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Does Monetary Policy Influence Banks' Perception of Risks?

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Abstract

This paper studies the extent to which monetary policy may affect banks' perception of credit risk and the way banks measure risk under the internal ratings-based approach. Specifically, we analyze the effect of different monetary policy indicators on banks' risk weights for credit risk. We present robust evidence of the existence of the risk-taking channel in the Czech Republic. Further, we show that the recent prolonged period of accommodative monetary policy has been instrumental in establishing this relationship. Finally, we obtain comparable results by extending the analysis to cover all the Visegrad Four countries. The presented findings have important implications for the prudential authority, which should be aware of the possible side-effects of monetary policy on how banks measure risk.

Abstrakt

Tato práce zkoumá, do jaké míry může měnová politika ovlivňovat vnímání úvěrového rizika bankami a způsob, jakým banky měří riziko v rámci přístupu založeného na interním ratingu. Konkrétně analyzujeme vliv vybraných měnověpolitických indikátorů na rizikové váhy bank pro úvěrové riziko. Uvádíme robustní odhady existence kanálu přijímání rizika v České republice. Dále ukazujeme, že k ustavení tohoto vztahu přispělo nedávné delší období uvolněné měnové politiky. Rozšířením analýzy na všechny země Visegrádské čtyřky získáváme porovnatelné výsledky. Prezentovaná zjištění mají důležité implikace pro obezřetnostní autoritu, která by měla vnímat možné vedlejší efekty měnové politiky ovlivňující měření rizika bankami.

JEL Codes: E52, E58, G21, G28.
Keywords: Banks, financial stability, internal ratings-based approach, risk-taking channel.

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Nontechnical Summary

In recent years, economists have been devoting considerable attention to the risk-taking channel of monetary policy, which postulates that a prolonged period of very accommodative monetary conditions can significantly influence the risk perceptions and risk tolerance of financial institutions. One way accommodative monetary policy can induce financial institutions to take on more risk is through its impact on the risk parameter estimates which then enter the calculation of banks' capital requirements and risk weights under the internal ratings-based (IRB) approach. Low interest rates may facilitate a decline in the values of these parameters either directly or indirectly through their impact on collateral value and firms' valuation, income, and cash flow.

In this paper, we analyze the effect of changes in various monetary policy proxies on the implicit risk weights of credit exposures, with an emphasis on banks using the IRB approach. We draw on two panel data sets covering quarterly data for 20 banks in the Czech Republic and annual data for 58 banks in the Visegrad Four countries for the period 2003–2016. For the Czech Republic, we estimate a panel data model across different model specifications and monetary policy proxies, including the interbank rate, the shadow rate, and two monetary conditions indexes, which provide a robust overview of the effect of monetary policy changes. We also conduct an analysis of the issue in the context of the Visegrad Four countries to check the robustness of the results for the Czech Republic, exploiting the similarity of their banking systems.

We present robust evidence of the risk-taking channel in the Czech Republic for banks using the IRB approach. Specifically, we find a strong, statistically significant relationship between monetary policy easing and lower implicit risk weights of IRB banks, after controlling for banks' asset composition, a wide range of other bank-specific variables, the business cycle, and regulatory pressures. The effect is even stronger for banks mainly using the Advanced IRB approach, i.e., banks that are permitted to estimate not only their own value of PD, but also LGD and EAD. Further, the prolonged period of accommodative monetary conditions seems to have been instrumental in establishing the risk-taking channel in the Czech Republic. In particular, the relationship between monetary policy indicators and risk weights is statistically significant if we include this period and statistically insignificant if we exclude it. Additionally, we obtain comparable results by extending the analysis to cover all the Visegrad Four countries, which further supports our main conclusions.

The presented findings add to the stream of literature stressing that the effect of monetary policy on financial stability is not neutral. A great advantage of the IRB approach is that it allows for higher sensitivity of the capital requirements to the risk structure of banks' assets. Nevertheless, the IRB approach may also have significant weaknesses, including its dependence on historical data and its complexity. Such dependence may allow monetary policy to manifest itself through the estimated risk parameters and, consequently, banks' risk weights. Therefore, it is important to regularly assess whether the evolution and current level of risk weights give rise to any risk of underestimating (and potentially also overestimating) the necessary level of capital. The prudential authority should pay special attention to prolonged periods of low interest rates accompanied by signs of increased risk-taking, including a combination of excessive credit growth and asset price growth and a decline in risk weights.

1. Introduction

In recent years, economists have been devoting considerable attention to the risk-taking channel of monetary policy, which postulates that a prolonged period of very accommodative monetary conditions can significantly influence the risk perceptions and risk tolerance of financial institutions (Rajan, 2005; Gambacorta, 2009; Adrian and Shin, 2009; Borio and Zhu, 2012; Adrian and Liang, 2014; Jiménez et al., 2014; Dell'Ariccia et al., 2017, see, for example,). In the short run, a monetary policy easing enhances the stability of banks, as low interest rates improve the overall quality of their loan portfolios. In the long run, on the other hand, low interest rates may encourage banks to raise both the size and the riskiness of their balance sheets in order to attain their original interest margins (the search-for-yield hypothesis; Rajan, 2005; Borio and Zhu, 2012; Adrian and Shin, 2009).

Another way in which accommodative monetary policy can induce financial institutions to take on more risk is through its impact on the risk parameter estimates which then enter the calculation of banks' capital requirements and risk weights under the internal ratings-based (IRB) approach. Low interest rates may facilitate a decline in the values of these parameters either directly or indirectly through their impact on collateral value and firms' valuation, income, and cash flow (Gambacorta, 2009). For instance, low interest rates and increasing asset prices tend to reduce asset price volatility and increase collateral value, which, in turn, reduces risk perceptions and risk parameter estimates. Further, higher asset prices increase the value of a firm's equity relative to its debt and thus reduce its leverage. Such a firm looks safer and the risk of holding its shares seems lower. Consequently, a decline in risk parameter estimates translates into lower risk weights, leading, ceteris paribus, to a higher capital ratio. All in all, assuming an unchanged asset structure and constant risk, the bank can look safer and healthier without its level of capital actually increasing.

The main objective of this paper is to analyze the extent to which monetary policy may affect banks' perception of credit risk and the way banks measure risk under the IRB approach. In other words, we look at the impact of monetary policy on banks' risk weights while controlling for different bank-specific and macroeconomic factors. We focus primarily on the Czech Republic, but we also examine the existence of this relationship in the Visegrad Four (V4) countries (the Czech Republic, Slovakia, Hungary, and Poland). The analysis draws on quarterly bank-level data for 20 banks in the Czech Republic and annual data for 58 banks in the V4 countries between 2003 and 2016. Methodologically, we employ dynamic panel data estimators corrected for potential endogeneity bias. To our best knowledge, there is no other similar study for this region, so this paper should serve as a first attempt in this area to find a reasonable methodological framework and to test the sufficiency of the existing data.

We identify a few patterns and reach a few conclusions. First, using a set of four different monetary policy indicators (the short-term interbank rate, the shadow rate, and two monetary conditions indexes), we present robust evidence of the existence of the risk-taking channel in the Czech Republic for banks using the IRB approach. Specifically, we obtain a strong, statistically significant downward impact of monetary policy easing on risk weights. Second, we show that the recent prolonged period of accommodative monetary policy has been instrumental in establishing this relationship; the effect disappears once we exclude the period from the estimation sample. Third, the analysis using the expanded panel of V4 countries supports the main conclusion and provides evidence of the risk-taking channel in the region.

The remainder of the paper is organized as follows. Section 2 provides a literature review, section 3 presents the econometric framework, and section 4 describes the data. Section 5 reports our main findings and provides a robustness analysis, and section 6 concludes.

2. Literature Review

The nature of the proposed research question requires us to review some basics about the regulatory approaches to calculating capital requirements for credit risk and, consequently, to determining risk weights, and to provide a literature review of the risk-taking channel of monetary policy. Both these issues are discussed in the following two subsections.

2.1 Risk-taking Channel of Monetary Policy

The risk-taking channel refers to a broad set of possible ways in which monetary policy can influence the risk perceptions and risk tolerance of financial institutions (see, for example, Borio and Zhu, 2012; Gambacorta, 2009). As already mentioned in the introduction, monetary policy can work through the search-for-yield process and through its impact on risk estimates and valuation techniques.[1]

The first group of effects refers to a situation in which low interest rates induce banks to take on more risk by investing in higher-yield, riskier assets in order to attain their target returns. This process may become especially important when target rates are rigid while the difference between targeted returns and market rates remains significant. Rajan (2005) shows that low interest rates may induce additional procyclicality into the financial system and warns of an upward spiral between the search for yield and asset prices. Using an extensive dataset of individual loans for Spain, Jiménez et al. (2014) find that lower overnight interest rates induce banks to engage in riskier lending. Moreover, this pattern is stronger for less-capitalized banks – lower interest rates induce less-capitalized banks to grant more loan applications to ex ante risky firms than better-capitalized banks. Using confidential data on U.S. banks' internal ratings, Dell'Ariccia et al. (2017) find that the quality of lending as measured by the risk rating of new loans goes down in response to lower short-term interest rates.

The second group of effects refers to a situation in which accommodative monetary policy contributes to growth in asset prices (and, consequently, collateral value and firms' income and cash flow), which inherently increases the risk tolerance of financial institutions. There are several empirical papers which examine these effects. For instance, Adrian and Shin (2008) find a strong correlation between balance sheet growth and monetary policy easing; as a consequence, they warn of a positive feed-back loop between higher asset prices and risk-taking (financial institutions increase their leverage during asset price booms and reduce it during busts). Gambacorta (2009) finds a significant link between a prolonged period of low interest rates and expected default frequencies.[2] Using a sample of U.S. bank holding companies, De Nicolò et al. (2010) support the existence of the risk-taking channel by estimating the effect of monetary policy on risk weights. Specifically, they identify a negative relationship between the real federal funds rate and risk weights.

Our paper falls into the second branch of the literature. In the context of the Czech Republic and the V4 countries, we are not aware of any other study closely related to our paper.[3] In general, little

[1] In addition, Borio and Zhu (2012) define a third group of possible effects covering the communication policies and reaction function of the central bank, in the sense that the transparency of the central bank and the credibility of its commitments may also affect risk-taking by banks. Irrespective of the modes of transmission, the authors generally agree that more attention should be given to this channel of monetary policy, especially in the light of increased financial liberalization and substantial prudential changes.
[2] The expected default frequency, EDF, is a forward-looking indicator of credit risk computed by Moody's KMV which builds on Merton's model to price corporate bond debt.
[3] The only relevant study is Podpiera and Weill (2010), which analyzes excessive risk-taking by banks; however, there is no connection to monetary policy in their paper.

attention is given in the literature to analyzing the impact of monetary policy on banks' internal estimates of risk parameters and risk weights. One closely related paper – which employs a similar methodological approach and a measure of banks' risk perceptions – is the study by De Nicolò et al. (2010). Nevertheless, they do not control for bank-specific characteristics and different regulatory approaches. This might be a problem, because there are a number of factors other than monetary policy that could affect banks' risk weights (see section 4).

In general, banks may adjust their risk-weighted exposures through a combination of changes in asset structure and changes in asset riskiness (Cohen and Scatigna, 2014). Other adjustments are also possible for banks reporting under the IRB approach. A number of studies have shown that IRB risk weights are systematically lower than those of STA banks and that this does not necessarily reflect lower or better-managed credit risk. For instance, Behn et al. (2016a) document that the internal risk estimates of banks that have switched to the IRB approach systematically underpredict actual default rates. Mariathasan and Merrouche (2014) analyze a panel of 115 banks from 21 OECD countries and find that once regulatory approval for the IRB approach has been granted the risk-weight density becomes lower and that *"this phenomenon cannot be explained by modelling choices, or improved risk-measurement alone"*. The authors attribute part of this decline to banks' strategic risk-modeling, i.e., risk-weight manipulation.

Another weakness of risk-sensitive capital regulation is its tendency to amplify the inherent procyclicality of banks' behavior (see, for example, Borio et al., 2001; Rochet, 2008; Repullo et al., 2010; Cannata et al., 2011; Andersen, 2011; Saurina and Trucharte, 2007; Behn et al., 2016b). Risk estimates generally vary over time, being lower in booms and higher in busts, which may lead to underestimation of the portfolio's real loss potential. So, in good times, the IRB approach may not capture the level of exposure risk accurately. The Basel Committee on Banking Supervision has addressed this issue in a consultation document (Bank for International Settlements, 2016).

2.2 Regulatory Framework

For almost three decades, Czech banks have been subject to prudential regulation designed to raise and maintain the resilience of the banking sector and improve its ability to absorb financial and economic shocks. This regulation has included the first, second, and third Basel accords (aka Basel I, II, and III). The first revision of the regulatory framework – Basel II, introduced in 2007 – was aimed at improving the risk sensitivity of the capital requirements for calculating capital charges for credit risk (BCBS, 2006). It introduced one of the most important innovations – model-based capital regulation, allowing banks to use their own internal risk measures to calculate the regulatory capital requirements for credit risk. Since then, banks have had the option of using three different approaches: the standardized approach (STA), the foundation internal ratings-based (F-IRB) approach, and the advanced internal ratings-based (A-IRB) approach.[4] Implementation of the IRB approach is subject to approval and a thorough validation review by the regulator.

The STA approach is based on a breakdown according to exposure classes, as first proposed in Basel I. In addition, banks can differentiate between counterparties within the same loan category with respect to their external credit rating. Unlike the IRB approach, the STA approach does not

[4] The current rules for determining risk-weighted exposures can be found in the implementing act of Basel III in Europe: the CRD IV/CRR regulatory framework. CRD IV – the Capital Requirements Directive – refers to Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms; CRR – the Capital Requirements Regulation – refers to Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms.

allow the use of internal data and models. The IRB approach is based on the determination of four key risk characteristics of an exposure: the probability of default (PD; the likelihood that an obligor will default in the course of one year),[5] the loss given default (LGD; the percentage of the exposure the bank might lose in the event of default), the exposure at default (EAD; an estimate of the outstanding amount in the event of default), and the maturity (M; the effective maturity of the exposure). These risk measures are used to calculate risk-weighted exposures and regulatory capital requirements by means of a specific formula proposed by the Basel Committee (BCBS, 2005). The formula varies depending on the exposure category.[6] Under the F-IRB approach, banks are permitted to estimate their own value for PD, while the values for LGD, EAD, and M are determined by the regulator. Under the A-IRB approach, banks provide their own estimates of PD, LGD, and EAD, while M is calculated by means of a formula provided by the regulator.[7]

The specific formulas proposed to calculate risk-weighted exposures represent only the unexpected loss (UL) and do not include the expected loss (EL).[8] ELs should be covered on a continuous basis through provisioning or direct pricing into the credit exposure. The regulatory capital requirements are intended to cover the risks stemming from ULs (BCBS, 2005). The core inputs into the risk-weighted formula – PD and LGD – can be estimated using different modeling techniques.[9] The estimation usually depends on a broad set of macroeconomic and obligor-specific information, including labor market data, GDP growth rates, the consumer price index, various interest rates and spreads, interest rate volatility, asset price volatility, market prices of bonds and equity, corporate financial ratios, and information about the type and amount of collateral assigned to the exposure. For instance, Drehmann et al. (2008), Volk (2013), Bonfim (2009), and Carling et al. (2007) incorporate GDP growth, real interest rate growth, and the yield curve slope alongside obligor-specific characteristics in their framework for modeling PD. In general, the authors find a significant positive effect of the interest rate on PD, while the effect of GDP growth is mostly negative. Jiménez and Saurina (2006) identify similar effects for non-performing loans, which are directly related to PD. Much less attention is given to modeling the relationship between LGD, macroeconomic variables, and interest rates; however, Altman et al. (2002) assert that there is a significant positive correlation between PD and LGD. Nevertheless, Jiménez and Saurina (2006) stress that during recessions (when PD usually increases) banks may require higher collateral, which would increase LGD; in such case, LGD and PD would be negatively correlated.

[5] A default occurs when either or both of the following conditions is met: (i) the obligor is unlikely to pay its credit obligations in full, (ii) the obligor is past due more than 90 days on any material credit obligation. For more details, see Article 178(1) of the CRR.

[6] Under the IRB approach, banks categorize their exposures into the following categories – central governments and central banks, institutions, corporates, retail, and equity.

[7] See Article 162 of the CRR.

[8] EL refers to the forecasted average loss that a bank can expect from an exposure over a given time period, while UL is the loss that it incurs above EL. In the current regulatory framework, UL is known as the variation in the expected loss and is calculated as a standard deviation at a certain confidence level (i.e., credit VaR).

[9] There are three broad ways to estimate LGD: as a market LGD, a workout LGD, or an implied market LGD (Schuermann, 2004). PD can be estimated, for example, using a reduced-form approach (Jarrow and Turnbull, 1995), a structural approach (Merton model, KMV model), or a pooling approach (cohort method, duration method). Both LGD and PD can also be estimated using various statistical techniques (e.g., logit model, probit model, neural networks, discriminant analysis).

