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Risk-return Portfolio Level Trade-off for Czech Banks

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Abstract

This paper examines the validity of the risk-return trade-off for a sample of Czech banks over the period 2002–2022 by analysing the relationship between the bank risk and risk-adjusted returns. I find evidence of a significant negative association between the regulatory risk measure and risk-adjusted returns, indicating that the risk-return trade-off does not hold. Specifically, a 100 bps increase in the risk is associated with about a 7 bps decrease in the return on risk-adjusted assets (RORWA) and an 11 bps decrease in the risk-adjusted net interest margin (rNIM) in the short run. The long-run effect is about double for RORWA and almost triple for rNIM. I also find evidence that during the period of low interest rates, the effect for RORWA was about a half smaller, albeit still negative. On the contrary, when non-regulatory measures of risk or risk-adjusted profitability are used, the risk-return trade-off seems to hold.

Keywords: bank profitability, bank risk, risk-return trade-off, RORWA, RAROC, dynamic panel regression

JEL Codes: C33, G11, G14, G21

1. Introduction

Bank profitability, being the dominant source of shareholder value in terms of capital gains and dividend yields, helps attract external capital. It is also the bank's main internal source of capital. Capital and current period profit provide a capacity for further credit expansion and a buffer

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against incurred losses. Higher and stable profitability thus enhances the bank's soundness, resilience, and willingness to lend credit during downturns, which contributes to the stability of the financial system. For these reasons, bank profitability attracts the attention of managers, financial markets, regulators, supervisors, and monetary authorities.

A bank's profitability is influenced by a number of internal and external factors with the risk taken by the bank being one of them. Modern portfolio theory suggests that, under strict assumptions, higher risk-taking yields higher expected profits (risk-return trade-off). However, higher or excessive risk-taking can threaten the bank's stability and consequently the stability of the financial system. The bank should therefore ensure that risk taken is appropriately compensated. One way of looking at the sustainability of bank profits is through the lens of the risk-adjusted profitability measure (RAPM). Assuming that the risks are appropriately compensated for, risk-adjusted profits should be independent of the level of risk undertaken, all other things equal.

I aim to provide evidence on whether the risk-return trade-off holds for Czech banks. I do so by looking at a sample of Czech banks over the period from 2002 to 2022 and estimating the relationship between the risk assumed by the banks and the risk-adjusted profits. I also focus on the potentially different effects during a period of low interest rates and periods after extensive regulatory changes in the area of risk measurement.

I find some evidence of a statistically significant negative relationship between the risk-adjusted metrics of profitability and the regulatory measure of the banks' risk suggesting that the risk-return trade-off did not completely hold for the Czech banks during the considered period. I also find that the relationship was not substantially different during the periods of low interest rates and after the major regulatory changes as it was still negative. However, the results did not prove completely robust when non-regulatory measures of the other risk and risk-adjusted profit were considered, suggesting the need for further research using more precise or market-based measures of the risk.

The paper contributes to the literature on the determinants of risk-adjusted profitability, an area that has received less attention, and to the literature that focuses on the validity of the risk-return trade-off for banks. By testing the relationship over different time periods, I also complement the literature that examines the effects of accommodative monetary policy on bank performance. Finally, the paper adds to the research on the profitability of Czech banks by considering other risk and profit measures and different time periods.

The remainder of the paper is organised as follows. Section 2 reviews the literature and defines the research hypotheses. The analytical framework of this paper is presented in Section 3, while Section 4 presents the results of the empirical analysis. The last section concludes.

2. Literature Review and Hypotheses

The literature on the determinants of bank profitability is extensive. The determinants are commonly divided into bank-specific, sector-specific, and macroeconomic. Bank-specific determinants include size, capitalization, risk, business model and strategy (balance sheet structure, revenues diversification, etc.), operational efficiency, market share and others. Sector concentration, ownership, supervisory stringency, financial cycle position or structure of capital markets are usually considered as sector-specific factors. Macroeconomic factors include business and financial cycles, inflation and interest rate environment (Athanasoglou et al., 2008; Bikker and Vervliet, 2017; Kok et al., 2015; Albertazzi and Gambacorta, 2009).

