables) and the output gap of the euro area economy (exogenous control variable).[25] Table 7 shows the structure of the underlying VAR models. It gives information on the endogenous and exogenous variables used in each particular VAR. The estimations are based on 50 quarterly observations; 2 lags were mostly sufficient to get rid of autocorrelation in the residuals. Since the sample contains the global financial crisis, the additional robustness check is carried out by excluding the critical 2009 year to understand whether some of the reported findings are due to the global recession. Further on, we try adding a dummy variable that takes the value one during a financial crisis and zero otherwise. During both exercises, the impulse response functions have not been changed significantly in a sense of changing findings of the study.

(i) Impact of risk weights on financial indicators

The leverage ratio rose and the capital ratio fell as the risk weights increased (see Figure 6). Banks reacted to the growth in risks by topping up their capital, which led to an increase in the leverage ratio. However, the rise in capital was smaller than the rise in risk-weighted assets, so the capital ratio decreased. When the risk-weighted assets decreased, by contrast, the capital ratio rose and the leverage ratio fell. This shows that the two capital tools are complementary.

The response to a change in risk weights differed across bank types in the period under review (see Figure 6). The effect of a change in risk weights on the leverage ratio was particularly strong for medium-sized banks. It was insignificant for building societies, probably due to their specific business model and relatively stable risk weights.

By contrast, the effect of a change in risk weights on the capital ratio was particularly significant for building societies. This can be explained by their low risk weights, which imply a lower capital requirement, i.e. a lower numerator in the capital ratio. An increase in its denominator, or risk-weighted assets, then causes a larger decline in the capital ratio. Conversely, an increase in the total capital ratio, for example in the form of the introduction of a macroprudential capital buffer, will not necessarily increase the capital requirement significantly in a situation of low risk weights.

To sum up, the current decline in the risk weights of the individual bank types (see Figure 4) during the ongoing economic recovery is increasing the relevance of the introduction of the leverage ratio.

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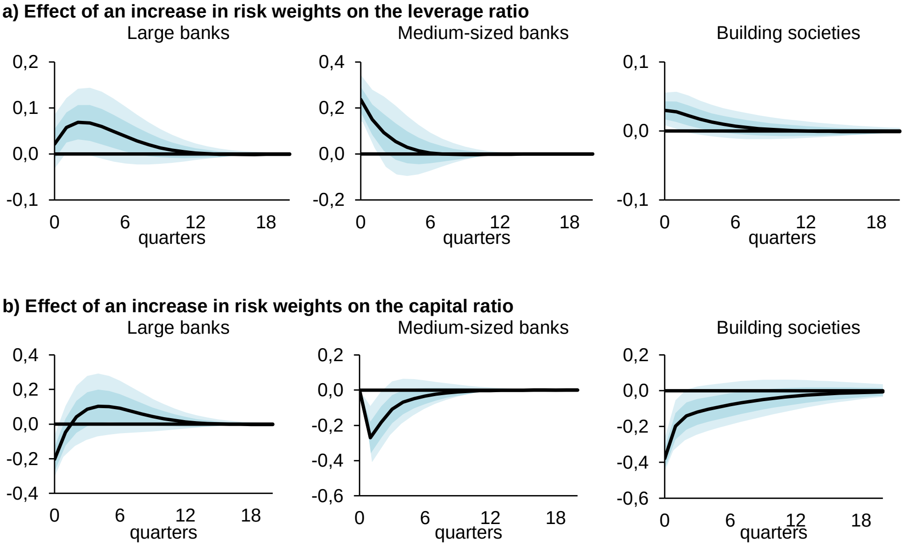
[24] Changes in the volume of a capital of small banks are often specific because of the initial phase of the life cycle of many of them.

[25] Stationarity was ensured by converting the variables to year-on-year growth.