3. Econometric Framework

3.1 Models

To assess the extent to which monetary policy may affect banks' perception of credit risk, we use a dynamic panel data model.[10] The empirical specification is designed to capture the impact of various monetary policy proxies on banks' average risk weights while controlling for a wide range of factors possibly affecting the dependent variable. Specifically, we construct the following empirical model for the Czech Republic:

$$RW_{i,t} = \alpha_1 RW_{i,t-1} + \beta_1 MP_t + \gamma_1 X_{i,t-1} + \delta_1 \,\%\Delta GDP_t + \delta_2 VIX_t + \delta_3 Reg_{i,t} + v_{1,i} + \varepsilon_{1,i,t} \quad (1)$$

where $RW_{i,t}$ are implicit risk weights calculated as the ratio of risk-weighted exposures to total assets in period t and for bank i, MP_t is a monetary policy proxy, $X_{i,t}$ are bank-specific control variables, $\%\Delta GDP_t$ is real GDP growth, and VIX is a volatility index.[11] In addition, we include a dummy variable for regulatory pressures $Reg_{i,t}$, which takes the value of 1 if banks' total regulatory capital ratio is less than 1.5 pp above the minimum of 8% (Berrospide and Edge, 2010). $v_{1,i}$ captures bank-level fixed effects.

Risk-weighted exposures might be affected by a number of factors; among the most important are the regulatory approach, the business model, and the overall macroeconomic situation (see, for example, Cannata et al., 2011; Mariathasan and Merrouche, 2014; CNB, 2015b; Behn et al., 2016a).[12] Another factor which may play a role is the size and capitalization of the bank. With respect to this, the vector of control variables $X_{i,j,t}$ includes different asset categories (bonds, interbank loans, cash with central bank, and different loan categories), the natural logarithm of total assets, the ratio of loan loss provisions to total assets, and the ratio of regulatory capital to total assets.

Different asset categories are included to capture the different levels of risk associated with different asset classes. This should ensure that the effect of monetary policy does not reflect the shift in asset composition. In general, higher risk weights are assigned to riskier assets (see section 4 and Figure 2). The fact that monetary policy can influence the asset structure is well entrenched in the literature, especially that on the credit channel of monetary policy and its two components, the balance sheet channel and the bank lending channel (Bernanke and Gertler, 1995).[13]

[10] Dynamic panel data models are often used in similar areas of research (see, for example, Brei and Gambacorta, 2014; Borio et al., 2015; Berrospide and Edge, 2010).

[11] Calculated and published by the Chicago Board Options Exchange.

[12] For instance, Cannata et al. (2011) document procyclicality of risk weights for credit risk under the IRB approach using supervisory data for Italian banks. Mariathasan and Merrouche (2014) analyze a panel of 115 banks from 21 OECD countries and find that once regulatory approval for the IRB approach is granted the risk-weight density becomes lower. Behn et al. (2016a) document that the internal risk estimates of banks that have switched to the IRB approach systematically underpredict actual default rates. CNB (2015b) discusses the impact of the aforementioned three aspects using data for the Czech banking sector.

[13] The balance sheet channel asserts that changes in monetary policy affect borrowers' balance sheets, cash flows, and net worth, which directly affects the external finance premium. The bank lending channel theorizes that changes in monetary policy affect the supply of available loans and demand for bonds (banks' assets) by affecting the supply of banks' funds (banks' liabilities). Empirically, the existence of this channel has been examined by, for example, Kashyap and Stein (1994, 2000); Altunbaş et al. (2002); Favero et al. (1999) and Gambacorta (2005). The decrease in the supply of loans may also originate in the balance sheet channel: a monetary tightening increases debt service, which can prompt sales of real assets, reducing their value and causing a loss of creditworthiness and a reduction of lending, while a monetary easing has the opposite effect (Gambacorta, 2005). Thus, in times of monetary tightening, there is an incentive for banks to switch to less risky projects, i.e., to start a "flight to quality" (Bernanke et al., 1994; Lang and Nakamura, 1995).

The ratio of regulatory capital to total assets is included as a proxy for banks' loss-absorbing capacity – banks with more capital may choose to take on more portfolio risk (Flannery and Rangan, 2008).[14] Loan loss provisions serve as an indicator of the riskiness of banks' loan portfolios (see, for example, Milne and Whalley, 2001; Brei and Gambacorta, 2014). Banks are expected to build up loan loss provisions in response to increased credit risk and higher future losses. This should be reflected in the risk parameter estimates used to calculate regulatory capital and risk-weighted exposures under the IRB approach. The proxy for bank size – the natural logarithm of total assets – is intended to capture the fact that larger banks usually face lower risk (Berger et al., 2008; Flannery and Rangan, 2008; Brei and Gambacorta, 2014). In addition, larger banks may tend to behave less prudently because they may believe that in the case of any difficulty they will receive support from the regulator or the government (the "too-big-to-fail" hypothesis; Afonso et al., 2014). All bank-specific control variables are included in lagged form in order to mitigate the possible endogeneity problem, which is addressed in more depth in the next subsection.

In the case of the Czech Republic, we estimate the model separately for banks using the IRB approach. Due to limited data availability, we are not able to do the same for the V4 countries. Nevertheless, we can partly overcome this problem by interacting a dummy $d2008_t$ (which equals 1 since 2008 and 0 otherwise) with the monetary policy variable in order to capture the change in banks' behavior due to the shift to the IRB approach. We are aware that this is a rough measure compared to the detailed information available in the analysis for the Czech Republic. However, it should give us at least some idea of the possible difference in the effect between these two periods. With this in mind, we estimate the following model for the V4 countries:

$$\begin{aligned} RW_{i,j,t} = &\alpha_2 RW_{i,j,t-1} + \left(\beta_2 + \beta_3 d2008_t\right) MP_{j,t} + \gamma_2 X_{i,j,t-1} + \delta_4 \,\%\, \Delta GDP_{j,t} \\ &+ \delta_5 VIX_t + \delta_6 Reg_{i,j,t} + v_{2,i} + \varepsilon_{2,i,j,t} \end{aligned} \tag{2}$$

where the subscript j stands for country.

3.2 Estimation Techniques

One of the possible identification problems in the context of dynamic panel data models with one-way fixed effects is endogeneity bias. Nickell (1981) shows that this bias is introduced by applying the within (demeaning) transformation in attempt to remove unobserved heterogeneity within the panel data – subtracting the individual's mean from the relevant variable creates a correlation between the regressor and the error term. Endogeneity bias is especially serious in panels with a high number of individuals (large N) and a low number of time periods (low T). This bias, however, shrinks substantially with higher T. Simulations by Judson and Owen (1999) suggest that the bias is minor in panels with more than 30 observations.

There are a few possible estimation methods which can help mitigate endogeneity bias. They can be divided into two main groups – generalized method of moments (GMM) estimators and bias-corrected least square dummy variables (LSDV) estimators. GMM estimators are well established in similar areas of research, but they are suitable for panels with very large N and small T. One particular weakness of GMM estimators (especially the System-GMM) is that when T is large relative to N, the huge number of instruments produced may render the GMM estimator invalid even though the individual instruments may be valid (Roodman, 2009). Some studies also show that using the

[14] The causality may also be reversed – well capitalized banks are generally considered to be less risky (Gambacorta, 2009) and more risk-averse banks (with a higher risk profile or volatile earnings) are expected to hold a higher level of capital (Gale and Ogur, 2005; Brei and Gambacorta, 2014). The test for Granger causality between capital risk weights at various orders indicates no simultaneity problem.

instrumental variables technique to avoid bias often leads to poor small sample properties (Kiviet, 1995; Bun and Windmeijer, 2010).

Motivated by these disadvantages, Kiviet (1995) pioneered the introduction of a group of bias-corrected LSDV estimators. They were shown to have superior small sample properties compared to GMM estimators; they maintain relatively small coefficient uncertainty while removing most of the bias. Soon after, a few modifications to the Kiviet (1995) estimator emerged, allowing for heteroscedasticity (Bun, 2010; Bun and Carree, 2005; Everaert and Pozzi, 2007; De Vos et al., 2015). One of these – the bootstrap-based bias corrected LSDV estimator by De Vos et al. (2015)[15] – is used in this study for both the Czech and V4 panel data models.[16] Given that the panel for V4 countries has a low number of time periods (T=14) relative to the number of individuals (N=58), the bootstrap-based bias corrected LSDV estimator is complemented by the System-GMM estimator (Arellano and Bover, 1995; Blundell and Bond, 1998). In order to reduce the number of instruments generated, principal component analysis is used (see, for example, Mehrhoff, 2009). Specifically, we chose such a number of principal components as to explain 80% of the variance of the initial set of instruments. To implement the System-GMM, we use the Stata routine *xtabond2*.

Last but not least, we have to address the generated regressor problem, which in our case arises from the use of three estimated monetary policy indicators (see the next section). As one possible solution, the literature suggests using bootstrapped standard errors (see, for example, Cameron and Trivedi, 2013; Ashenfelter and Card, 2010; Bernanke et al., 2005; Bellak et al., 2010; Agostino et al., 2009). In our case, therefore, the proposed bootstrap-based bias corrected LSDV estimator with bootstrapped standard errors is suitable for tackling this issue.[17]

4. Data

Our primary focus is on the Czech Republic, as we possess expert knowledge of the Czech banking sector and have access to a wide range of bank-level data at quarterly and monthly frequency. In addition, we provide an analysis for the group of V4 countries (including the Czech Republic); this should serve as a robustness check of the identified effects in the region. Unfortunately, the data available for the whole region are less detailed and of lower frequency. This should be borne in mind when interpreting the results.

4.1 Data for the Czech Republic

Our sample covers 20 banks and 56 quarters from 2003 Q1 to 2016 Q4, which gives an unbalanced panel of 963 observations in total.[18] We use implicit risk weights, calculated as the ratio of risk-

[15] De Vos et al. (2015) build on the model by Everaert and Pozzi (2007); instead of analytical expressions for the bias, usually derived under strict assumptions, they make use of numerical evaluation by bootstrap resampling. This procedure is far simpler and turns out to perform well.

[16] A likelihood-ratio test indicates that there is heteroscedasticity in our dataset; therefore, draws from the normal distribution with estimated heterogeneous (cross-section specific) variance are used by implementing the Stata routine *xtbcfe*. For each model, 1,000 iterations are produced and 800 enter the final inference. For more details on the implementation of this routine and a description of the methodology, see De Vos et al. (2015).

[17] It is worth noting that for the purposes of this analysis we do not estimate the monetary policy indicators explicitly. Instead, we take them from the Czech National Bank's (CNB) databases. This means that concepts based on joint or two-step estimation, which are also recommended in the literature, are not feasible in our case.

[18] At the end of 2016, the Czech banking sector consisted of 17 banks, 5 building societies, and 23 foreign bank branches. The foreign bank branches are excluded from the analysis, as they are not subject to domestic capital regulation and are thus not required to report the data we need for our analysis. Moreover, the Czech Export Bank

weighted exposures to total assets, as a proxy for banks' perception of risk and the way banks measure risk. For the sake of simplicity, in this article we work solely with the risk-weighted exposures for credit risk (which accounted for almost 90% of total risk-weighted exposures as of 2016 Q4) and take into account only balance sheet items.[19]

As mentioned in section 3, banks' risk weights can be affected by a number of factors. At least three rank among the most important – the regulatory approach (STA vs IRB), the bank's business model (asset structure), and the overall macroeconomic conditions. After controlling for them, we should be able to determine whether monetary policy also has an effect. The macroeconomic conditions are proxied by real GDP growth[20] (capturing the domestic business cycle) and the VIX index (as a proxy for global volatility on financial markets). The asset structure is captured by various asset classes used as control variables. Finally, we estimate the model separately for banks using the IRB and A-IRB approaches in order to control for regulatory approach. In what follows, we describe in more detail the Czech banking sector with respect to regulatory approaches and banks' business models.

In the Czech Republic, the IRB approach was adopted in the five largest universal banks and the majority of their subsidiaries in four waves starting in 2007 Q3. Their combined market share was approximately 80% as of 2016 Q4. All IRB banks also use the STA approach for a certain (usually very small) portion of their exposures. Figure 1 documents the evolution of the risk weights of IRB and STA banks; it shows that the risk weights for IRB banks started to fall simultaneously with the switch to the IRB approach, while those for STA banks began to decrease slowly a few quarters later. In the case of STA banks, the decline can be explained by a fall in the ratio of loans to total assets (see CNB, 2016, p. 144) and a rise in the ratio of less risky exposures to the central bank (see Figure 2(b)). The fall in the risk weights of IRB banks cannot be explained solely by the change in asset structure, so migration to the IRB approach also played a role. It is also interesting to note that the difference between the risk weights for the STA and IRB exposures of IRB banks is significant, at least in the first few years after the switch. This is due to the relatively high share of corporate exposures under the STA approach of the bank that switched to the IRB approach in 2011 Q1.

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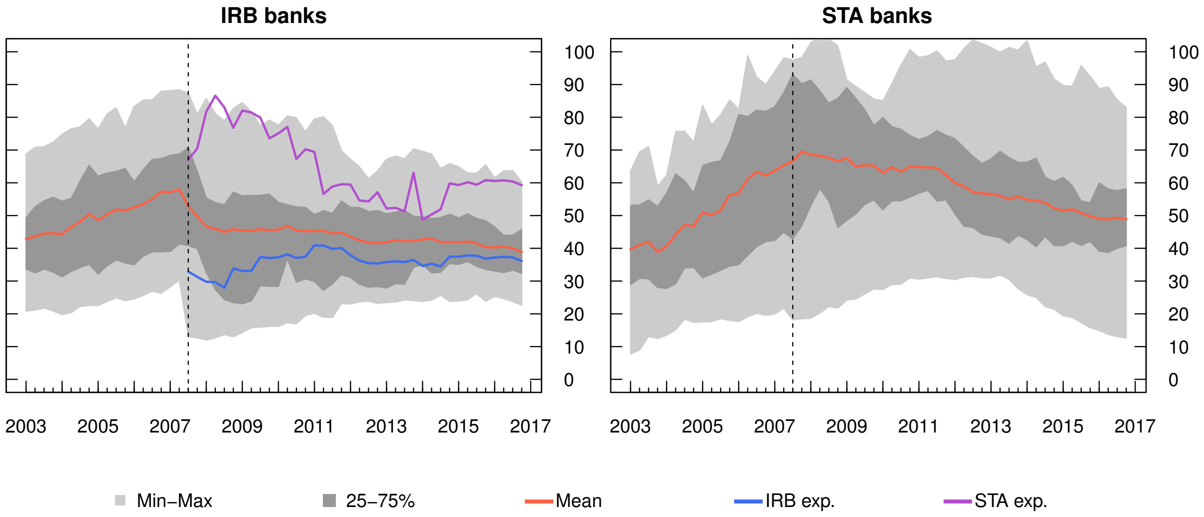
and the Czech-Moravian Guarantee and Development Bank were also excluded from the analysis because they are wholly owned by the Czech state (providing implicit state guarantees for their liabilities) and have different business models and volatile credit portfolios. Further, the capital ratio was adjusted for outliers – unreliably high values of a few small banks in the initial quarters after they entered the market.

[19] Bank-level data are obtained from the CNB's internal database (FINREP and COREP reporting statements). COREP (Common Reporting) and FINREP (Financial Reporting) are standardized reporting frameworks issued by the European Banking Authority for Capital Requirements Directive reporting. We consider data on a solo basis.

[20] Real GDP is obtained from the Czech Statistical Office.

Figure 1: Implicit Risk Weights – IRB and STA Banks (%)



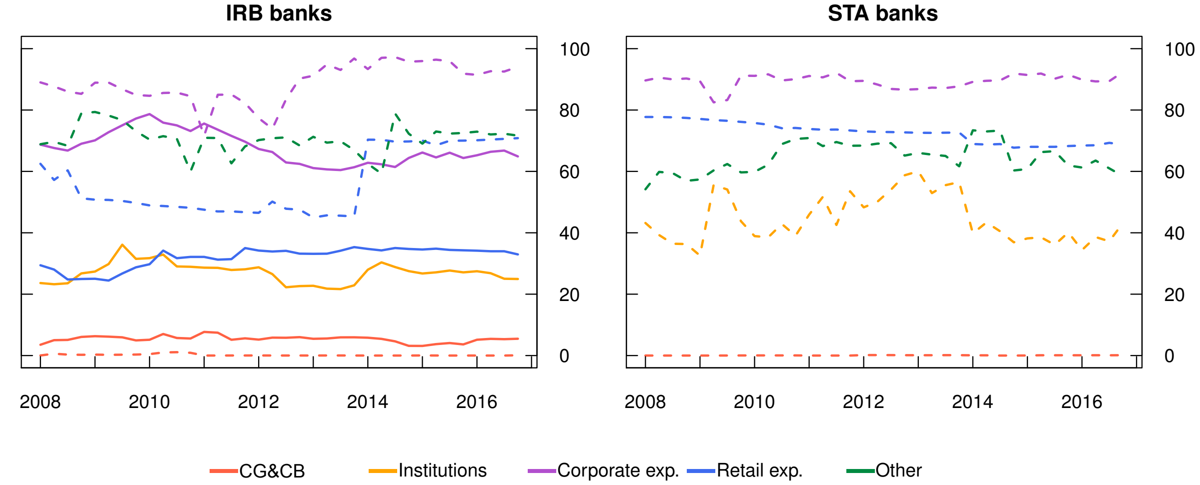
Note: Implicit risk weights are calculated as risk-weighted exposures divided by total assets; vertical line = 2007 Q3 (when five large or medium-sized banks started to use the IRB approach; three others followed a few quarters later; the last one started to use the IRB approach in 2011 Q1); IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; STA banks – banks using solely the STA approach as of 2016 Q4. All IRB banks also use the STA approach for a certain portion of their exposures; therefore, we additionally distinguish between risk weights calculated using the STA exposures of IRB banks (STA exp.) and the IRB exposures of IRB banks (IRB exp.).