The paper focuses on the risk determinant of the bank's profitability. One of the first attempts to understand the risk-return trade-off was portfolio theory by Markowitz (1952), followed by Sharpe (1964) and Ross (1976) with the capital asset pricing model and the arbitrage pricing theory respectively. Banks reflect the risk in the price, i.e., in the interest rate (or a fee) charged on the asset as a compensation (risk premium) (Modigliani and Modigliani, 1997). Ideally, the bank is able to correctly estimate the risk so that the premium balances the risk. The bank can increase its expected return by accepting more risk, thus charging higher rates. However, in the world of imperfect information, the bank's return may increase less rapidly than the interest rate (e.g., due to higher-than-expected losses), and it may decrease at some point, indicating the existence of a concave risk-return relationship (Stiglitz and Weiss, 1981).

In practice, the evidence on the risk-return relationship for banks is inconclusive. Some have documented a negative relationship between credit risk (proxied by the ratio of non-performing loans) and bank profitability measured by return on assets or return on capital as a result of higher loan loss provision or incurred losses on riskier assets (Athanasoglou, 2008; Bikker and Vervliet, 2017; Kok et al., 2015, Altavilla et al., 2018, Molyneux et al., 2019). Others have found a positive effect of risk on return on assets and net interest margin when the ratio of risk-weighted assets to total assets (regulatory measure of the risk) is used (Sutorova and Teply, 2014; Kerbl and Sigmund, 2017). Hanzlik and Teply (2020), Kosmidou et al. (2008), Cruz-Garcia and de Guevara (2019) and Molyneux et al. (2019) have also found a positive relationship between credit risk (measured by loan loss provisions to gross loans) and banks' net interest margin.

None of the above papers have considered potential non-linearity, such as incorporating a squared risk variable in regression analysis, as the risk-return link has been estimated simply as a by-product within the broader focus of research. This paper addresses this gap.

Less research focus has also been dedicated to the analysis of determinants of bank risk-adjusted profitability. Yet, such a measure enables us to evaluate the performance of banks with different risk appetite. Comparing risk-adjusted performance helps assess whether the risks are adequately compensated for (Modigliani and Modigliani, 1997). The papers that have studied this link, however, have used a set of control variables similar to the ones in simple profitability models and have not found considerably different effects (Dao et al., 2020; Janda and Kravtsov, 2020; Paltrinieri et al., 2021; Fredriksson and Moro, 2014). In these papers, the link between the risk and RAPM was either not tested or statistically significant results were not found. Based on the above, I define the first research hypothesis.

> ***Hypothesis 1:*** *The risk that Czech banks undertake is adequately compensated for in their returns (risk-return trade-off holds), i.e., there is no statistically significant relationship between risk and the RAPM.*

In the years after the global financial crisis (GFC), which were marked by a prolonged period of low interest rates in an attempt to revive the economic growth, research focus shifted to the short-term and long-term consequences of this monetary policy stance, including bank profitability and risk.

In the short or medium term, bank profitability inclines to increase as costs of funds usually decrease faster than asset yields (the extent depends on the degree of maturity transformation), leading to a higher net interest margin. Lower interest rates also decrease the debt service burden for borrowers and increase their creditworthiness, which leads to lower probability of default, and hence to reduced provisions for non-performing loans (Altavilla et al., 2018; Bikker and Vervliet, 2017; Genay and Podjasek, 2014; Gambacorta and Mistrulli, 2004). Decreasing interest rates also tend to boost economic growth, which is fuelled by provided credit (Malovana et al., 2020). With increased credit, non-interest income is likely to increase as well (Bikker and Vervliet, 2017). A positive effect on securities valuation is expected, although only temporary (Borio et al., 2017).

However, with persistently low interest rates, the negative effects can offset the positive ones. The bank's net interest margin can be squeezed when deposits rates hit zero lower bound (a major concern when negative interest rates are introduced), while rates on loans continue to decline (Altavilla et al., 2018; Claessens et al., 2018; Genay and Podjasek, 2014; Kerbl and Sigmund, 2017). In case the banks fully pass low (negative) rates on to their clients, they might prefer other assets over deposits at banks. This can trigger deposit outflow, which can undermine the financial stability of the sector (Arseneau, 2020). However, Altavilla et al. (2018) document that substantial adverse effects only materialize after a relatively long period of time and tend to be counterbalanced by improvements in macroeconomic conditions.