Figure 6 Effect of an increase in risk weights

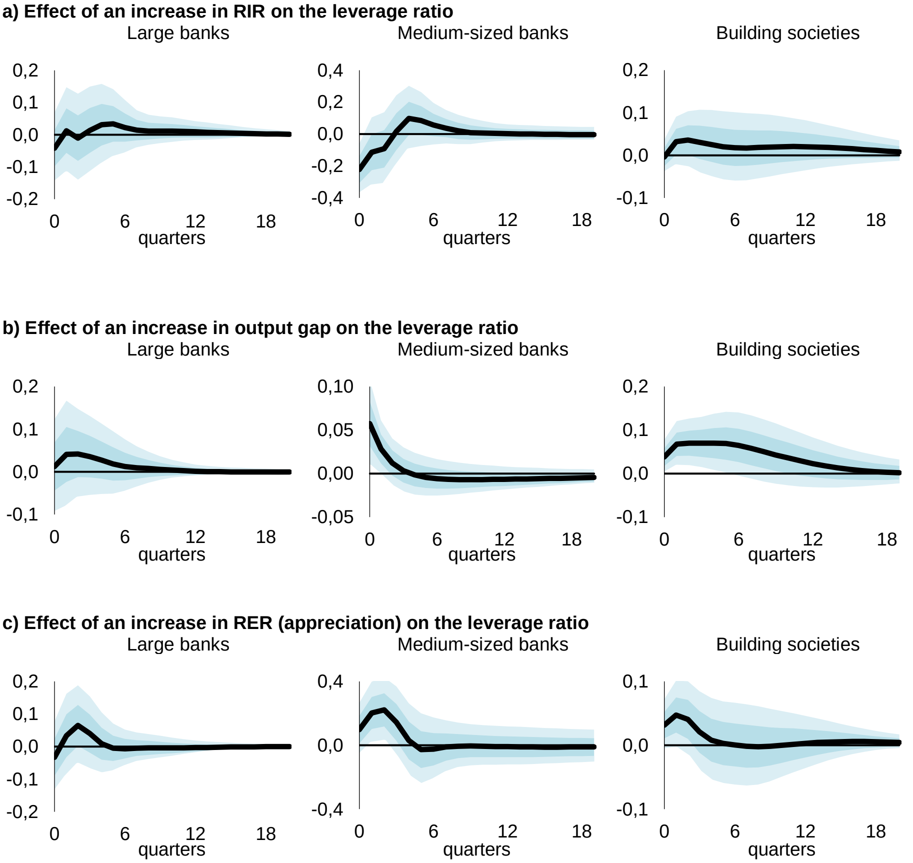


Notes: The charts present the impulse responses. The x-axis shows the number of quarters after the shock and the y-axis the strength of the response to the shock generated as a single variance. The continuous line indicates the mean response and the blue fields show the confidence intervals at the 95% and 68% confidence levels.
Source: CNB, authors' calculations.

(ii) Impact of monetary conditions and real economy on financial indicators

The resilience of banks is affected by internal processes as well by external environment. Therefore, we consider shocks to monetary and real economy conditions and their impact on the leverage ratio. The shocks are drawn from real interest rate gap (RIR), real exchange rate gap (RER) and output gap and can be interpreted as follows: unexpected increase in the RIR is viewed as restrictive monetary policy shock; an increase in RER represents currency appreciation shock and increase in positive output gap is a positive productivity shock. Impulse response functions are depicted in Figure 7. It should be noted that Czech banks had a large capital buffer and were relatively stable during analysed period, so they did not decrease much of their capital buffer. As a result, the impact of defined shocks was significant only for the medium-sized bank. In this group of banks were a few objects not as stable as the rest of the Czech financial sector.

Figure 7 Effect of a change in macroeconomic conditions



Notes: The charts present the impulse responses. The x-axis shows the number of quarters after the shock and the y-axis the strength of the response to the shock generated as a single variance. The continuous line indicates the mean response and the blue fields show the confidence intervals at the 95% and 68% confidence levels.
Source: CNB, authors' calculations.

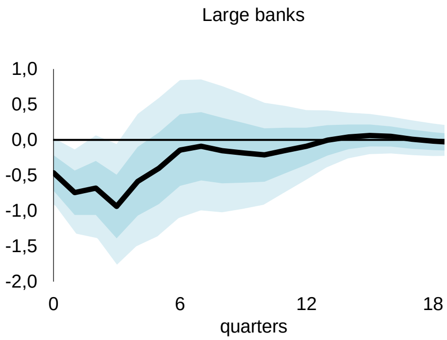
Higher interest rates as a result of monetary policy restriction will lead to lower credit activity. We would thus expect banks to increase the ratio of less risky assets in their portfolios which results in lower risk weights (this is well documented for the medium-sized banks in Figure 8b). When the risk-weighted assets decreased, the leverage ratio may be reduced (Figure 6a), due to the withdrawal of Tier capital. Higher interest rates may, therefore, reduce the leverage ratio. This behaviour is visible in Figure 7a, especially in medium-sized banks response. The reactions of large banks and building societies remained negligible.