With respect to banks' business models, we can divide banks' credit exposures into four main asset classes: (i) exposures to central governments and central banks, (ii) exposures to institutions, (iii) corporate exposures, and (iv) retail exposures. The remaining exposures for STA banks are reported as "others."[21] Figure 2(a) shows that the risk weights differ considerably across the main asset classes. The risk weights for IRB exposures remain relatively stable over time, except for a decline in those for corporate exposures between 2010 and 2013. The risk weights for exposures to central governments and central banks are lower for STA banks; for other comparable categories, the risk weights of IRB banks are lower than those of STA banks, especially for retail exposures.

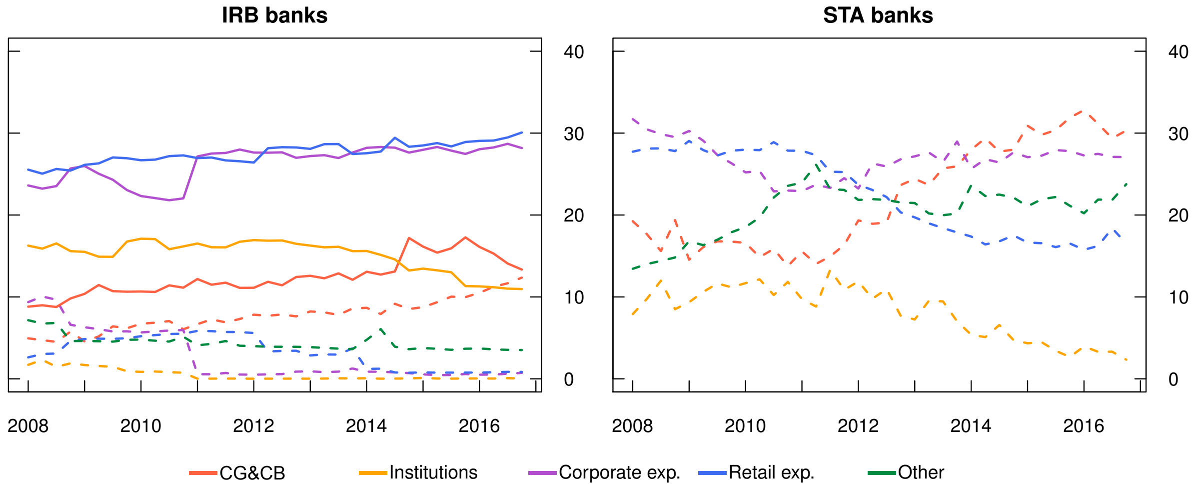
[21] The classification differs slightly between STA and IRB banks. While for IRB banks we can distinguish only the aforementioned four asset classes, for STA banks exposures are classified into a large number of classes. To be able to compare between STA and IRB banks, for STA banks we report the four main classes and refer to the remaining exposures as "others." These include exposures to regional governments or local authorities, public sector entities, multilateral development banks, and international organizations, exposures secured by residential property, exposures in default, exposures associated with particularly high risk, exposures in the form of covered bonds, items representing secularization positions, exposures to institutions with a short-term credit assessment and in collective investment undertakings, equity exposures, and other items.

Figure 2: Implicit Risk Weights and Exposures by Asset Classes – IRB vs STA Banks

(a) Risk Weights by Main Asset Classes (%; Solid Lines – IRB Exposures, Dashed Lines – STA Exposures)



(b) Shares of Asset Classes in Total Non-weighted Exposures (%)



Note: Implicit risk weights are calculated as risk-weighted exposures divided by total assets; IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; STA banks – banks using solely the STA approach as of 2016 Q4. The share of STA exposures to institutions of IRB banks (the yellow dashed line) is zero or nearly zero for the majority of the period analyzed, so we do not report the average risk weight for this category. CG&CB – central government and central bank.

Table 1 reports summary statistics for implicit risk weights by bank business model and regulatory approach. We distinguish between banks with a universal business model, banks specializing in providing loans for house purchase, and investment banks, whose business model is totally different from the others.

A few patterns emerge. First, the risk weights of building societies and mortgage bank subsidiaries (i.e., banks whose business model is focused almost exclusively on providing loans for house purchase) are, on average, significantly lower than for the rest of the sample (by 24.5 pp). This may be partly due to the fact that the largest building societies, one medium-sized building society, and one medium-sized mortgage bank are IRB banks. Moreover, loans secured by residential property – which form a significant share of loans provided by building societies and the entire loan portfolio of mortgage banks – are generally less risky than other types of loans. Nevertheless, the risk may be undervalued in IRB building societies. The average risk weight of retail loans other than those secured by residential property is significantly lower for IRB building societies than for other IRB banks (about 28% vs 50% as of 2016 Q4). Moreover, the average risk weight of loans secured by residential property is also lower for IRB building societies than for other IRB banks (about 22% vs 27% as of 2016 Q4). For further discussion of this issue, see CNB (2017). Second, the risk weights of investment banks are, on average, only slightly higher than for the rest of the banking sector. Third, the risk weights for banks using predominantly the IRB approach are lower than those for banks using solely the STA approach (by 13.9 pp on average); the results remain comparable even after investment banks are excluded.

Table 1: Implicit Risk Weights – Summary Statistics for the Czech Republic

Group	No. of obs.	No. of banks	Mean	Diff.	St. dev.	Min.	Max.
All	983	20	51.02		21.17	7.78	105.10
Universal banks	497	11	60.80	19.78 ***	18.38	12.61	105.10
Building soc. and mortgage banks	374	7	35.87	-24.46 ***	14.92	12.00	88.40
Investment banks	112	2	58.23	8.14 ***	21.31	7.78	98.83
IRB banks	319	9	41.61	-13.93 ***	15.52	12.00	87.36
STA banks	664	11	55.54	13.93 ***	22.03	7.78	105.10
STA banks (excl. inv. banks)	552	9	55.00	13.39 ***	22.15	12.61	105.10

Note: Summary statistics are calculated on a solo basis. Implicit risk weights are calculated as risk-weighted exposures divided by total assets. ***, **, and * denote whether the t-test of the difference in the mean between the given group of banks and the rest of the sample is significant at, respectively, the 1%, 5%, and 10% levels.

Monetary policy proxies. Regarding the monetary policy variable, there was a consensus in academia and the central banking community in the pre-crisis period that the short-term policy rate was a good measure of both the monetary policy stance and the policy instrument. It thus became a standard proxy for monetary policy shocks in studying transmission and for the monetary policy stance in core structural macro-models. However, this began to be questioned once policy rates had reached their lower bounds and unconventional measures were implemented. The CNB operated with its monetary policy rates at the zero lower bound from November 2012 to the end of our data sample. It started to use the exchange rate as an unconventional monetary policy instrument within its inflation targeting regime in the form of a publicly declared, one-sided exchange rate commitment in November 2013 and decided to discontinue that commitment in April 2017. Given this, we provide some alternative measures that are informative of the monetary policy stance in such a situation. All the monetary policy indicators capture to some extent and on various scales the effect of the prolonged period of monetary policy easing in recent years.

We chose four monetary policy indicators representing some of the most common measures used in the literature to account for the effect of both conventional and unconventional monetary policy and to overcome the problem of the zero lower bound on interest rates (see Figure 3). First, we use a short-term interbank rate – specifically the 3-month Pribor. The main advantage of the interbank rate over the other three proposed monetary policy proxies is that it is a market-based, non-estimated measure; on the other hand, it is restricted by the lower bound and does not capture the possible impact of unconventional monetary policy measures. Therefore, in our regressions with the 3-month Pribor we additionally control for the yield curve slope, which should help capture the effect of unconventional monetary policy and the prolonged period of monetary easing; the yield curve slope is proxied by the spread between the 10-year Czech government bond yield and the 3-month Pribor. In this respect, we were inspired by Borio et al. (2015) and Borio and Gambacorta (2017), who use the same combination.[22]

Second, we use a shadow short rate estimated as suggested by Krippner (2012, 2015). He constructs a hypothetical shadow yield curve (including the shadow short rate) by adjusting the yield curve for the currency option effect (the effect of the existence of cash holdings imposing the lower bound on interest rates, estimated as the value of a call option within an option-pricing model). The model employs an arbitrage-free Nelson-Siegel model with two state variables (the level and slope of the yield curve) and is estimated using an iterated extended Kalman filter.[23]

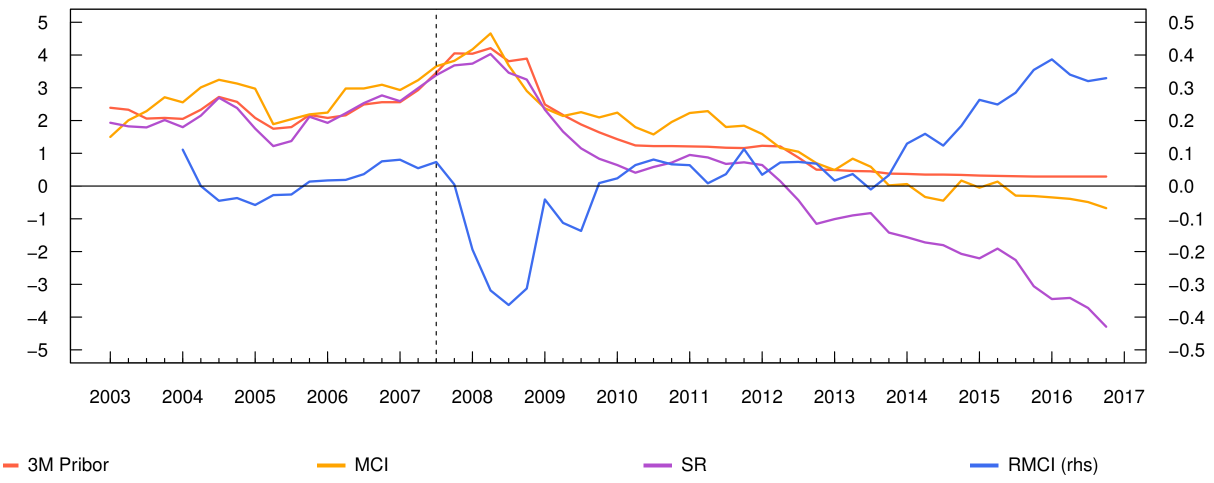
The third indicator is the monetary policy index (MCI) proposed by Malovana and Frait (2017). It is estimated using dynamic factor analysis and a wide range of monetary policy variables, including interest rates and yields at various maturities, central bank balance sheet items, and the exchange rate. The final index is computed as a weighted sum of the chosen factors, with the weights equal to the variance explained by each factor; it is normalized using the mean and the standard deviation of the 3-month Pribor.

As the fourth indicator, we use the real monetary conditions index (RMCI) estimated by the CNB (2015a) and regularly updated and published in its inflation reports. The basic version of the RMCI is calculated as a weighted average of the deviations of the domestic ex ante real interest rate and the real exchange rate from their equilibrium levels. As for the interest rate component, the 3-month Pribor adjusted for financial market inflation expectations one year ahead was chosen. The exchange rate component was proxied by the real exchange rate vis-à-vis the effective euro area.

[22] The estimated coefficient on the spread (the slope of the yield curve) is not interpreted directly as the change in monetary policy, because it can be influenced by a number of different factors. For instance, until 2009 a decrease might be viewed as a result of monetary tightening. Afterwards, the decline in the spread is rather a sign of accommodative policy resulting from reaching the ZLB, when long rates gradually decrease while short rates have no further room to decline.

[23] The shadow rate estimates can be relatively sensitive to the model specification and data. To avoid this, we use the same specification of a two-factor model with a similar span of yield curve maturities as proposed by Krippner (2016), who asserts that it is more robust, especially in comparison with the three-factor model employed by Wu and Xia (2016).

Figure 3: Monetary Policy Indicators – Czech Republic



Note: MCI – the monetary conditions index as estimated by Malovana and Frait (2017); SR – the shadow rate as estimated by Krippner (2012); RMCI – the real monetary conditions index as estimated by CNB (2015a) and regularly published in the CNB's inflation reports; positive values of the RMCI refer to easy monetary conditions and negative values to tight monetary conditions. Vertical line = 2007 Q3 (when five large or medium-sized banks started to use the IRB approach; three others followed a few quarters later; the last one started to use the IRB approach in 2011 Q1).

4.2 Data for the Visegrad Four Countries

In the next step, we extend our panel by including data for banks in Hungary, Poland, and Slovakia;[24] together with the Czech Republic, they constitute the Visegrad Four (V4) group. The V4 countries are similar in several regards: they are small open economies, their monetary regime is inflation targeting,[25] and their banking sectors are dominated by subsidiaries of banks headquartered in the euro area (IMF, 2015). The comparable characteristics ensure that we can use the expanded dataset for a robustness analysis of the effects in the region. We use annual bank-level data from the BankScope database. Our sample covers 58 banks and the period 2003–2016, which gives us an unbalanced panel of 588 observations in total.[26] We use a similar set of control variables as in the analysis for the Czech Republic. Nevertheless, the final set of variables may differ slightly depending on data availability.[27]

[24] The dataset was created in such a way that the data for the Czech Republic described in the previous section were extended to include data for Hungary, Poland, and Slovakia. Because we have a full set of banks for the Czech Republic but only a limited number of banks are available in the BankScope database for the remaining countries, the Czech Republic may be over-represented in the V4 panel. Therefore, we check the sensitivity of the baseline results to the inclusion of banks from the Czech Republic.

[25] While Slovakia has been an inflation targeter since it joined the euro area in 2009, the Czech Republic started to target inflation in December 1997, Hungary in June 2001, and Poland in October 1998 (Kočenda and Varga, 2017).

[26] There are 20 banks in the Czech Republic, 11 banks in Hungary, 20 banks in Poland, and 7 banks in Slovakia. The list of all banks can be found in the Appendix. In the search strategy, we only take into account active banks with the following specializations: commercial banks, savings banks, cooperative banks, real estate and mortgage banks, and bank holdings and holding companies. We also adjust the data for visible outliers and infeasible – and presumably wrongly reported – values; this pertains to only three values of risk-weighted assets, though.

[27] Data for real GDP, interbank rates, long-term government bond yields, and the VIX index were obtained from the Federal Reserve Economic Data (FRED) database.

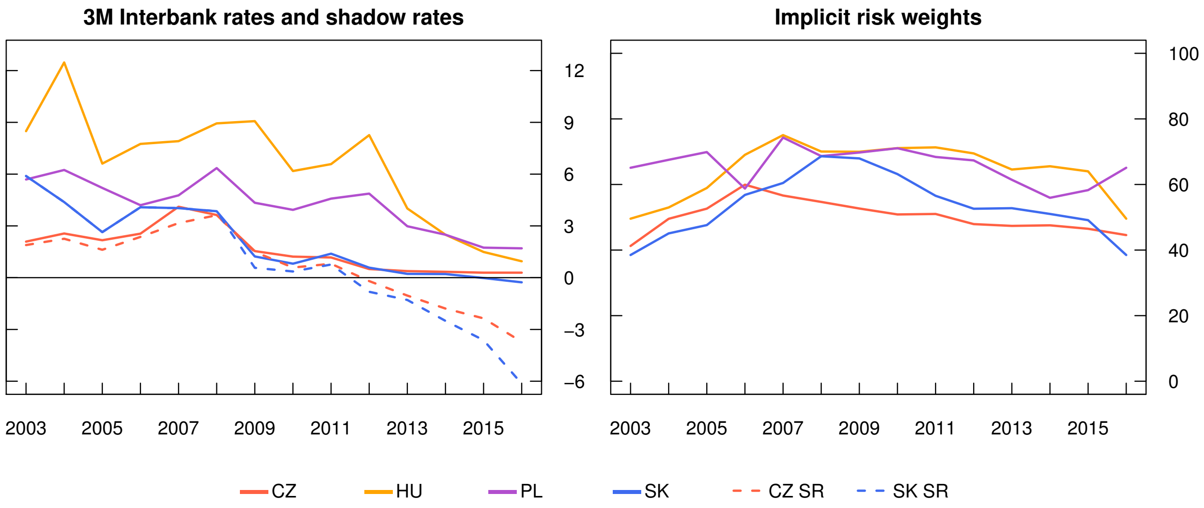
Table 2 reports summary statistics for implicit risk weights by country. On average, the risk weights are the lowest in the Czech Republic (by 11 pp compared to the other three countries) and the highest in Poland (by 11 pp). The risk weights in Slovakia are the least variable, ranging between 30% and 81%. After 2008, the risk weights are more or less stable for all countries and remain between 50% and 70% (see Figure 4).