With respect to the effects of the low interest rate environment (LIRE) on bank risk, Altunbas et al. (2010) found that the LIRE over an extended period of time contributes to an increase in bank risk-taking. In search for higher yields or their preservation, the banks may be induced to expand in areas outside their core markets, extend their range of services or shift investment strategies (Bikker and Vervliet, 2017). Roengpitya et al. (2014) found that alterations in the business model often lead to deterioration of banks' performance.

Although low interest rates can lower the probability of borrowers' default, in the long run, the banks might ease their lending standards to cope with decreasing profitability by increasing credit volumes. This can eventually lead to deterioration of portfolio quality and higher credit losses (Jiménez et al., 2014; Ioannidou et al., 2009; Maddaloni and Peydró, 2011). This risk-taking channel of monetary policy is broadly accepted in the literature (Borio and Zhu, 2012). Malovana et al. (2017) adds that accommodative monetary policy contributes to growth in asset prices and has adverse effects on risk parameter estimates which enter the calculation of banks' capital requirements and risk weights under the internal ratings-based (IRB) approach. This increases the inherent risk tolerance of financial institutions.

Bearing in mind the evidence on effects of accommodative monetary policy on bank profitability and risk, I define the following hypothesis to test potential changes in the risk-return trade-off during the LIRE.

> ***Hypothesis 2:*** *There is no statistically significant difference in the risk-return trade-off during the LIRE as compared to neutral monetary policy times, i.e., the relationship between risk and risk-adjusted profitability is the same.*

In the empirical section, I use the metric of risk-weighted assets to total assets (RWATA) as a proxy for bank risk. In the Czech Republic, the calculation of risk-weighted assets has been subject to substantial regulatory changes. First, from 2007 the banks were able to use the IRB approach for the estimation of risk-weighted assets. The IRB approach should be more risk-sensitive compared to the standardized approach (STA). In 2014, the CRR[1] regulation came into effect. The regulation brought changes to the calculation of risk-weighted assets (RWA) under both IRB and STA approaches to make the calculation more risk-sensitive. Thus, I define the following hypothesis to verify whether the risk-return link differed after the application of these changes.

1 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 and amending Regulation (EU) No 648/2012

Hypothesis 3: *There is no statistically significant difference in the risk-return trade-off before and after the introduction of significant regulatory changes in the area of risk measurement.*

3. Research Design

3.1 Data

The sample consists of 13 banks and five building societies (hereinafter referred collectively as “banks”) registered in the Czech Republic as at the end of 2022[2]. Data span the period from 2002 to 2022 on an annual and individual basis. Due to some data limitations, the sample is an unbalanced panel of 328 observations. Table A1 lists the banks in the sample. The bank-level data were obtained using a combination of the banks’ annual reports, the Amadeus database and the Orbis Europe database. The macroeconomic data were derived from the ARAD[3]. The credit-to-GDP gap was obtained from the BIS Data Portal.

3.2 Methodology

I use various analytical techniques to shed light on the relationship between the risk that the bank assumes and related returns. I use simple graphical tools of descriptive statistics and then employ a correlation analysis. To obtain more robust evidence of the relationship, I carry out a regression analysis.

In the analysis I suppose that if the bank’s returns correspond to the risk level, i.e., the risk-return trade-off holds completely, I should not be able to find a statistically significant relationship between the risk level and RAPM. In other words, the bank’s profitability adjusted for the risk should not be, controlling for other factors, dependent on the said risk level.

Regression model

To estimate the relationship between risk and the RAPM, I develop the following dynamic panel data multiple linear regression model:

2 Branches of foreign banks in EU/EEA and third countries, credit unions, specialized mortgage banks and two state-owned banks – the National Development Bank and the Czech Export Bank, were excluded from the sample for their specific nature.