Similarly, the effect of exchange rate appreciation shocks was the most significant for medium-sized banks for which exchange rate differences constitute generally higher proportion of the total revenue. In this case, the exchange rate appreciation leads to a leverage ratio increase. Response for the large banks is not significant. Based on information in Figure 8a, the level of risky assets reduces when hit by currency appreciation shock.

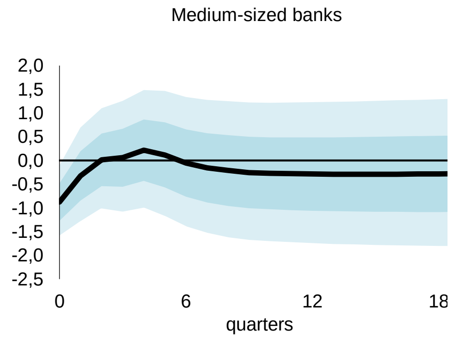
The positive productivity shock is reflected in higher leverage ratio. The impact of defined shocks on capital ratio was not statistically significant in the entire sample and respective IRFs are not presented here. Czech banking sector is well capitalized and remained profitable during the reporting period, the impulse response analysis of macroeconomic shocks confirmed this fact.

Figure 8 Effect of an increase in risk weights

a) Effect of an increase in RER on the RWA



b) Effect of an increase in RIR on the RWA



Notes: The charts present the impulse responses. The x-axis shows the number of quarters after the shock and the y-axis the strength of the response to the shock generated as a single variance. The continuous line indicates the mean response and the blue fields show the confidence intervals at the 95% and 68% confidence levels.
Source: CNB, authors' calculations.

5. Conclusion

This article provided evidence of a complementary relationship between the leverage and capital ratios. Using a simple vector autoregression model, this relationship was documented on Czech data by showing the different responses of the two instruments to a change in the risk weight. Then, we conducted sensitivity scenarios of leverage ratio responses on changed monetary and macroeconomic conditions. The real exchange rate appreciation affected the most significantly the medium-sized banks. To the contrary, the real interest rate increase revealed strong negative impact on leverage ratio of medium-sized banks. The reactions of large banks and building societies remained negligible. The positive productivity shock is reflected in higher leverage ratio. Czech banking sector is well capitalized and remained profitable during the reporting period, the impulse response analysis of macroeconomic shocks confirmed this fact.

The introduction of a microprudential leverage ratio increases banks' resilience to less risky exposures. The setting of a macroprudential leverage ratio could also have a positive effect on macroprudential policy effectiveness in terms of mitigating cyclical and structural risks, especially if systemic risk arises at a time when risk weights are below the CARW for a large number of institutions with large market shares. To set the macroprudential leverage ratio, it may be appropriate to apply a fixed rule that keeps the CARW constant for all banks over time and hence also keeps the constraining effect of the two capital regulation tools stable and predictable. When the fixed rule is applied, the initial CARW level has a significant effect on the level of macroprudential leverage ratio.

The VAR model estimates confirmed intuitive relationship between the risk weights and capital and leverage ratio. So the increase of the risk weights decreased the capital ratio and increased the leverage ratio by refilling capital subsequently in reaction to the risk shock. Effect varied among different bank types. The strongest effect of a change in risk weights on the capital ratio was observed at building societies, which revealed the lowest risk weight during whole period.

Furthermore, we examined effect of change in macroeconomic conditions to leverage ratio. Czech bank sector has been well capitalized during entire period with safety capital surplus, therefore the impact of change in monetary conditions and real economy had significant response for medium-sized banks only. Higher real interest rates caused weaker credit activity and shifted bank portfolio to lower riskiness, which put up capital ratio inherently and allowed to reduce leverage ratio by holding less Tier capital. The real exchange rate appreciation of domestic currency improved leverage ratio of the medium-sized banks significantly, which might have been caused by relatively higher share of liabilities in foreign currencies. Decline of risk weights as a reaction to real exchange rate appreciation was visible for large banks. Output gap increase was accompanied rather by growth of leverage ratio due to favorable bank profitability development and vice versa, but the Czech banking sector remained resistant even in crisis.

Continued decline in risk weights and a change in the balance-sheet structures of individual types of Czech banks towards less risky assets is increasing the relevance of the microprudential leverage ratio and subsequently also the macroprudential leverage ratio as a supplementary capital regulation tool.

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