Table 2: Implicit Risk Weights – Summary Statistics for the Visegrad Four Countries

Country	Number of obs.	Number of banks	Mean	Difference	St. dev.	Min.	Max.
Czech Republic	260	20	51.48	-11.42 ***	20.73	12.59	102.56
Hungary	96	11	62.84	5.96 ***	16.31	21.84	97.99
Poland	168	20	66.03	11.45 ***	13.42	5.21	92.74
Slovakia	64	7	54.76	-3.47 **	11.93	30.13	80.92
All	588	58	57.85		18.48	5.21	102.56

Note: Summary statistics are calculated on a solo basis. Implicit risk weights are calculated as risk-weighted assets divided by total assets. ***, **, and * denote whether the t-test of the difference in the mean between the given group of banks and the rest of the sample is significant at, respectively, the 1%, 5%, and 10% levels.

Figure 4: 3-month Interbank Rates and Implicit Risk Weights – the Visegrad Four Countries (%)



As for the monetary policy proxies, we use 3-month interbank rates (for all countries) and a combination of 3-month interbank rates (for Poland and Hungary) and estimated shadow rates (for Slovakia and the Czech Republic). The Czech Republic and Slovakia reached the zero lower bound in November 2012 and May 2013, respectively;[28] benchmark interest rates in Hungary and Poland did not attain the zero lower bound in our sample period. In Figure 4, we can see a clear downward trend in interbank rates across the V4 countries. There seems to be a premium for Hungary and Poland, while the series for Slovakia contains a clear structural break in 2009. At that time, Slovakia adopted the euro and the 3-month Bribor was replaced with the 3-month Euribor. Also, all rates exhibit a notable increase before the global financial crisis, followed by a drop in the initial years after 2008 and a repeated tightening around 2011–2012, except in the case of the Czech Republic.

[28] We assume that the zero lower bound starts to apply at the technical zero value of 0.05%.

5. Results

5.1 Estimation Results for the Czech Republic

The estimation results for the Czech Republic are reported in Tables 3 and 4. Table 3 presents the results obtained from the baseline model of equation (1) and is divided into three columns based on the regulatory approach and different categories of risk weights. First, we estimate the specification with the *total* implicit risk weights of *all* banks (column 1); second, we use the *total* implicit risk weights of *IRB* banks (i.e., banks using the IRB approach for at least some portion of their exposures in a given quarter; column 2); third, we use only the *IRB* implicit risk weights (i.e., the risk weights of exposures under the IRB approach) of banks with at least 75% of their risk-weighted exposures calculated under the *A-IRB* approach as of 2016 Q4 (henceforth "banks mainly using the A-IRB approach"; column 3).[29] By using different categories of risk weights, we aim to explain the effect of monetary policy changes on banks' risk weights under different regulatory approaches. Table 4 presents the results of the baseline model adjusted for the length of the sample, i.e., excluding or including the prolonged period of accommodative monetary policy. Specifically, we exclude the period of unconventional monetary policy (from 2013 Q4 to the end of the sample) and the period of the zero lower bound (from 2012 Q4 to the end of the sample). For the sake of brevity, only the coefficients on the monetary policy proxies, the standard errors, and the significance levels are reported; the complete estimation results can be found in the Appendix.

The estimation across different model specifications and monetary policy proxies provides a robust overview of the effect of monetary policy changes. The bootstrap-based bias corrected LSDV estimator ensures efficiency and consistency of the estimates and standard errors provided. As for the interpretation of the size of the impact, a value of the coefficient on the monetary policy proxies equal to 0.1 implies that if the monetary policy proxy increases by 1 pp/unit, the implicit risk weights increase by 0.1 pp. An increase in all the monetary policy variables except the RMCI can be interpreted as monetary tightening; positive values of the RMCI relate to easy monetary conditions. Our sample mainly covers the period of accommodative monetary conditions (see Figure 3), so the estimated coefficients cannot reasonably be interpreted in terms of monetary policy tightening. This should not be of great concern, as we are interested mainly in the effect of easing monetary policy.

In general, the results are consistent across model specifications and monetary policy proxies and confirm the existence of the risk-taking channel of monetary policy. As indicated in Table 4, there is a strong, statistically significant relationship between monetary policy easing and lower implicit risk weights of IRB banks, after controlling for banks' asset composition, a wide range of other bank-specific variables, the business cycle, and regulatory pressures (columns 2 and 3). The effect disappears if we consider the whole sample of banks, i.e., both STA and IRB banks (column 1). This is in line with the theory discussed in section 2 stating that accommodative monetary policy might influence banks' risk weights through the estimates of risk parameters under the IRB approach; unlike IRB banks, STA banks are not allowed to estimate their own risk parameters. The effect is even stronger for banks mainly using the A-IRB approach (column 3), i.e., banks that are permitted to estimate not only their own value of PD, but also LGD and EAD.

In terms of the size of the effect, the interpretation is slightly more difficult. Only the coefficients on the 3-month Pribor and the shadow rate are directly comparable to each other, because they are both interest rates; in some sense the MCI can also be compared to these measures, as it is standardized using the 3-month Pribor (for more details, see Malovana and Frait, 2017). A 1 pp decrease in these three monetary policy proxies transmits, on average, to a 0.3–0.7 pp decrease in the risk weights of

[29] Because of the short time series, we cannot directly use only risk-weighted exposures under the A-IRB approach.

IRB banks and a 0.4–0.9 pp decrease in the risk weights of banks mainly using the A-IRB approach. The interpretation of the coefficient on the RMCI is less straightforward, because it is calculated as a weighted average of the deviations of domestic ex ante real interest rates and the real exchange rate from their equilibrium levels. Nevertheless, the estimates indicate that more accommodative monetary conditions (a greater deviation from the equilibrium levels) lead to lower risk weights.

Table 3: Estimation Results – the Czech Republic (1)

	(1)		(2)		(3)	
Banks:	All		IRB		A-IRB	
Dependent variable:	RW		RW		RW IRB	
3-month Pribor†	-0.047	(0.152)	0.696**	(0.269)	0.885***	(0.300)
Shadow rate	0.074	(0.085)	0.307**	(0.127)	0.382***	(0.135)
MCI	0.084	(0.126)	0.583***	(0.189)	0.721***	(0.190)
RMCI	-0.287	(0.968)	-3.469***	(1.189)	-2.451**	(1.223)
Observations	963/899‡		310		204	

Note: This table presents the bootstrap-based corrected LSDV regression (De Vos et al., 2015) estimates of equation (1). Bootstrapped standard errors are reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. RW – total risk weights calculated as risk-weighted exposures divided by total assets; RW IRB – IRB risk weights calculated as risk-weighted exposures under the IRB approach divided by non-risk-weighted exposures under the IRB approach. IRB banks – banks using the IRB approach for at least some portion of their exposures in a given quarter; A-IRB banks – banks with at least 75% of their risk-weighted exposures calculated under the A-IRB approach as of 2016 Q4. MCI – the monetary conditions index as estimated by Malovana and Frait (2017); RMCI – the real monetary conditions index as estimated by CNB (2015a) and regularly published in the CNB's inflation reports; positive values of the RMCI refer to easy monetary conditions and negative values to tight monetary conditions. † In the regression with the 3-month Pribor we additionally control for the slope of the yield curve. ‡ The lower number of observations refers to the regression with the RMCI, which is available only from 2004 Q1.

With respect to asset composition, we control for a wide range of different asset classes associated with different risk weights. This should ensure that the effect captured by the monetary policy proxies does not reflect the shift in asset composition. Risk weights can decrease due either to a bank viewing the same assets as less risky, or to a bank shifting its portfolio to less risky assets, or a combination of the two. The two options have different interpretations for monetary policy and for financial stability (the latter option could imply that the bank actually became more risk averse). Therefore, controlling for asset composition properly is crucial.

In the baseline regression, the effect of most of the asset classes is statistically insignificant. The exception is retail loans other than those secured by property, whose higher share is associated with the lower risk weights of banks mainly using the A-IRB approach. The average risk weight on this category of loans of IRB banks is lower than the total average risk weight.[30] Therefore, the sign goes in the expected direction. In addition to the baseline specification, we control for period-to-period percentage growth of different asset classes in a sensitivity analysis in section 5.3; this exercise reveals that other asset classes may also be important determinants of risk weights. In particular, the implicit risk weights decrease in response to higher growth in retail loans secured by property, bonds, and cash with the central bank. All these three categories are usually considered less risky and bear lower risk weights than other asset classes (Figure 2a). This finding implies that the asset

[30] Risk weights for retail exposures average 32%, risk weights on corporate exposures 68%, and risk weights on other exposures except for those to central banks and governments 47%. The averages are calculated for 2008–2016.

structure channel – the effect of change in the composition of banks' portfolios on risk weights – also plays a role for IRB banks.

The coefficient estimates of the remaining control variables have the expected sign. Loan loss provisions – which are supposed to control for bank credit risk – are associated with higher implicit risk weights of IRB banks, suggesting that IRB banks reflect a recognized deterioration in loan quality in their risk-weighted exposures. Size receives a positive and significant coefficient in specifications with IRB banks, implying that larger IRB banks tend to hold higher risk weights. This is due to the fact that smaller IRB banks include building societies. They specialize mainly in providing loans for house purchase secured by property, which are generally less risky and bear lower risk weights. The dummy for regulatory pressures has a positive and significant coefficient in all specifications. This suggests that regulatory restrictions do seem to be binding in a way that affects banks' implicit risk weights. VIX has a positive, statistically significant effect in specifications with IRB banks, indicating that IRB banks take into account increased risk of higher volatility in financial markets in their estimation of risk parameters.

Table 4: Estimation Results – the Czech Republic (2)

End of the sample:	(1) 2012 Q4	(2) 2013 Q4	(3) 2014 Q4	(4) 2015 Q4	(5) 2016 Q4
3-month Pribor†	0.448	1.137***	1.177***	1.026***	0.696**
	(0.415)	(0.409)	(0.354)	(0.311)	(0.269)
Shadow rate	-0.027	0.558**	0.634***	0.531***	0.307**
	(0.298)	(0.278)	(0.208)	(0.166)	(0.127)
MCI	0.589	1.064***	0.890***	0.799***	0.583***
	(0.372)	(0.308)	(0.237)	(0.217)	(0.189)
RMCI	1.002	-1.072	-3.991**	-4.674***	-3.469***
	(1.735)	(1.819)	(1.789)	(1.464)	(1.189)
Observations	166	202	238	274	310

Note: This table presents the estimation results for the group of IRB banks with implicit risk weights (RW) as the dependent variable. Bootstrapped standard errors are reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. † In the regression with the 3M Pribor, we additionally control for the slope of the yield curve. For more details, see the note under Table 3.

Interesting patterns emerge if we exclude the prolonged period of monetary easing and repeat the estimation exercise for IRB banks. We obtain evidence of the existence of the risk-taking channel once we include the period 2013–2016. Specifically, the relationship between monetary policy variables and risk weights is statistically significant if we include these years and statistically insignificant if we exclude them (see Table 4).[31] We interpret this finding as meaning that the prolonged period of accommodative monetary conditions has been instrumental in establishing the risk-taking channel of monetary policy in the Czech Republic.

The sign and statistical significance of the coefficients of the control variables remain similar to the baseline model specification (see the Appendix). In addition, the coefficients on the share of corporate loans and interbank loans become statistically significant and positive once we exclude the year 2016, indicating that with a higher share of these riskier asset classes the implicit risk weights increase. In some specifications, the ratio of regulatory capital to total assets also receives

[31] An additional estimation exercise excluding the year 2012 confirms this pattern; the coefficients on monetary policy proxies remain insignificant in all cases. However, this specification is based on only 130 observations and therefore needs to be taken with caution.

a negative and statistically significant coefficient. This contradicts our initial expectation that banks with higher loss-absorbing capacity would be willing to take on more risk.

5.2 Estimation Results for the Visegrad Four Countries

Table 5 presents the results obtained from the model of equation (2) and is divided into four columns based on the estimation technique and control variables. Columns 1a and 2a refer to specifications without control variables for banks' asset structure, while columns 1b and 2b refer to specifications with these controls.[32] In addition, we report results under both the corrected LSDV estimator and the System-GMM estimator, as we work with a panel of 14 time periods and 58 banks. With respect to monetary policy proxies, we use either the 3-month interbank rate for all four countries, or a combination of the 3-month interbank rate and the shadow rate (for the Czech Republic and Slovakia; see section 4).[33] Table 5 presents only the coefficients on monetary policy variables; the complete estimation results can be found in the Appendix.[34]

Table 5: Estimation Results – the Visegrad Four Countries

Estimation method:	Corrected LSDV		System-GMM	
	(1a)	(1b)	(2a)	(2b)
3M IR×d2008	0.953**	0.717	0.826***	1.972**
	(0.394)	(0.933)	(0.307)	(0.760)
3M IR×(1-d2008)	-0.688*	0.760	0.871***	1.684*
	(0.416)	(0.167)	(0.315)	(0.851)
3M IR or shadow rate×d2008‡	0.591**	0.343	0.506**	1.126**
	(0.277)	(0.576)	(0.232)	(0.462)
3M IR or shadow rate×(1-d2008)‡	0.348	1.040	0.611*	0.797
	(0.365)	(0.823)	(0.337)	(1.731)
Observations	496	301	507	308

Note: This table presents estimates of equation (2) using bootstrap-based corrected LSDV regression (De Vos et al., 2015) and the System-GMM Blundell and Bond (1998) with instruments generated by principal component analysis; robust standard errors are reported in parentheses; Windmeijer (2005) finite-sample correction is applied to the reported standard errors; ***, **, and * denote the 1%, 5%, and 10% significance levels. Columns (1b) and (2b) – we control additionally for banks' asset structure. ‡ The shadow rate is used for the Czech Republic and Slovakia.

In general, the estimated effects are in line with the results for the Czech Republic. Nevertheless, there are some differences with respect to model specifications and estimation techniques. There is a strong, statistically significant relationship between monetary policy easing and lower implicit risk weights in most of the specifications. The significance disappears if we control for banks' asset structure and we use the corrected LSDV method at the same time (column 1b); however, the results remain significant if we use the System-GMM method. We suspect that this is due to a non-negligible decline in the number of available observations once we include different asset classes as control variables – we are able to do this only at the expense of a shorter panel; as a

[32] We present both specifications because the number of available observations decreases significantly if we want to control for banks' asset structure. Unfortunately, these variables are only available for a limited number of banks and periods.

[33] Slovakia imports monetary policy from the Eurozone, so the shadow rate for the Eurozone as estimated by Krippner (2017) is used as from euro adoption in 2009; until then the 3-month interbank rate is used.

[34] Because of the possible over-representation of banks from the Czech Republic (see section 4.2) in the V4 panel, we check the sensitivity of the results to the inclusion of banks from the Czech Republic. Excluding these banks does not significantly affect the effects identified, i.e., they remain robust to the inclusion of banks from the Czech Republic. These results are not reported but are available upon request.

result, the average length of our dataset shrinks to approximately 9 years. The corrected LSDV method might be less suitable for such a short panel, while the System-GMM might perform much better (for a more detailed discussion see section 3.2). In addition, the effect is stronger in the latter period (2008–2016) if we control for the asset structure and use the System-GMM (column 2b). This is consistent with the effects identified for the Czech Republic and may indicate that either a switch to the IRB approach or a prolonged period of accommodative monetary policy, or both, have contributed to the strength of the pass-through.

5.3 Robustness Analysis

Czech Republic. In the baseline specification, we already use different proxies for monetary policy, different categories of risk weights, and different groups of banks; we also control for banks' asset structure using a wide range of different asset classes. All this together should provide a robust overview of the effect of monetary policy changes on banks' risk weights. In addition to that, we test the robustness of the baseline regression results in several other ways. As mentioned earlier, the asset structure is one of the major determinants of total average risk weights, so controlling for it properly is crucial in order to separate the effect of monetary policy. Thus, we provide two sensitivity checks with respect to the asset structure. First, we compare the baseline results with a more parsimonious specification in which we do not consider different asset classes. This allows us to assess the importance of this additional control. In the second test, we control for the growth (percentage increase or decrease) of each asset class relative to the previous period instead of the relative percentage share of each asset class in banks' total assets.

The results indicate that the impact of monetary policy proxies remain comparable in terms of size, sign, and significance (see Tables A8–A11 in the Appendix). The effects are slightly weaker in regressions in which we do not control for asset composition; this might indicate that monetary policy may also affect average risk weights through the asset structure but in the opposite direction, influencing the shift in asset composition towards a higher share of riskier asset classes such as loans (consistently with the credit channel of monetary policy).