3 Time series system, which is a public database that is part of the information service of the Czech National Bank.

$$y_{it} = \alpha_0 + \alpha_1 y_{it-1} + \beta_0 RISK_{it} + \beta_1 RISK^2_{it} + \gamma X_{it} + \delta Y_t + \zeta Z_t + \theta_i + \varepsilon_{it} \quad (1)$$

where i stands for the bank and t refers to the year. The dependent variable y_{it} is a measure of the RAPM, its one-year lag value is included amongst the independent variables to control for the potential inertia of the profitability, giving the model its dynamic nature, which is a common assumption (e.g., Athanasoglou et al., 2008; Albertazzi, Gambacorta, 2009; Borio et al., 2017; Altavilla et al., 2018). $RISK_{it}$ denotes the measure of the bank's risk. I also include its quadratic form $RISK_{it}^2$ to test for potential non-linearity. X_{it} is a vector of bank-specific control variables, Y_t is a vector of sector control variables, Z_t is the set of macroeconomic control variables, θ_i is a bank-specific fixed effect to control for bank-specific time-invariant heterogeneity and ε_{it} is an error term, assumed to be well-behaved. The coefficients β_0 and β_1 are of the main interest of this paper. A statistically significant value, regardless of its direction, would imply that the risk-return trade-off does not hold perfectly. The mathematical expression of Hypothesis 1 is:

– H_0: $\beta_0 \wedge \beta_1 = 0$

– H_1: $\beta_0 \vee \beta_1 \neq 0$

I introduce the dummy variable $LIRE_t$ into Equation (1) and interact it with $RISK_{it}$ to test Hypothesis 2. The dummy takes the value of 1 if the PRIBOR 3M rate equals or is lower than 0.50%, and 0 otherwise. The coefficient of the interaction term $RISK_{it} \times LIRE_t$ indicates whether the risk-return trade-off link differed in the LIRE period compared to normal times. The model becomes:

$$y_{it} = \alpha_0 + \alpha_1 y_{it-1} + \beta_0 RISK_{it} + \vartheta LIRE_t + \mu RISK_{it} \times LIRE_t + \gamma X_{it} + \delta Y_t + \zeta Z_t + \theta_i + \varepsilon_{it} \quad (2)$$

The mathematical expression of Hypothesis 2 follows:

– H_0: $\mu = 0$

– H_1: $\mu \neq 0$

Similarly, I test whether the risk-return trade-off differed in periods after the introduction of regulatory changes (Hypothesis 3). I place the dummy variables IRB_t and CRR_t into Equation (2) and interact them alternately with the variable $RISK_{it}$. The coefficients of the interaction term may signal potential breaks in the risk-return trade-off. The model is:

$$\begin{aligned} y_{it} = {} & \alpha_0 + \alpha_1 y_{it-1} + \beta_0 RISK_{it} + \sigma dummy_t + \varphi RISK_{it} \times dummy_t + \gamma X_{it} + \delta Y_t + \\ & + \zeta Z_t + \theta_i + \varepsilon_{it} \end{aligned} \quad (3)$$

where $dummy_t$ is an IRB_t or CRR_t dummy. IRB_t equals 1 in the periods after the IRB approach for the calculation of RWA was enabled (end of 2007 and afterwards), and 0 otherwise. CRR_t equals 1 in the periods after the implementation of CRR (2014 and afterwards), and 0 otherwise.

The mathematical expression of Hypothesis 3 follows:

– H_0: $\varphi = 0$

– H_1: $\varphi \neq 0$

Variables

Following the literature on the determinants of bank profitability, including Bourke (2009), Molyneux and Thornton (1992), Athanasoglou et al. (2008), Claeys et al. (2008), Albertazzi and Gambacorta (2009), Saona (2011) and Demirguc-Kunt and Huizinga (2016), I control for bank-specific, sector-specific, and macroeconomic control variables. The vector of bank-specific controls X_{it} includes variables to account for different aspects of the bank such as size, asset and liability structure, capitalization, funding profile, liquidity, profit, and loss structure, and managerial (operational) effectiveness. The sector-specific controls in Y_t include market share and concentration. The macroeconomic controls in Z_t comprise a proxy for business and financial cycle, price level and controls for interest rate environment. Appendix details individual variables (Table A2) and provides summary statistics (Table A3).