Besides these two tests, we control for different behavior of less-capitalized IRB banks compared to their better-capitalized peers. The literature suggests that low-capitalized banks with capital ratios close to the regulatory requirements tend to rebuild their capital, while unconstrained banks tend to maintain their current level of capital (Heid et al., 2004; Berger et al., 2008; Gropp and Heider, 2010). In terms of risk-sensitive regulatory capital ratios, this can be done through a change in either the numerator (the capital level) or the denominator (risk-weighted exposures). Banks may change their risk-weighted exposures through a combination of changes in portfolio size, portfolio structure, and risk estimates (under the IRB approach). With respect to this, we hypothesized that, after controlling for the level of capital and the asset composition, banks with less capital relative to their risk-weighted exposures will reflect low interest rates in their risk parameter estimates more strongly than better-capitalized banks. Confirming this hypothesis would indicate that the response of average risk weights to monetary policy might be asymmetric and might depend on whether or not a bank faces regulatory pressure. To test the hypothesis, we enrich the baseline model by including an interaction dummy $dCAR25_{i,t}$ for the lower quartile of the total regulatory capital ratio:

$$\begin{aligned} RW_{i,t} =& \alpha_3 RW_{i,t-1} + \left(\beta_4 + \beta_5 dCAR25_{i,t}\right) MP_t + \gamma_3 X_{i,t-1} + \delta_7 \,\%\,\Delta GDP_t \\ & + \delta_8 VIX_t + \delta_9 Reg_{i,t} + v_{3,i} + \varepsilon_{3,i,t} \end{aligned} \quad (3)$$

As expected, the coefficient on the interaction between the lower-quartile dummy and the monetary policy proxies indicates that the relationship is much stronger for less-capitalized banks (Table 6).

Because the sample used in the estimation predominantly covers periods of monetary easing, we can interpret this effect only with respect to accommodative monetary policy. Whether the impact of a monetary policy tightening would also be stronger for less-capitalized banks can reasonably be studied only with a longer sample including more significant periods of monetary policy tightening.

In the fourth and final test, we control for annual growth in residential property prices. As discussed in the introduction, low interest rates may affect risk weights through their impact on asset prices and collateral value, which, in turn, may reduce risk perceptions and estimates of risk parameters. Residential property price growth serves as a proxy trying to capture this effect. In this case, too, the main conclusions were confirmed – introducing the additional control variable did not change the baseline results. Even though the coefficient on residential property price growth is of the expected sign (negative, indicating that a higher collateral value reduces risk weights), it is not statistically significant (see Table A14 in the Appendix).

Table 6: Robustness Analysis for the Czech Republic – Less vs Better-Capitalized Banks

(a) Banks using the IRB approach for at least some part of their exposures

MP proxy:	(1) 3-month Pribor†	(2) Shadow rate	(3) MCI	(4) RMCI
Less-capitalized (1st quartile)	1.656***	1.256***	1.652***	-6.745***
	(0.276)	(0.249)	(0.231)	(2.218)
Better-capitalized (2nd–4th quartile)	-0.277	0.061	-0.015	-2.627**
	(0.260)	(0.132)	(0.182)	(1.314)
Observations	310	310	310	310

(b) Banks mainly using the A-IRB approach

MP proxy:	(1) 3-month Pribor†	(2) Shadow rate	(3) MCI	(4) RMCI
Less-capitalized (1st quartile)	1.071***	0.897***	1.036***	-4.046*
	(0.303)	(0.226)	(0.210)	(2.380)
Better-capitalized (2nd–4th quartile)	0.460	0.267**	0.501**	-2.083
	(0.319)	(0.131)	(0.200)	(1.320)
Observations	310	310	310	310

Note: Bootstrapped standard errors are reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. † In the regression with the 3M Pribor, we additionally control for the slope of the yield curve. For more details, see the note under Table 3.

Visegrad Four Countries. We perform the robustness analysis with respect to banks' capitalization for the V4 countries as well. The results remain in line with our initial expectation (see Table 7). The effect of monetary policy on risk weights is considerably stronger for less-capitalized banks irrespective of the model specification (i.e., the monetary policy proxy, controlling for asset structure and estimation techniques).

Table 7: Robustness Analysis for the Visegrad Four – Less vs Better-Capitalized Banks

(a) MP proxy: 3-month interbank rate

Estimation method:	Corrected LSDV		System-GMM	
	(1a)	(1b)	(2a)	(2b)
Less-capitalized (1st quartile)	1.457***	1.514**	1.357***	3.198***
	(0.382)	(0.726)	(0.245)	(0.967)
Better-capitalized (2nd–4th quartile)	0.567	0.474	0.562**	1.525***
	(0.387)	(0.692)	(0.252)	(0.552)
Observations	496	301	507	308

(b) MP proxy: 3-month interbank rate or shadow rate

Estimation method:	Corrected LSDV		System-GMM	
	(1a)	(1b)	(2a)	(2b)
Less-capitalized (1st quartile)	1.243***	1.443**	1.125***	2.935***
	(0.315)	(0.665)	(0.226)	(0.828)
Better-capitalized (2nd–4th quartile)	0.381	0.382	0.351*	1.139***
	(0.263)	(0.493)	(0.186)	(0.380)
Observations	496	310	507	319

Note: Standard errors are reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. Columns (1b) and (2b) – we control additionally for banks' asset structure. For more details, see the note under Table 5.

6. Conclusions

This paper studies the extent to which monetary policy may affect banks' perception of credit risk and the way banks measure risk. Specifically, we analyze the effect of changes in different monetary policy indicators on the implicit risk weights of credit exposures, with an emphasis on banks using the internal ratings-based approach. We draw on two panel data sets covering quarterly data for 20 banks in the Czech Republic and annual data for 58 banks in the Visegrad Four countries in the period 2003–2016.

Using four monetary policy indicators and different model specifications, we present robust evidence of the risk-taking channel in the Czech Republic. Specifically, we find a strong, statistically significant relationship between monetary policy easing and lower implicit risk weights of IRB banks, after controlling for banks' asset composition, a wide range of other bank-specific variables, the business cycle, and regulatory pressures. The effect is even stronger for banks mainly using the Advanced IRB approach, i.e., banks that are permitted to estimate not only their own value of PD, but also LGD and EAD. Further, the prolonged period of accommodative monetary conditions seems to have been instrumental in establishing the risk-taking channel in the Czech Republic – the relationship between monetary policy indicators and risk weights is statistically significant if we include this period and statistically insignificant if we exclude it. Additionally, we obtain comparable results by extending the analysis to cover all the Visegrad Four countries, which further supports our main conclusions.

The presented findings add to the stream of literature stressing that the effect of monetary policy on financial stability is not neutral. A great advantage of the IRB approach is that it allows for higher sensitivity of the capital requirements to the risk structure of banks' assets. Nevertheless, the IRB approach may also have significant weaknesses, including its dependence on historical data and its complexity. Such dependence may allow monetary policy to manifest itself through the estimated risk parameters and, consequently, banks' risk weights. Therefore, it is important to regularly assess whether the evolution and current level of risk weights give rise to any risk of underestimating (and potentially also overestimating) the necessary level of capital. The prudential authority should pay special attention to prolonged periods of low interest rates accompanied by signs of increased risk-taking, including a combination of excessive credit growth and asset price growth and a decline in risk weights.

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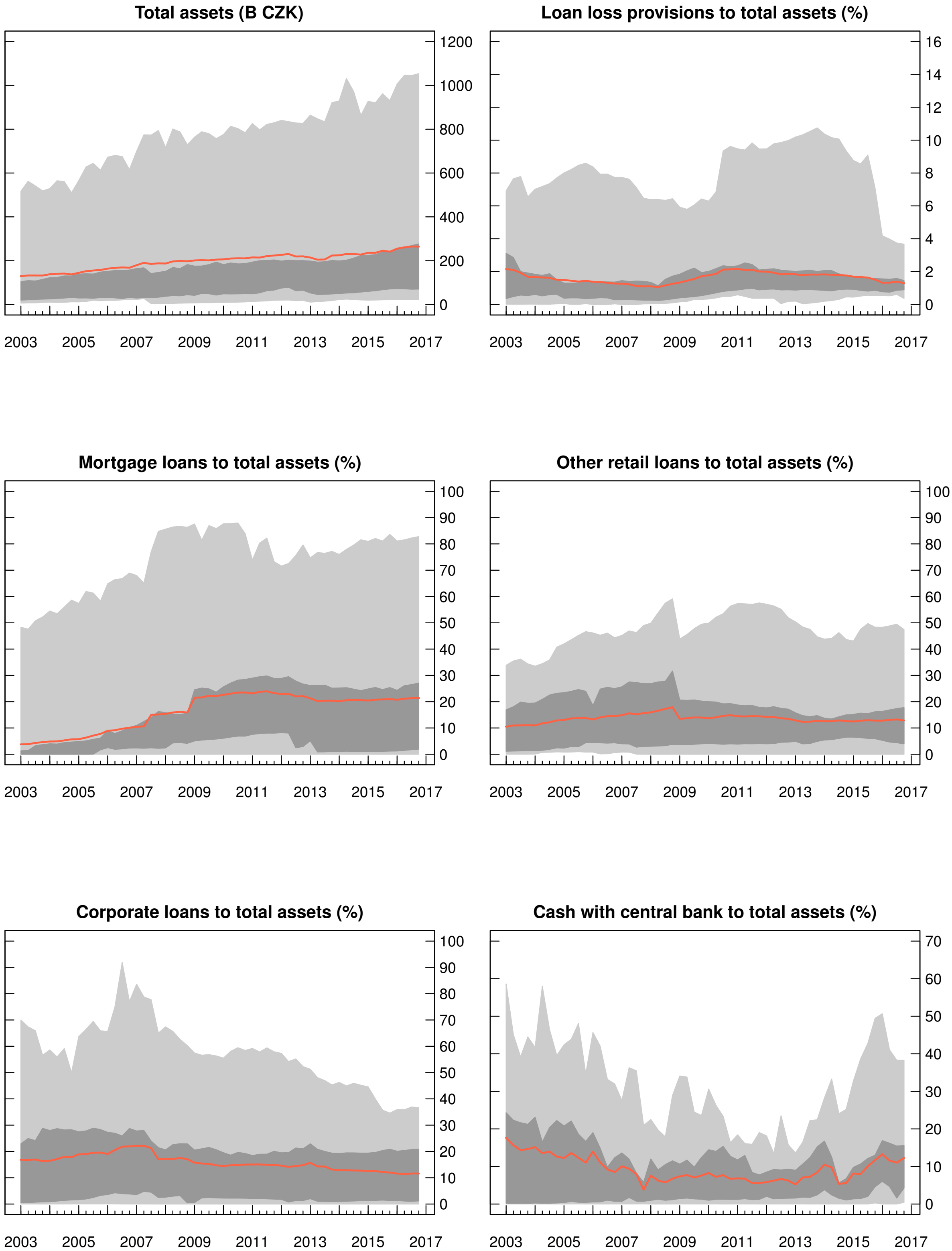
Appendix

Table A1: List of Banks

No.	Bank	Country	No.	Bank	Country
1	Air Bank	CZ	30	Raiffeisen Bank	HU
2	Ceska sporitelna	CZ	31	UniCredit Bank Hungary	HU
3	Ceskomoravska stav. sporitelna	CZ	32	Alior Bank	PL
4	CSOB	CZ	33	Bank BGZ BNP Paribas	PL
5	Equa bank	CZ	34	Bank BPH	PL
6	Expobank CZ	CZ	35	Bank Handlowy w Warszawie	PL
7	Fio banka	CZ	36	Bank Millennium	PL
8	Hypotecni banka	CZ	37	Bank Ochrony Srodowiska	PL
9	J&T Banka	CZ	38	Bank Pekao SA	PL
10	Komercni banka	CZ	39	Bank Polskiej Spoldzielczosci	PL
11	Modra pyramida stavebni sporitelna	CZ	40	Bank Zachodni WBK	PL
12	MONETA Money Bank	CZ	41	Euro Bank	PL
13	PPF banka	CZ	42	Getin Noble Bank	PL
14	Raiffeisen stav. sporitelna	CZ	43	Idea Bank	PL
15	Raiffeisenbank	CZ	44	ING Bank Slaski	PL
16	Sberbank CZ	CZ	45	mBank	PL
17	Stav. sporitelna CS	CZ	46	MBank Hipoteczny	PL
18	UniCredit Bank	CZ	47	Pekao Bank Hipoteczny	PL
19	Wüstenrot hypotecni banka	CZ	48	PKO Bank Hipoteczny	PL
20	Wüstenrot stav. sporitelna	CZ	49	PKO BP	PL
21	CIB Bank	HU	50	Raiffeisen Bank Polska	PL
22	EB und Hypo Bank Burgenland Sopron	HU	51	Santander Consumer Bank SA	PL
23	Erste Bank Hungary	HU	52	CSOB Stavebna Sporitelna	SK
24	FHB Mortgage Bank	HU	53	Prima banka Slovensko	SK
25	K&H Bank	HU	54	Privatbanka	SK
26	MKB Bank	HU	55	Sberbank Slovensko	SK
27	NHB Bank	HU	56	Slovenska sporitel'na	SK
28	OTP Bank	HU	57	Tatra Banka	SK
29	OTP Mortgage Bank	HU	58	Vseobecna Uverova Banka	SK

Figure A1: Bank-specific Variables – the Czech Republic



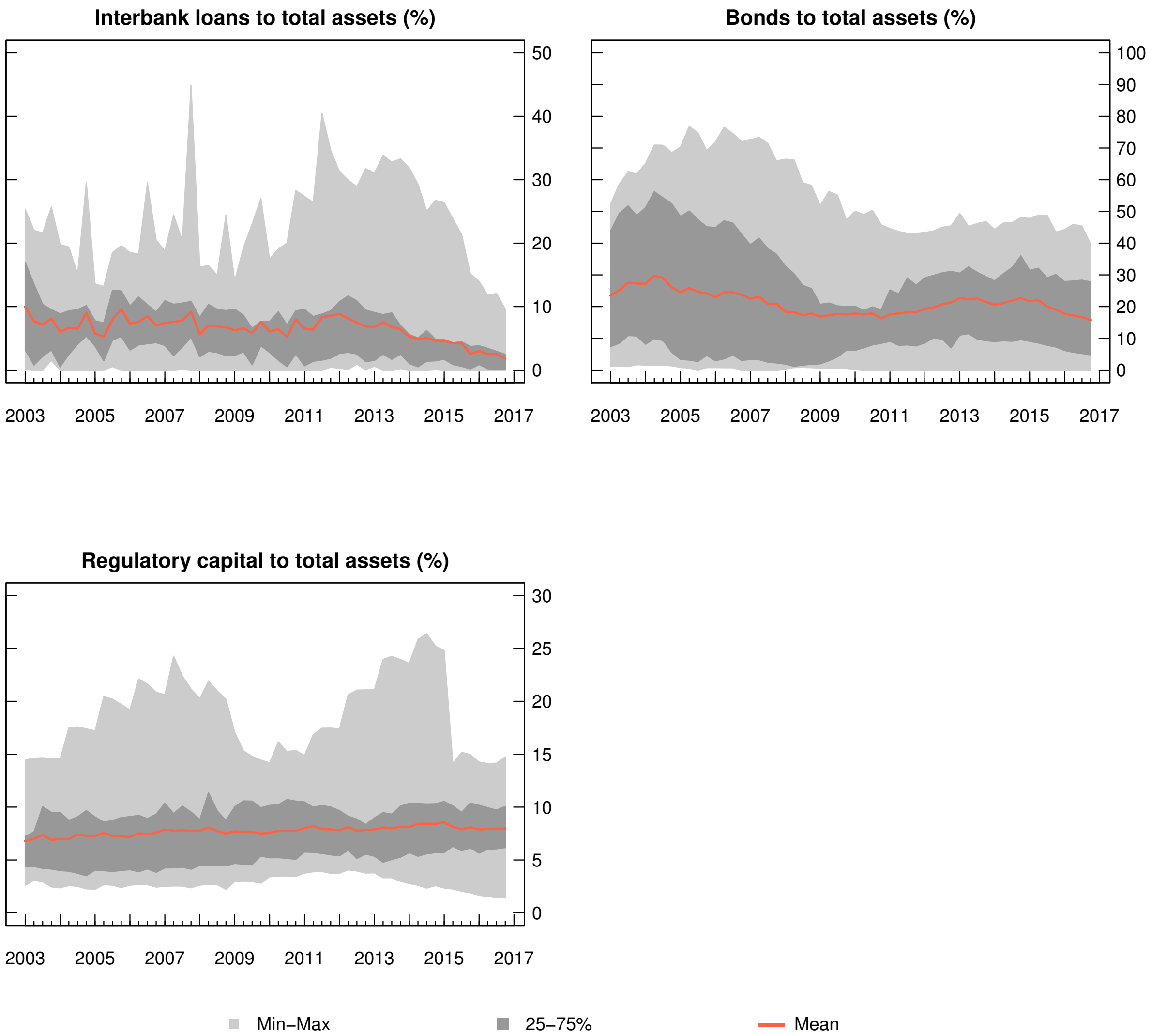

Interbank loans to total assets (%)
Bonds to total assets (%)
Regulatory capital to total assets (%)
2003
2005
2007
2009
2011
2013
2015
2017
Min−Max
25−75%
Mean