Risk-adjusted profitability measures (RAPM)

I use several different RAPM in the variable y_{it}. The first one is return on the risk-weighted assets (RORWA) as a counterpart to simple return on assets (ROA). RORWA measures accounting profit for the period (NI_{it}) per unit of risk:

$$RORWA = \frac{NI_{it}}{\frac{\left(RWA_{t-1} + RWA_t\right)}{2}} \tag{4}$$

The second measure is RAROC (risk-adjusted return on capital) as a counterpart to return on equity (ROE). There are several approaches to calculate RAROC (Hull, 2012); I follow Janda and Kravtsov (2020) and define RAROC as:

$$RAROC_{it} = \frac{ER_{it}}{EC_{it}} \tag{5}$$

where ER_{it} is the expected rate of return and EC_{it} is the economic capital of the bank i at the period t. ER_t is defined as:

$$ER_{it} = NI_{it-1} + \omega_i \tag{6}$$

where ω_i is profit fluctuation, i.e., standard deviation to account for all ex-ante predictability (given available information) in returns. Standard deviation for the past 3 years (comprising 12 quarter observations) is used. Economic capital EC_{it} is:

$$EC_{it} = \frac{RWA_{it}}{CAR^{regmin}} \tag{7}$$

where CAR^{regmin} is the minimum required regulatory capital threshold.

I supplement the analysis with the risk-adjusted net interest margin (rNIM), which is calculated as:

$$rNIM_{it} = \frac{Interest\,income_{it} - Interest\,expense_{it}}{\frac{\left(RWA_{t-1} + RWA_t\right)}{2}} \tag{8}$$

Risk measures

I use an available and commonly used measure of risk: the density ratio (RWATA), which is calculated as the amount of RWA divided by total assets (TA) of a bank. There are several issues with this risk metric, however, which may result in incorrect reflection of the true risk levels such as imperfect risk sensitivity, procyclicality (Ayuso et al., 2004; Cannata et al., 2011; Brei and Gambacorta, 2016), excessive variability, systematic underestimation or manipulation, especially in the case of the IRB approach (Vallascas and Hagendorff, 2013; Mariathasan and Merrouche, 2014; Döme and Kerbl, 2017).

Thus, as a part of the robustness check, I estimate models in Equation (1) using the Z-score as a risk proxy. The Z-score captures the bank's propensity to default as it compares the bank's buffer composed of capital and returns with the volatility of those returns (World Bank, 2023). The Z-score is a traditionally used metric of a bank's solvency, or solvency risk (Cihak and Hesse, 2008). It is also used on an aggregated level for the whole banking sector as a measure of financial stability (Tabak et al., 2016) and is computed as:

$$Z - score_{it} = \frac{ROA_{it} + Leverage_{it}}{\sigma ROA} \tag{9}$$

where ROA_{it} is the return on assets in a given period, $Leverage_{it}$ is total equity to total assets, and σROA is the standard deviation of ROA over the previous 3 years (comprising 12 quarter observations). Note that the higher the Z-score, the lower the risk.

Estimation method

When using panel data, it is necessary to deal with unobserved heterogeneity. It is commonly done by applying the within (demeaning) transformation as in a fixed-effect estimator or LSDV (Baum, 2013). However, using a fixed-effect estimator in a dynamic model results in dynamic panel bias (Nickell, 1981) that makes the estimator inconsistent.

One way to deal with this issue is to use instrumental variables (IV) or GMM estimators (Arellano and Bond, 1991; Arellano and Bover, 1998; Bun and Carree, 2005). The drawback of these estimators is that with increasing *T*, the number of valid instrument rises, which can lead to poor performance of the estimator (Roodman, 2009). Given that the panel used in this paper consists of 18 cross-sections (*N*) and 20 *T*, it does not seem suitable to use IV or GMM estimators. Several papers have then proved that for specific panels (small panels), other estimators outperform GMM estimators, which are more suitable for small *T* and large *N* panels (Kiviet, 1995; Judson and Owen, 1999; Bun and Carree, 2005; Baum, 2013). These estimators are bias-corrected LSDV estimators. I use the bootstrap-based bias-corrected LSDV (BCLSDV) estimator by De Vos et al. (2015). De Vos et al. (2015) built on bias-corrected LSDV estimators proposed by Kiviet (1995) and Everaert and Pozzi (2007).