Figure A2: Bank-specific Variables – the Visegrad Four Countries

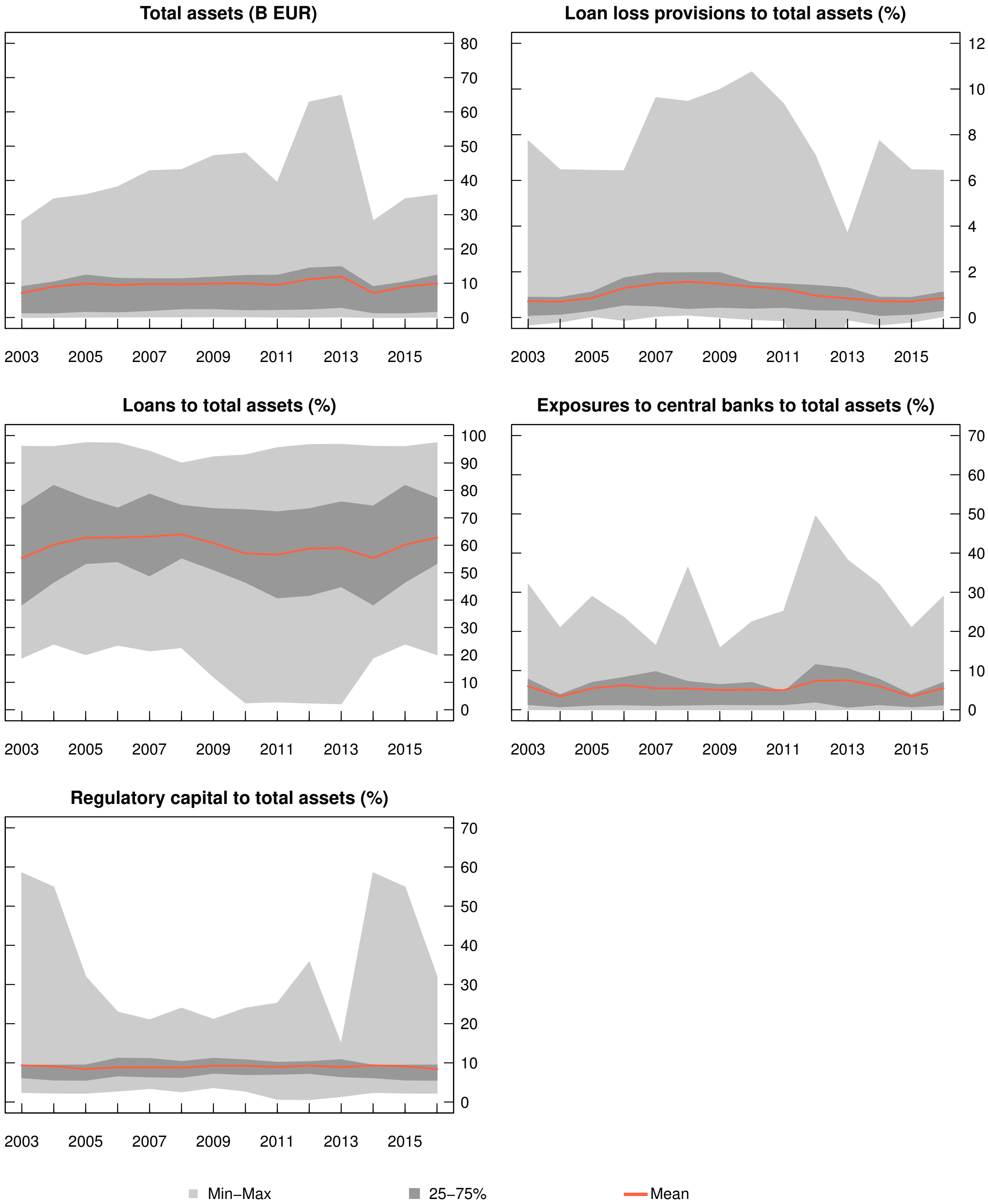


Table A2: Estimation Results for the Czech Republic (1)

	(1)	(2)	(3)	(4)	(5)	(6)
Banks:	All	IRB	A-IRB	All	IRB	A-IRB
Dependent variable Y (t)	RW	RW	RW IRB	RW	RW	RW IRB
Y (t-1)	0.954***	0.712***	0.810***	0.954***	0.714***	0.810***
	(0.015)	(0.048)	(0.046)	(0.015)	(0.047)	(0.041)
3-month Pribor	-0.047	0.696**	0.885***			
	(0.152)	(0.269)	(0.300)			
MCI				0.084	0.583***	0.721***
				(0.126)	(0.189)	(0.190)
Spread	0.421***	0.370*	0.399**			
	(0.149)	(0.193)	(0.176)			
Log(assets) (t-1)	0.206	4.786**	6.638***	0.068	4.761**	6.740***
	(0.470)	(1.986)	(1.955)	(0.447)	(1.974)	(1.877)
Loan loss provisions/assets (t-1)	-0.057	2.535***	0.822	0.031	2.445***	0.691
	(0.228)	(0.721)	(0.789)	(0.226)	(0.640)	(0.712)
Regulatory capital/assets (t-1)	-0.013	0.111	0.206	-0.049	0.092	0.205
	(0.094)	(0.194)	(0.205)	(0.093)	(0.191)	(0.207)
Mortgage loans/assets (t-1)	-0.005	-0.046	-0.072	0.005	-0.047	-0.081
	(0.025)	(0.067)	(0.055)	(0.025)	(0.065)	(0.050)
Other retail loans/assets (t-1)	-0.024	-0.029	-0.154***	-0.020	-0.029	-0.158***
	(0.027)	(0.074)	(0.058)	(0.027)	(0.073)	(0.057)
Corporate loans/assets (t-1)	0.017	0.158	0.076	0.016	0.156	0.073
	(0.020)	(0.102)	(0.091)	(0.020)	(0.101)	(0.086)
Cash with CB/assets (t-1)	0.079***	-0.022	0.037	0.084***	-0.016	0.053
	(0.023)	(0.052)	(0.042)	(0.023)	(0.051)	(0.041)
Interbank loans/assets (t-1)	0.039	0.044	0.019	0.050*	0.049	0.019
	(0.030)	(0.065)	(0.062)	(0.030)	(0.064)	(0.057)
Bonds/assets (t-1)	-0.021	-0.097	0.002	-0.010	-0.092	0.001
	(0.022)	(0.060)	(0.059)	(0.022)	(0.059)	(0.052)
Real GDP growth	0.046	0.013	0.033	-0.027	-0.030	-0.014
	(0.048)	(0.070)	(0.058)	(0.043)	(0.060)	(0.051)
Regulatory pressures	1.989***	3.648***	2.315**	1.901***	3.814***	2.679***
	(0.437)	(1.264)	(1.050)	(0.441)	(1.207)	(1.005)
VIX	-0.026	0.022	0.005	-0.034**	0.031*	0.015
	(0.017)	(0.020)	(0.018)	(0.017)	(0.019)	(0.017)
Observations	963	310	204	963	310	204

Note: Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; RW IRB – implicit risk weights calculated as risk-weighted exposures under the IRB approach divided by non-risk-weighted exposures under the IRB approach. IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; A-IRB banks – banks with at least 75% of their risk-weighted exposures calculated under the A-IRB approach as of 2016 Q4.

Table A3: Estimation Results for the Czech Republic (2)

	(7)	(8)	(9)	(10)	(11)	(12)
Banks:	All	IRB	A-IRB	All	IRB	A-IRB
Dependent variable Y (t)	RW	RW	RW IRB	RW	RW	RW IRB
Y (t-1)	0.954***	0.717***	0.832***	0.939***	0.724***	0.863***
	(0.015)	(0.048)	(0.042)	(0.017)	(0.046)	(0.040)
Shadow rate	0.074	0.307**	0.382***			
	(0.085)	(0.127)	(0.135)			
RMCI				-0.287	-3.469***	-2.451**
				(0.968)	(1.189)	(1.223)
Log(assets) (t-1)	0.123	4.343**	6.180***	-0.190	4.094**	4.295**
	(0.460)	(1.977)	(1.845)	(0.484)	(1.795)	(1.658)
Loan loss provisions/assets (t-1)	0.034	2.288***	0.456	0.011	2.222***	0.086
	(0.224)	(0.633)	(0.713)	(0.261)	(0.631)	(0.687)
Regulatory capital/assets (t-1)	-0.043	0.039	0.194	0.005	-0.012	0.191
	(0.093)	(0.194)	(0.196)	(0.093)	(0.183)	(0.180)
Mortgage loans/assets (t-1)	0.004	-0.046	-0.086	0.008	-0.039	-0.062
	(0.025)	(0.067)	(0.058)	(0.027)	(0.066)	(0.057)
Other retail loans/assets (t-1)	-0.021	-0.026	-0.154**	-0.016	-0.026	-0.109*
	(0.027)	(0.076)	(0.062)	(0.029)	(0.074)	(0.063)
Corporate loans/assets (t-1)	0.015	0.155	0.070	0.018	0.151	0.031
	(0.020)	(0.102)	(0.085)	(0.022)	(0.100)	(0.088)
Cash with CB/assets (t-1)	0.082***	-0.013	0.057	0.109***	-0.012	0.048
	(0.023)	(0.051)	(0.042)	(0.026)	(0.051)	(0.046)
Interbank loans/assets (t-1)	0.047	0.041	0.004	0.069**	0.045	0.044
	(0.030)	(0.066)	(0.060)	(0.034)	(0.065)	(0.062)
Bonds/assets (t-1)	-0.012	-0.091	-0.014	0.007	-0.076	0.000
	(0.022)	(0.060)	(0.059)	(0.025)	(0.058)	(0.060)
Real GDP growth	-0.030	-0.017	-0.011	-0.024	0.037	0.028
	(0.042)	(0.059)	(0.051)	(0.046)	(0.058)	(0.051)
Regulatory pressures	1.881***	3.857***	2.450**	2.183***	3.698***	2.725**
	(0.440)	(1.246)	(1.055)	(0.442)	(1.271)	(1.074)
VIX	-0.037**	0.032*	0.012	-0.020	0.047**	0.029
	(0.017)	(0.019)	(0.018)	(0.016)	(0.018)	(0.018)
Observations	963	310	204	899	310	204

Note: Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; RW IRB – implicit risk weights calculated as risk-weighted exposures under the IRB approach divided by non-risk-weighted exposures under the IRB approach. IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; A-IRB banks – banks with at least 75% of their risk-weighted exposures calculated under the A-IRB approach as of 2016 Q4.

Table A4: Estimation Results for the Czech Republic (3)

End of the sample:	(13) 2012 Q4	(14) 2013 Q4	(15) 2014 Q4	(16) 2015 Q4	(17) 2016 Q4
RW (t-1)	0.415***	0.468***	0.531***	0.593***	0.712***
	(0.071)	(0.062)	(0.058)	(0.053)	(0.048)
3-month Pribor	0.448	1.137***	1.177***	1.026***	0.696**
	(0.415)	(0.409)	(0.354)	(0.311)	(0.269)
Spread	0.837***	1.008***	0.817***	0.560**	0.370*
	(0.291)	(0.280)	(0.254)	(0.220)	(0.193)
Log(assets) (t-1)	4.347	7.176**	8.735***	6.378**	4.786**
	(3.300)	(3.450)	(3.167)	(2.507)	(1.986)
Loan loss provisions/assets (t-1)	-0.198	0.529	1.586*	2.407***	2.535***
	(0.952)	(0.996)	(0.925)	(0.840)	(0.721)
Regulatory capital/assets (t-1)	-0.640**	-0.427	-0.447*	-0.392*	0.111
	(0.263)	(0.280)	(0.262)	(0.232)	(0.194)
Mortgage loans/assets (t-1)	0.056	0.144	0.019	0.067	-0.046
	(0.161)	(0.156)	(0.099)	(0.083)	(0.067)
Other retail loans/assets (t-1)	0.023	0.110	-0.016	0.047	-0.029
	(0.170)	(0.164)	(0.106)	(0.086)	(0.074)
Corporate loans/assets (t-1)	0.710**	0.478	0.261*	0.161	0.158
	(0.340)	(0.320)	(0.155)	(0.113)	(0.102)
Cash with CB/assets (t-1)	-0.016	0.023	-0.097	-0.081	-0.022
	(0.117)	(0.120)	(0.076)	(0.057)	(0.052)
Interbank loans/assets (t-1)	0.306**	0.370**	0.235**	0.241***	0.044
	(0.149)	(0.149)	(0.101)	(0.093)	(0.065)
Bonds/assets (t-1)	0.032	0.100	-0.010	0.020	-0.097
	(0.142)	(0.140)	(0.090)	(0.080)	(0.060)
Real GDP growth	0.229***	0.141*	0.122	0.104	0.013
	(0.071)	(0.074)	(0.075)	(0.080)	(0.070)
Regulatory pressures	3.637***	4.500***	3.925***	3.937***	3.648***
	(1.260)	(1.513)	(1.429)	(1.298)	(1.264)
VIX	0.015	0.007	0.016	0.031	0.022
	(0.022)	(0.022)	(0.022)	(0.021)	(0.012)
Observations	166	202	238	274	310

Note: The table presents the estimation results for the group of IRB banks with implicit risk weights (RW) as the dependent variable; RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4. Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels.

Table A5: Estimation Results for the Czech Republic (4)

End of the sample:	(18) 2012 Q4	(19) 2013 Q4	(20) 2014 Q4	(21) 2015 Q4	(22) 2016 Q4
RW (t-1)	0.416***	0.473***	0.541***	0.599***	0.714***
	(0.075)	(0.064)	(0.057)	(0.052)	(0.047)
MCI	0.589	1.064***	0.890***	0.799***	0.583***
	(0.372)	(0.308)	(0.237)	(0.217)	(0.189)
Log(assets) (t-1)	4.402	7.093**	8.789***	6.239**	4.761**
	(3.041)	(3.505)	(3.207)	(2.495)	(1.974)
Loan loss provisions/assets (t-1)	0.509	0.755	1.318*	2.152***	2.445***
	(0.872)	(0.878)	(0.783)	(0.735)	(0.640)
Regulatory capital/assets (t-1)	-0.681***	-0.470*	-0.475*	-0.414*	0.092
	(0.250)	(0.275)	(0.262)	(0.233)	(0.191)
Mortgage loans/assets (t-1)	0.066	0.147	0.021	0.066	-0.047
	(0.165)	(0.152)	(0.097)	(0.082)	(0.065)
Other retail loans/assets (t-1)	0.010	0.099	-0.016	0.051	-0.029
	(0.173)	(0.160)	(0.104)	(0.086)	(0.073)
Corporate loans/assets (t-1)	0.699**	0.475	0.269*	0.160	0.156
	(0.349)	(0.321)	(0.156)	(0.113)	(0.101)
Cash with CB/assets (t-1)	-0.024	0.020	-0.067	-0.060	-0.016
	(0.123)	(0.119)	(0.074)	(0.056)	(0.051)
Interbank loans/assets (t-1)	0.308**	0.368**	0.235**	0.244***	0.0489
	(0.153)	(0.146)	(0.101)	(0.092)	(0.064)
Bonds/assets (t-1)	0.034	0.102	-0.001	0.026	-0.092
	(0.146)	(0.138)	(0.089)	(0.079)	(0.059)
Real GDP growth	0.107	0.027	0.050	0.037	-0.030
	(0.075)	(0.073)	(0.068)	(0.064)	(0.060)
Regulatory pressures	3.163**	4.272***	4.139***	4.241***	3.814***
	(1.401)	(1.515)	(1.421)	(1.261)	(1.207)
VIX	0.027	0.032	0.038*	0.044**	0.031*
	(0.021)	(0.020)	(0.021)	(0.020)	(0.019)
Observations	166	202	238	274	310

Note: The table presents the estimation results for the group of IRB banks with implicit risk weights (RW) as the dependent variable; RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4. Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels.