Given the relatively long *T* of the panel data, I test for the stationarity using a Fisher-type test, specifically an augmented Dickey-Fuller unit root test (hereafter ADF), which is suitable for unbalanced panels (Dickey and Fuller, 1981). A unit root test is performed on each panel series separately. The null hypothesis is that all the panels contain unit roots. Based on the results of the test, the null hypothesis could not be rejected for total assets and their squared value (ln_TA, ln_TA_sq), market share (MS), concentration (HHI), credit-to-GDP gap (CGDP), short-term interest rate (STR) and yield curve slope (YCS). I transformed the respective variables into their first differences to achieve stationarity. CGDP showed signs of non-stationarity even in its first difference form; the variable was therefore removed from the model to avoid the risk of spurious regression.

4. Empirical Results

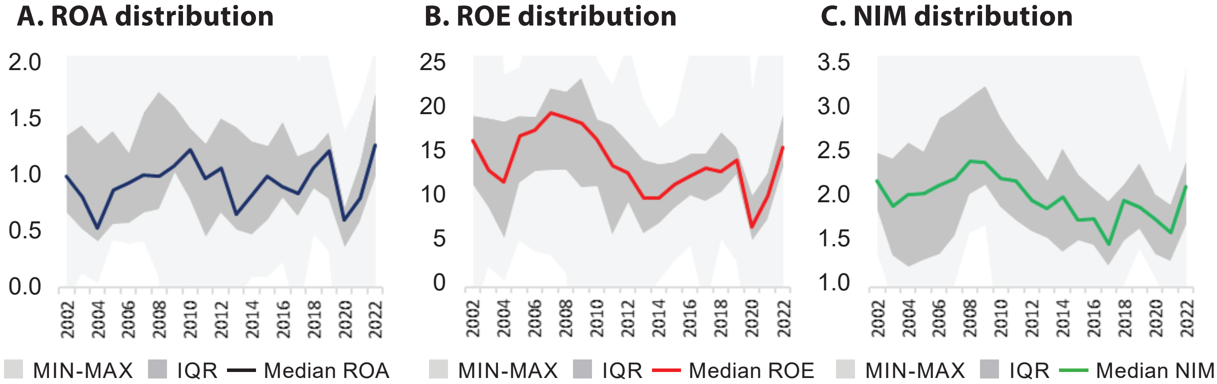
4.1 Descriptive analysis

The Czech banking sector enjoys an above-average level of profitability compared to its European peers, despite a generally lower risk level (CBA, 2022; CBA, 2021). The profitability of the Czech banks included in the sample, measured by ROA, ROE and NIM (Figure 1), increased after the restructuring of the banking sector at the beginning of the century and before the GFC. With the onset of the GFC, the profitability started to decline, which is noticeable especially in the context of the banks' return on capital and interest rate margin. With the European debt crisis, followed by accommodative monetary policy to boost economic growth, the Czech banks' profitability further decreased. During this episode, the banks suffered from the credit crunch and struggled with decreasing fee and commission income, declining lending spreads (due to increasing market competition and a low interest rate environment) and still relatively high-risk costs.

After the economic recovery, from 2014 onward, the profitability started to increase again, though in relative terms it has never returned to pre-GFC levels. As economic growth resumed, borrowers' repayment morale improved, leading to falling default rates and lower risk costs. The banks also managed to keep administrative costs relatively under the control.

The COVID-19 pandemic negatively influenced the banks' profits, mainly through the creation of higher loan loss provisions on affected loans, although these never fully materialized due to moratoria and other national support measures implemented in response to the COVID-19 pandemic. The release of pandemic-related loan loss provisions together with higher interest income, which followed the rise of the monetary policy rates due to accelerating inflation, contributed to profitability growth in the following years.