Table A6: Estimation Results for the Czech Republic (5)

End of the sample:	(23) 2012 Q4	(24) 2013 Q4	(25) 2014 Q4	(26) 2015 Q4	(27) 2016 Q4
RW (t-1)	0.400***	0.471***	0.537***	0.598***	0.717***
	(0.076)	(0.066)	(0.059)	(0.052)	(0.048)
Shadow rate	-0.027	0.558**	0.634***	0.531***	0.307**
	(0.298)	(0.278)	(0.208)	(0.166)	(0.127)
Log(assets) (t-1)	3.276	6.261*	8.021**	5.769**	4.343**
	(3.074)	(3.430)	(3.149)	(2.458)	(1.977)
Loan loss provisions/assets (t-1)	0.082	0.650	1.478*	2.176***	2.288***
	(0.939)	(0.949)	(0.831)	(0.752)	(0.633)
Regulatory capital/assets (t-1)	-0.799***	-0.567**	-0.536**	-0.465**	0.039
	(0.265)	(0.277)	(0.261)	(0.233)	(0.194)
Mortgage loans/assets (t-1)	0.015	0.130	0.021	0.066	-0.046
	(0.170)	(0.157)	(0.097)	(0.082)	(0.067)
Other retail loans/assets (t-1)	-0.032	0.082	-0.021	0.047	-0.026
	(0.178)	(0.165)	(0.105)	(0.086)	(0.076)
Corporate loans/assets (t-1)	0.777**	0.510	0.262*	0.156	0.155
	(0.357)	(0.328)	(0.157)	(0.113)	(0.102)
Cash with CB/assets (t-1)	-0.022	0.038	-0.074	-0.063	-0.013
	(0.132)	(0.125)	(0.076)	(0.057)	(0.051)
Interbank loans/assets (t-1)	0.265*	0.343**	0.226**	0.235**	0.041
	(0.157)	(0.149)	(0.100)	(0.092)	(0.066)
Bonds/assets (t-1)	0.002	0.094	-0.002	0.025	-0.091
	(0.153)	(0.143)	(0.090)	(0.080)	(0.060)
Real GDP growth	0.195**	0.087	0.063	0.059	-0.017
	(0.076)	(0.076)	(0.069)	(0.063)	(0.059)
Regulatory pressures	3.319**	4.256***	3.934***	4.114***	3.857***
	(1.531)	(1.630)	(1.478)	(1.304)	(1.246)
VIX	0.031	0.026	0.031	0.041**	0.032*
	(0.023)	(0.022)	(0.022)	(0.021)	(0.019)
Observations	166	202	238	274	310

Note: The table presents the estimation results for the group of IRB banks with implicit risk weights (RW) as the dependent variable; RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4. Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels.

Table A7: Estimation Results for the Czech Republic (6)

	(28)	(29)	(30)	(31)	(32)
End of the sample:	2012 Q4	2013 Q4	2014 Q4	2015 Q4	2016 Q4
RW (t-1)	0.393***	0.472***	0.553***	0.612***	0.724***
	(0.075)	(0.066)	(0.058)	(0.050)	(0.046)
RMCI	1.002	-1.072	-3.991**	-4.674***	-3.469***
	(1.735)	(1.819)	(1.789)	(1.464)	(1.189)
Log(assets) (t-1)	3.188	5.510	6.654**	4.876**	4.094**
	(3.061)	(3.339)	(2.828)	(2.162)	(1.795)
Loan loss provisions/assets (t-1)	-0.052	0.048	1.090	1.969***	2.222***
	(0.931)	(0.914)	(0.820)	(0.719)	(0.631)
Regulatory capital/assets (t-1)	-0.808***	-0.664**	-0.655***	-0.569**	-0.012
	(0.265)	(0.273)	(0.251)	(0.223)	(0.183)
Mortgage loans/assets (t-1)	0.019	0.097	0.034	0.081	-0.039
	(0.169)	(0.167)	(0.099)	(0.081)	(0.066)
Other retail loans/assets (t-1)	-0.022	0.063	-0.004	0.058	-0.026
	(0.177)	(0.175)	(0.105)	(0.085)	(0.074)
Corporate loans/assets (t-1)	0.803**	0.570*	0.275*	0.147	0.151
	(0.357)	(0.337)	(0.158)	(0.112)	(0.100)
Cash with CB/assets (t-1)	-0.014	0.055	-0.053	-0.053	-0.012
	(0.132)	(0.135)	(0.080)	(0.058)	(0.051)
Interbank loans/assets (t-1)	0.268*	0.306*	0.230**	0.243***	0.045
	(0.155)	(0.156)	(0.100)	(0.090)	(0.065)
Bonds/assets (t-1)	0.001	0.077	0.024	0.051	-0.076
	(0.153)	(0.153)	(0.092)	(0.079)	(0.058)
Real GDP growth	0.192***	0.186***	0.153**	0.128**	0.037
	(0.064)	(0.067)	(0.065)	(0.064)	(0.058)
Regulatory pressures	3.424**	4.624**	4.042**	4.016***	3.698***
	(1.546)	(1.850)	(1.614)	(1.377)	(1.271)
VIX	0.030	0.049**	0.064***	0.067***	0.047**
	(0.021)	(0.021)	(0.020)	(0.020)	(0.018)
Observations	166	202	238	274	310

Note: The table presents the estimation results for the group of IRB banks with implicit risk weights (RW) as the dependent variable; RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4. Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels.

Table A8: Estimation Results for the Czech Republic – Robustness wrt Asset Classes (1)

	(1)	(2)	(3)	(4)	(5)	(6)
Banks:	All	IRB	A-IRB	All	IRB	A-IRB
Dependent variable Y (t)	RW	RW	RW IRB	RW	RW	RW IRB
Y (t-1)	0.952***	0.711***	0.841***	0.955***	0.700***	0.835***
	(0.020)	(0.046)	(0.044)	(0.020)	(0.044)	(0.043)
3-month Pribor	0.015	0.472**	0.610**	-0.050	0.690***	0.773***
	(0.161)	(0.232)	(0.238)	(0.161)	(0.249)	(0.249)
Spread	0.508***	0.365**	0.342**	0.481***	0.316*	0.320*
	(0.155)	(0.180)	(0.167)	(0.154)	(0.185)	(0.181)
Log(assets) (t-1)	-0.141	2.544*	4.609***	-0.246	2.244	4.657**
	(0.452)	(1.339)	(1.552)	(0.459)	(1.380)	(1.805)
Loan loss provisions/assets (t-1)	-0.047	2.781***	0.742	-0.053	2.620***	0.988
	(0.243)	(0.655)	(0.697)	(0.241)	(0.663)	(0.761)
Regulatory capital/assets (t-1)	-0.020	-0.027	0.439**	-0.016	-0.054	0.357*
	(0.088)	(0.170)	(0.191)	(0.089)	(0.175)	(0.201)
Real GDP growth	0.086*	-0.021	0.015	0.092*	-0.005	0.005
	(0.049)	(0.066)	(0.056)	(0.049)	(0.067)	(0.059)
Regulatory pressures	1.792***	4.551***	3.182***	1.810***	4.770***	3.146***
	(0.421)	(1.200)	(0.972)	(0.423)	(1.178)	(0.927)
VIX	-0.030*	0.028	-0.005	-0.030*	0.030	0.001
	(0.017)	(0.019)	(0.018)	(0.017)	(0.019)	(0.019)
Mortgage loans, % change (t-1)				0.016***	-0.049***	-0.032*
				(0.005)	(0.018)	(0.018)
Other retail loans, % change (t-1)				-0.006	-0.094**	-0.048
				(0.006)	(0.038)	(0.035)
Corporate loans, % change (t-1)				-0.004	-0.001	-0.003
				(0.004)	(0.005)	(0.004)
Cash with CB, % change (t-1)				0.001	-0.001	-0.003**
				(0.001)	(0.002)	(0.002)
Interbank loans, % change (t-1)				0.000345	-0.000766	-0.00164
				(0.001)	(0.001)	(0.001)
Bonds, % change (t-1)				0.002	0.018	-0.028**
				(0.004)	(0.015)	(0.013)
Observations	963	310	204	963	310	204

Note: Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; RW IRB – implicit risk weights calculated as risk-weighted exposures under the IRB approach divided by non-risk-weighted exposures under the IRB approach. IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; A-IRB banks – banks with at least 75% of their risk-weighted exposures calculated under the A-IRB approach as of 2016 Q4.

Table A9: Estimation Results for the Czech Republic – Robustness wrt Asset Classes (2)

	(1)	(2)	(3)	(4)	(5)	(6)
Banks:	All	IRB	A-IRB	All	IRB	A-IRB
Dependent variable Y (t)	RW	RW	RW IRB	RW	RW	RW IRB
Y (t-1)	0.951***	0.711***	0.839***	0.953***	0.701***	0.837***
	(0.021)	(0.046)	(0.042)	(0.021)	(0.044)	(0.042)
MCI	0.143	0.453***	0.530***	0.096	0.551***	0.603***
	(0.136)	(0.169)	(0.178)	(0.136)	(0.174)	(0.189)
Log(assets) (t-1)	-0.252	2.588*	4.643***	-0.314	2.139	4.600***
	(0.409)	(1.318)	(1.497)	(0.429)	(1.363)	(1.752)
Loan loss provisions/assets (t-1)	0.070	2.862***	0.681	0.050	2.485***	0.778
	(0.242)	(0.578)	(0.638)	(0.239)	(0.591)	(0.723)
Regulatory capital/assets (t-1)	-0.065	-0.041	0.430**	-0.050	-0.077	0.340*
	(0.082)	(0.167)	(0.191)	(0.087)	(0.173)	(0.202)
Real GDP growth	0.006	-0.071	-0.025	0.010	-0.036	-0.024
	(0.043)	(0.057)	(0.051)	(0.043)	(0.058)	(0.055)
Regulatory pressures	1.690***	4.526***	3.333***	1.683***	4.971***	3.416***
	(0.416)	(1.148)	(0.920)	(0.426)	(1.122)	(0.869)
VIX	-0.038**	0.034*	0.003	-0.041**	0.037**	0.010
	(0.015)	(0.018)	(0.017)	(0.017)	(0.019)	(0.018)
Mortgage loans, % change (t-1)				0.016***	-0.047***	-0.028
				(0.005)	(0.017)	(0.017)
Other retail loans, % change (t-1)				-0.005	-0.092**	-0.044
				(0.006)	(0.036)	(0.033)
Corporate loans, % change (t-1)				-0.003	-0.001	-0.004
				(0.004)	(0.005)	(0.004)
Cash with CB, % change (t-1)				0.002	-0.001	-0.003**
				(0.001)	(0.002)	(0.002)
Interbank loans, % change (t-1)				0.000	-0.001	-0.002
				(0.001)	(0.001)	(0.001)
Bonds, % change (t-1)				0.003	0.017	-0.027**
				(0.004)	(0.015)	(0.013)
Observations	963	310	204	963	310	204

Note: Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; RW IRB – implicit risk weights calculated as risk-weighted exposures under the IRB approach divided by non-risk-weighted exposures under the IRB approach. IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; A-IRB banks – banks with at least 75% of their risk-weighted exposures calculated under the A-IRB approach as of 2016 Q4.

Table A10: Estimation Results for the Czech Republic – Robustness wrt Asset Classes (3)

	(1)	(2)	(3)	(4)	(5)	(6)
Banks:	All	IRB	A-IRB	All	IRB	A-IRB
Dependent variable Y (t)	RW	RW	RW IRB	RW	RW	RW IRB
Y (t-1)	0.952***	0.713***	0.858**	0.953***	0.704***	0.856***
	(0.022)	(0.046)	(0.043)	(0.021)	(0.044)	(0.042)
Shadow rate	0.108	0.236**	0.268**	0.079	0.282**	0.316***
	(0.094)	(0.107)	(0.112)	(0.090)	(0.110)	(0.119)
Log(assets) (t-1)	-0.189	2.234*	4.151***	-0.263	1.760	4.125**
	(0.428)	(1.283)	(1.482)	(0.443)	(1.340)	(1.800)
Loan loss provisions/assets (t-1)	0.070	2.698***	0.445	0.052	2.314***	0.534
	(0.241)	(0.558)	(0.619)	(0.236)	(0.576)	(0.719)
Regulatory capital/assets (t-1)	-0.056	-0.079	0.381**	-0.044	-0.119	0.303
	(0.083)	(0.169)	(0.188)	(0.088)	(0.174)	(0.199)
Real GDP growth	0.002	-0.058	-0.019	0.006	-0.025	-0.019
	(0.043)	(0.056)	(0.049)	(0.043)	(0.058)	(0.054)
Regulatory pressures	1.676***	4.538***	3.208***	1.666***	4.943***	3.258***
	(0.416)	(1.175)	(0.950)	(0.426)	(1.158)	(0.902)
VIX	-0.040***	0.035*	0.005	-0.044***	0.034**	0.010
	(0.016)	(0.018)	(0.018)	(0.017)	(0.019)	(0.018)
Mortgage loans, % change (t-1)				0.016***	-0.044***	-0.025
				(0.005)	(0.016)	(0.017)
Other retail loans, % change (t-1)				-0.0054	-0.084**	-0.035
				(0.006)	(0.040)	(0.033)
Corporate loans, % change (t-1)				-0.003	-0.001	-0.003
				(0.004)	(0.005)	(0.004)
Cash with CB, % change (t-1)				0.002	-0.001	-0.003**
				(0.001)	(0.002)	(0.002)
Interbank loans, % change (t-1)				0.000	-0.001	-0.002
				(0.001)	(0.001)	(0.001)
Bonds, % change (t-1)				0.003	0.016	-0.030**
				(0.004)	(0.015)	(0.013)
Observations	963	310	204	963	310	204

Note: Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; RW IRB – implicit risk weights calculated as risk-weighted exposures under the IRB approach divided by non-risk-weighted exposures under the IRB approach. IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; A-IRB banks – banks with at least 75% of their risk-weighted exposures calculated under the A-IRB approach as of 2016 Q4.

Table A11: Estimation Results for the Czech Republic – Robustness wrt Asset Classes (4)

	(1)	(2)	(3)	(4)	(5)	(6)
Banks:	All	IRB	A-IRB	All	IRB	A-IRB
Dependent variable Y (t)	RW	RW	RW IRB	RW	RW	RW IRB
Y (t-1)	0.930***	0.720***	0.879***	0.933***	0.712***	0.874***
	(0.022)	(0.045)	(0.043)	(0.022)	(0.043)	(0.040)
RMCI	-0.774	-3.051***	-2.206**	-0.626	-3.808***	-2.521**
	(0.961)	(1.059)	(1.023)	(0.965)	(1.098)	(1.065)
Log(assets) (t-1)	-0.510	2.283*	3.362**	-0.496	1.827	3.265**
	(0.493)	(1.192)	(1.343)	(0.506)	(1.239)	(1.601)
Loan loss provisions/assets (t-1)	0.098	2.681***	0.225	0.137	2.272***	0.311
	(0.265)	(0.563)	(0.633)	(0.264)	(0.577)	(0.715)
Regulatory capital/assets (t-1)	-0.021	-0.083	0.345*	-0.003	-0.120	0.269
	(0.091)	(0.161)	(0.185)	(0.091)	(0.167)	(0.194)
Real GDP growth	0.021	-0.012	0.011	0.026	0.036	0.013
	(0.046)	(0.056)	(0.049)	(0.047)	(0.059)	(0.054)
Regulatory pressures	2.056***	4.331***	3.178***	1.963***	4.704***	3.236***
	(0.422)	(1.192)	(0.973)	(0.427)	(1.181)	(0.926)
VIX	-0.027*	0.045***	0.019	-0.030*	0.051***	0.027
	(0.016)	(0.017)	(0.017)	(0.016)	(0.018)	(0.018)
Mortgage loans, % change (t-1)				0.016***	-0.046***	-0.022
				(0.005)	(0.016)	(0.017)
Other retail loans, % change (t-1)				-0.005	-0.089**	-0.030
				(0.006)	(0.035)	(0.033)
Corporate loans, % change (t-1)				-0.003	0.000	-0.002
				(0.004)	(0.005)	(0.004)
Cash with CB, % change (t-1)				0.001	-0.001	-0.003**
				(0.001)	(0.001)	(0.001)
Interbank loans, % change (t-1)				0.001	-0.001	-0.001
				(0.001)	(0.001)	(0.001)
Bonds, % change (t-1)				0.004	0.0174	-0.028**
				(0.004)	(0.015)	(0.013)
Observations	899	310	204	899	310	204

Note: Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; RW IRB – implicit risk weights calculated as risk-weighted exposures under the IRB approach divided by non-risk-weighted exposures under the IRB approach. IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; A-IRB banks – banks with at least 75% of their risk-weighted exposures calculated under the A-IRB approach as of 2016 Q4.

Table A12: Estimation Results for the Czech Republic – Robustness wrt Banks' Capitalization (1)

	(1)	(2)	(3)	(4)
Banks:	IRB	IRB	A-IRB	A-IRB
Dependent variable Y (t)	RW	RW	RW IRB	RW IRB
Y (t-1)	0.615***	0.615***	0.804***	0.795***
	(0.043)	(0.043)	(0.047)	(0.041)
3-month Pribor*dCAR25	1.656***		1.071***	
	(0.276)		(0.303)	
3-month Pribor*(1-dCAR25)	-0.277		0.460	
	(0.260)		(0.319)	
MCI*dCAR25		1.652***		1.036***
		(0.231)		(0.210)
MCI*(1-dCAR25)		-0.0150		0.501**
		(0.182)		(0.200)
Spread	0.469**		0.423**	
	(0.185)		(0.174)	
Log(assets) (t-1)	1.632	1.726	5.699***	5.938***
	(1.824)	(1.813)	(1.869)	(1.770)
Loan loss provisions/assets (t-1)	2.628***	2.789***	0.450	0.576
	(0.618)	(0.557)	(0.757)	(0.683)
Regulatory capital/assets (t-1)	0.578***	0.577***	0.448**	0.438**
	(0.195)	(0.194)	(0.212)	(0.214)
Mortgage loans/assets (t-1)	-0.017	-0.001	-0.084	-0.080
	(0.064)	(0.064)	(0.056)	(0.051)
Other retail loans/assets (t-1)	-0.055	-0.035	-0.176***	-0.173***
	(0.0709)	(0.0710)	(0.0576)	(0.0560)
Corporate loans/assets (t-1)	0.073	0.084	0.061	0.059
	(0.096)	(0.095)	(0.091)	(0.086)
Cash with CB/assets (t-1)	-0.022	-0.028	0.043	0.050
	(0.049)	(0.049)	(0.043)	(0.041)
Interbank loans/assets (t-1)	0.005	0.055	-0.004	0.014
	(0.061)	(0.061)	(0.062)	(0.056)
Bonds/assets (t-1)	-0.047	-0.043	-0.015	-0.002
	(0.057)	(0.057)	(0.060)	(0.053)
Real GDP growth	-0.009	-0.082	0.011	-0.042
	(0.066)	(0.058)	(0.058)	(0.051)
Regulatory pressures	1.808	2.213*	1.377	1.841*
	(1.297)	(1.302)	(1.128)	(1.077)
VIX	0.029	0.032*	0.011	0.017
	(0.019)	(0.019)	(0.018)	(0.017)
Observations	310	310	204	204

Note: Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; RW IRB – implicit risk weights calculated as risk-weighted exposures under the IRB approach divided by non-risk-weighted exposures under the IRB approach. IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; A-IRB banks – banks with at least 75% of their risk-weighted exposures calculated under the A-IRB approach as of 2016 Q4.

Table A13: Estimation Results for the Czech Republic – Robustness wrt Banks' Capitalization (2)

	(1)	(2)	(3)	(4)
Banks:	IRB	IRB	A-IRB	A-IRB
Dependent variable Y (t)	RW	RW	RW IRB	RW IRB
Y (t-1)	0.670***	0.718***	0.813***	0.862***
	(0.049)	(0.048)	(0.042)	(0.043)
Shadow rate*dCAR25	1.256***		0.897***	
	(0.249)		(0.226)	
Shadow rate*(1-dCAR25)	0.0610		0.267**	
	(0.132)		(0.131)	
RMCI*dCAR25		-6.745***		-4.046*
		(2.218)		(2.380)
RMCI*(1-dCAR25)		-2.627**		-2.083
		(1.314)		(1.320)
Log(assets) (t-1)	2.070	3.374*	5.503***	4.181**
	(1.906)	(1.807)	(1.749)	(1.659)
Loan loss provisions/assets (t-1)	3.030***	2.389***	0.396	-0.010
	(0.636)	(0.659)	(0.662)	(0.738)
Regulatory capital/assets (t-1)	0.186	-0.024	0.363*	0.224
	(0.199)	(0.184)	(0.205)	(0.193)
Mortgage loans/assets (t-1)	0.003	-0.021	-0.063	-0.049
	(0.067)	(0.066)	(0.053)	(0.061)
Other retail loans/assets (t-1)	-0.014	-0.018	-0.159***	-0.103*
	(0.075)	(0.074)	(0.059)	(0.062)
Corporate loans/assets (t-1)	0.087	0.128	0.051	0.031
	(0.099)	(0.101)	(0.088)	(0.086)
Cash with CB/assets (t-1)	-0.022	-0.012	0.052	0.048
	(0.052)	(0.052)	(0.042)	(0.044)
Interbank loans/assets (t-1)	0.072	0.059	0.010	0.047
	(0.067)	(0.065)	(0.060)	(0.061)
Bonds/assets (t-1)	-0.040	-0.054	0.004	0.013
	(0.061)	(0.060)	(0.055)	(0.063)
Real GDP growth	-0.074	0.027	-0.049	0.018
	(0.062)	(0.061)	(0.052)	(0.053)
Regulatory pressures	2.065	3.181**	1.265	2.443**
	(1.315)	(1.310)	(1.117)	(1.093)
VIX	0.034*	0.049***	0.019	0.029*
	(0.020)	(0.019)	(0.018)	(0.018)
Observations	310	310	204	204

Note: Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; RW IRB – implicit risk weights calculated as risk-weighted exposures under the IRB approach divided by non-risk-weighted exposures under the IRB approach. IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; A-IRB banks – banks with at least 75% of their risk-weighted exposures calculated under the A-IRB approach as of 2016 Q4.

Table A14: Estimation Results for the Czech Republic – Robustness wrt House Price Growth

	(1)	(2)	(3)	(4)	(4)	(4)	(4)	(4)
Banks:	IRB	IRB	IRB	IRB	A-IRB	A-IRB	A-IRB	A-IRB
Dependent variable Y (t)	RW	RW	RW	RW	RW IRB	RW IRB	RW IRB	RW IRB
Y (t-1)	0.712***	0.717***	0.720***	0.731***	0.807***	0.823***	0.843***	0.870***
	(0.048)	(0.047)	(0.048)	(0.047)	(0.043)	(0.043)	(0.044)	(0.041)
3-month Pribor	0.947***				1.094***			
	(0.297)				(0.310)			
Shadow rate			0.314**				0.366***	
			(0.127)				(0.138)	
MCI		0.604***				0.700***		
		(0.189)				(0.194)		
RMCI				-4.009***				-2.683**
				(1.206)				(1.273)
Spread	0.121				0.195			
	(0.246)				(0.218)			
Log(assets) (t-1)	5.015**	4.857**	4.390**	4.358**	6.768***	6.446***	5.895***	4.459***
	(1.991)	(1.988)	(1.985)	(1.815)	(1.951)	(1.941)	(1.914)	(1.678)
Loan loss provisions/assets (t-1)	2.521***	2.210***	2.090***	1.981***	0.820	0.442	0.256	-0.132
	(0.724)	(0.677)	(0.667)	(0.653)	(0.781)	(0.746)	(0.752)	(0.748)
Regulatory capital/assets (t-1)	0.118	0.094	0.039	0.002	0.241	0.227	0.211	0.220
	(0.195)	(0.192)	(0.195)	(0.184)	(0.206)	(0.211)	(0.200)	(0.197)
Mortgage loans/assets (t-1)	-0.041	-0.059	-0.056	-0.056	-0.069	-0.093*	-0.094	-0.075
	(0.067)	(0.066)	(0.068)	(0.067)	(0.054)	(0.053)	(0.060)	(0.060)
Other retail loans/assets (t-1)	-0.022	-0.033	-0.029	-0.038	-0.147**	-0.157***	-0.151**	-0.113*
	(0.074)	(0.073)	(0.076)	(0.075)	(0.058)	(0.058)	(0.063)	(0.062)
Corporate loans/assets (t-1)	0.170*	0.166	0.163	0.162	0.084	0.075	0.070	0.044
	(0.102)	(0.102)	(0.103)	(0.101)	(0.089)	(0.089)	(0.087)	(0.086)
Cash with CB/assets (t-1)	-0.013	-0.012	-0.010	-0.007	0.039	0.055	0.053	0.052
	(0.052)	(0.051)	(0.052)	(0.051)	(0.042)	(0.041)	(0.043)	(0.044)
Interbank loans/assets (t-1)	0.049	0.037	0.031	0.025	0.020	0.004	-0.006	0.023
	(0.065)	(0.064)	(0.067)	(0.066)	(0.062)	(0.061)	(0.062)	(0.062)
Bonds/assets (t-1)	-0.094	-0.099*	-0.096	-0.086	0.000	-0.018	-0.027	-0.015
	(0.060)	(0.060)	(0.061)	(0.059)	(0.058)	(0.057)	(0.062)	(0.061)
Real GDP growth	0.089	0.050	0.047	0.129	0.092	0.045	0.031	0.088
	(0.087)	(0.087)	(0.089)	(0.087)	(0.076)	(0.076)	(0.074)	(0.076)
Regulatory pressures	3.608***	4.103***	4.090***	3.918***	2.369**	2.839***	2.579**	2.894***
	(1.271)	(1.210)	(1.257)	(1.282)	(1.054)	(1.020)	(1.070)	(1.094)
VIX	0.007	0.022	0.024	0.037*	-0.008	0.006	0.007	0.020
	(0.022)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
House price growth	-0.078	-0.051	-0.040	-0.054	-0.063	-0.039	-0.028	-0.041
	(0.051)	(0.037)	(0.037)	(0.038)	(0.043)	(0.032)	(0.032)	(0.031)
Observations	310	310	310	310	204	204	204	204

Note: Standard errors reported in parentheses; ***, **, and * denote the 1%, 5%, and 10% significance levels. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets; RW IRB – implicit risk weights calculated as risk-weighted exposures under the IRB approach divided by non-risk-weighted exposures under the IRB approach. IRB banks – banks using the IRB approach for at least some portion of their exposures as of 2016 Q4; A-IRB banks – banks with at least 75% of their risk-weighted exposures calculated under the A-IRB approach as of 2016 Q4.

Table A15: Estimation Results for the Visegrad Four Countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Corrected LSDV		System-GMM		Corrected LSDV		System-GMM	
RW (t-1)	0.794***	0.796***	0.862***	0.551**	0.804***	0.793***	0.882***	0.700***
	(0.075)	(0.125)	(0.084)	(0.138)	(0.077)	(0.127)	(0.084)	(0.063)
3M interbank rate*d2008	0.953***	0.717	0.826***	1.972**				
	(0.394)	(0.933)	(0.307)	(0.760)				
3M interbank rate*(1-d2008)	0.688*	0.760	0.871***	1.684*				
	(0.416)	(0.666)	(0.315)	(0.851)				
3M IR or shadow rate†*d2008					0.591**	0.343	0.506**	1.126**
					(0.277)	(0.576)	(0.232)	(0.462)
3M IR or shadow rate†*(1-d2008)					0.348	1.040	0.611*	0.797
					(0.365)	(0.823)	(0.337)	(1.731)
Spread	1.035**	1.360**	1.574***	2.058***	0.486	0.941	1.182***	0.814
	(0.511)	(0.658)	(0.431)	(0.699)	(0.447)	(0.591)	(0.368)	(0.540)
Log(assets) (t-1)	-0.185	0.095	-0.030	0.310	-0.209	0.312	0.018	0.239
	(1.592)	(2.585)	(0.318)	(0.532)	(1.626)	(2.627)	(0.341)	(0.238)
Loan loss provisions/assets (t-1)	-0.643	0.066	0.275	1.225	-0.620	0.107	0.100	1.055*
	(0.499)	(0.827)	(0.846)	(1.024)	(0.505)	(0.836)	(0.886)	(0.595)
Regulatory capital/assets (t-1)	0.091	0.099	0.229*	0.438***	0.088	0.105	0.236*	0.254
	(0.141)	(0.201)	(0.121)	(0.141)	(0.143)	(0.204)	(0.120)	(0.231)
Loans/assets (t-1)		0.058		0.134		0.066		0.119
		(0.062)		(0.160)		(0.064)		(0.097)
Cash with CB/assets (t-1)		0.079		0.288		0.078		0.298*
		(0.080)		(0.174)		(0.081)		(0.161)
VIX	-0.0378	-0.0729	0.0174	-0.107*	-0.0315	-0.0566	0.0174	-0.113
	(0.051)	(0.067)	(0.051)	(0.062)	(0.051)	(0.063)	(0.053)	(0.096)
Real GDP growth	0.280*	0.170	0.427*	0.295	0.250*	0.0754	0.395*	0.362
	(0.148)	(0.247)	(0.217)	(0.261)	(0.146)	(0.254)	(0.222)	(0.355)
Regulatory pressures	1.808	3.503*	2.929*	3.475	2.019	3.436*	3.335**	2.101
	(1.478)	(1.887)	(1.511)	(2.605)	(1.476)	(1.866)	(1.493)	(3.746)
Observations	496	301	507	308	496	301	507	308
AR(2)			0.520	0.252			0.539	0.225
Hansen			0.291	0.439			0.269	0.980
PCA components			35	35			35	55
KMO			0.694	0.881			0.694	0.881

Note: This table presents estimates of equation (2) using bootstrap-based corrected LSDV regression (De Vos et al., 2015) and the System-GMM Blundell and Bond (1998) with instruments generated by principal component analysis; robust standard errors are reported in parentheses; Windmeijer (2005) finite-sample correction is applied to the reported standard errors; ***, **, and * denote the 1%, 5%, and 10% significance levels. AR(2) test: Reports p-values for the null hypothesis that the errors in the first difference regression exhibit no second-order serial correlation. Hansen test: Reports p-values for the null hypothesis that the instruments used are not correlated with the residuals and hence the overidentifying restrictions are valid. PCA components – number of principal components generated; KMO – Kaiser-Meyer-Olkin measures of sampling adequacy. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets. † The shadow rate is used for the Czech Republic and Slovakia.

Table A16: Estimation Results for the Visegrad Four Countries – Robustness wrt Banks' Capitalization

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Corrected LSDV		System-GMM		Corrected LSDV		System-GMM	
RW (t-1)	0.756***	0.784***	0.854***	0.533***	0.767***	0.787***	0.877***	0.511**
	(0.070)	(0.125)	(0.089)	(0.132)	(0.072)	(0.127)	(0.087)	(0.197)
3M interbank rate*dCAR25	1.457***	1.514**	1.357***	3.198***				
	(0.382)	(0.726)	(0.245)	(0.967)				
3M interbank rate*(1-dCAR25)	0.567	0.474	0.562**	1.525***				
	(0.387)	(0.692)	(0.252)	(0.552)				
3M IR or shadow rate†*dCAR25					1.243***	1.443**	1.125***	2.935***
					(0.315)	(0.665)	(0.226)	(0.828)
3M IR or shadow rate†*(1-dCAR25)					0.381	0.382	0.351*	1.139***
					(0.263)	(0.493)	(0.186)	(0.380)
Spread	1.302**	1.440**	1.703***	2.089***	0.976**	1.135*	1.423***	1.354*
	(0.510)	(0.624)	(0.449)	(0.672)	(0.442)	(0.600)	(0.393)	(0.740)
Log(assets) (t-1)	0.077	0.225	-0.018	0.642	0.075	0.491	-0.009	0.707
	(1.547)	(2.557)	(0.307)	(0.879)	(1.583)	(2.641)	(0.314)	(0.850)
Loan loss provisions/assets (t-1)	-0.242	0.118	0.522	1.590	-0.249	0.112	0.408	1.596*
	(0.533)	(0.836)	(0.847)	(1.012)	(0.538)	(0.838)	(0.882)	(0.830)
Regulatory capital/assets (t-1)	0.119	0.140	0.276*	0.504**	0.114	0.151	0.277**	0.524**
	(0.134)	(0.200)	(0.140)	(0.189)	(0.136)	(0.206)	(0.138)	(0.225)
Loans/assets (t-1)		0.072		0.061		0.080		0.120
		(0.061)		(0.208)		(0.063)		(0.133)
Cash with CB/assets (t-1)		0.093		0.208		0.102		0.217
		(0.077)		(0.147)		(0.079)		(0.162)
VIX	-0.044	-0.087*	-0.004	-0.117**	-0.044	-0.093*	-0.007	-0.133***
	(0.045)	(0.051)	(0.050)	(0.052)	(0.046)	(0.053)	(0.055)	(0.046)
Real GDP growth	0.189	0.185	0.398**	0.148	0.177	0.193	0.381**	0.220
	(0.150)	(0.202)	(0.154)	(0.172)	(0.149)	(0.204)	(0.161)	(0.178)
Regulatory pressures	0.426	1.304	1.949	0.700	0.955	1.968	2.669*	1.163
	(1.402)	(1.798)	(1.384)	(3.225)	(1.384)	(1.733)	(1.394)	(2.048)
Observations	496	301	507	308	496	301	507	308
AR(2)			0.423	0.283			0.439	0.278
Hansen			0.552	0.239			0.552	0.482
PCA components			35	35			35	35
KMO			0.694	0.881			0.694	0.881

Note: This table presents estimates of equation (3) using bootstrap-based corrected LSDV regression (De Vos et al., 2015) and the System-GMM Blundell and Bond (1998) with instruments generated by principal component analysis; robust standard errors are reported in parentheses; Windmeijer (2005) finite-sample correction is applied to the reported standard errors; ***, **, and * denote the 1%, 5%, and 10% significance levels. AR(2) test: Reports p-values for the null hypothesis that the errors in the first difference regression exhibit no second-order serial correlation. Hansen test: Reports p-values for the null hypothesis that the instruments used are not correlated with the residuals and hence the overidentifying restrictions are valid. PCA components – number of principal components generated; KMO – Kaiser-Meyer-Olkin measures of sampling adequacy. RW – implicit risk weights calculated as risk-weighted exposures divided by total assets. † The shadow rate is used for the Czech Republic and Slovakia.

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