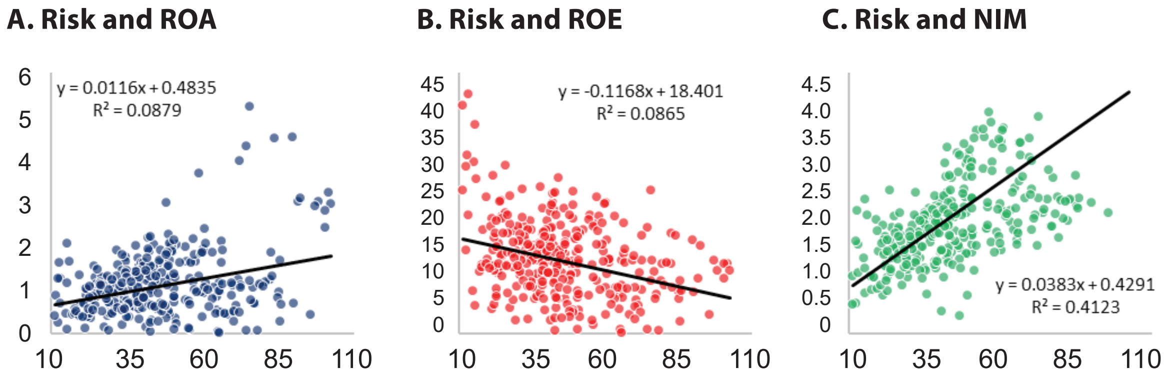
Figure 1: Profitability of Czech banks (in %)



Source: Annual reports, Amadeus, Orbis Europe, author

The first impression of the validity of the risk-return trade-off provide the plot charts. Figure 2 plots risk (RWATA) to simple profitability measures of the sampled banks. In the case of ROE, the risks do not seem to be adequately remunerated, given the negative correlation, while ROA and NIM seem to be positively correlated with the risk, pointing to potential validity of the risk-return trade-off. This positive correlation indicates that with higher risks, the banks achieved higher returns. However, the question remains whether these additional or higher returns are sufficient to compensate for the higher undertaken risk, i.e., whether risk-return trade-off holds completely or only partially for the Czech banks. The answer could be provided by looking at the link between the risk and risk adjusted returns.

Figure 2: Risk and profitability of Czech banks in 2002–2022



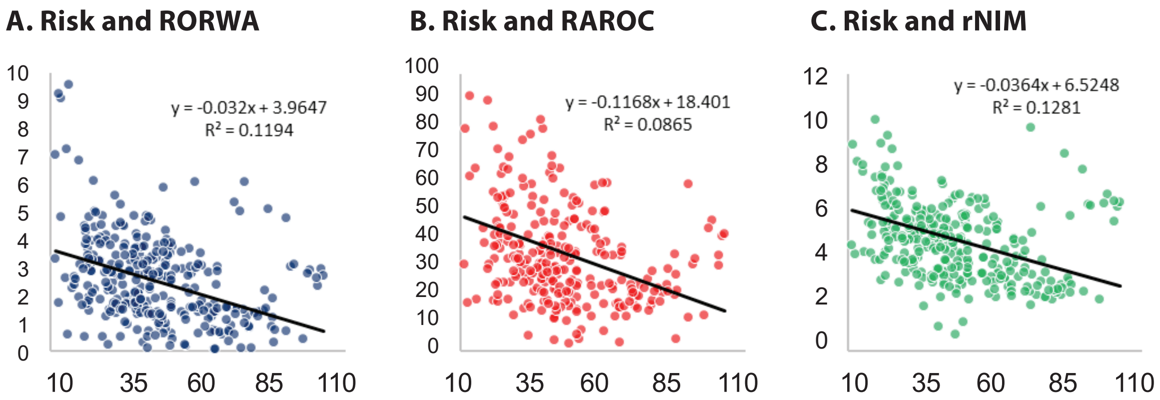
Note: x axis: RWATA as a risk measure; y axis: profitability measure; y axis bounded at the bottom by zero for better presentation.

Source: Annual reports, Amadeus, Orbis Europe, author

Figure 3 plots RWATA and RAPMs. The charts indicate to a negative relationship between the two, which suggests potential invalidity of the risk-return trade-off for the Czech banks in the considered period – with increasing risk, the banks' profitability either decreased or increased but to an extent that does not suffice to offset the risk taken.

The above analysis provides only superficial evidence of the association between risk and returns. The next section will provide more robust evidence.

Figure 3: Risk and risk-adjusted profitability of Czech banks in 2002–2022



Note: x axis: RWATA as a risk measure; y axis: profitability measure; y axis bounded at the bottom by zero for better presentation.

Source: Annual reports, Amadeus, Orbis Europe, author

4.2 Regression results

Table 1 summarizes the results of Equation (1) for all the RAPMs as dependent variables and with RWATA as a proxy for risk as the main independent variable. The estimation was carried out using the BCLSDV estimator by De Vos et al. (2015)[4].

The lagged dependent variable is significant in all the baseline models, which confirms the assumption of the profitability persistence. A negative relationship between the risk measure and the RAPM was confirmed, although it is statistically significant only for RORWA and rNIM. The results suggest that with increasing risk, the banks' RORWA and rNIM tend to decline, indicating that the risk is not adequately or completely compensated for. It is important to note that a negative relationship does not automatically mean that the risk-return trade-off is completely non-existent. As indicated in Figure 2, there is some evidence of the validity of the trade-off, but as the regression estimation results show, the trade-off does not seem to hold in full, as otherwise no link would be found between risk and the RAPMs. The results also show that the relationship is rather linear as concavity was not statistically confirmed for any of the RAPMs.

Specifically, the results show that with an increase of average risk weight by 1 pp, RORWA decreases on average by approx. 7 bps and rNIM by 11 bps. To put it into perspective, one standard

4 Implemented using the Stata routine *xtbcfe*. Each model accounts for cross-sectional heteroscedasticity by resampling within cross-sections; 1000 bootstrap iterations were used for the construction of the estimator and 800 iterations were used for inference. Bootstrapped standard errors are used with confidence intervals calculated directly from the bootstrap distribution.

deviation of average risk weight in our sample is 19.6 pp, which translates into a difference of approx. 1.4 pp in RORWA and 2 pp in rNIM, while the average RORWA of the sample is 2.49 pp and the average rNIM is 4.85 pp. To put it differently, a 1 pp change in the risk changes RORWA on average by 3% and rNIM by 2% of their averaged values. The dynamic nature of the model enables us to estimate the long-run effects[5]. The long-run effect of 1 pp higher risk results on average in 16 bps lower RORWA and 32 bps lower rNIM.

As for other bank-specific variables, it seems that the bank's asset structure and managerial effectiveness are key determinants as they have a significant influence on all three RAPMs. The result implies that with a higher portion of loans in banking books, the banks achieve lower risk-adjusted profits, which may be due to the fact that loans are generally riskier than other assets. Managerial effectiveness, on the other hand, proved to be an important factor for higher bank profitability – an increase in effectiveness (i.e., decrease in CIR, hence a negative relationship) leads to an increase in risk-adjusted profitability.

With respect to sector-specific and macro variables, both real GDP growth and short-term interest rate proved to be significant in all three baseline specifications. The results imply that with an increasing short-term interest rate, the banks' RAPM increases. The results are both statistically and economically significant. This can be explained by a relatively high portion of the variable rate or short-term fixation corporate loans in the Czech banking sector (CNB, 2023), for which the repricing to higher rates is quicker, and possibly due to excessive liquidity of the Czech banking sector. Excessive liquidity might be influential in two ways: (i) it does not put any immediate or additional pressure on banks to increase rates on client deposits, keeping funding costs lower and leading to increasing interest margin, and (ii) enables banks to deposit the liquidity at a two-week repo rate at the Czech National Bank via repo operations, which in the case of increasing rates positively stimulates profits.

The negative effect of real GDP growth indicated by the results seems rather surprising given the previous research, which concluded that plain profits are rather pro-cyclical (Athanasoglou et al., 2008; Albertazzi and Gambacorta, 2009). A possible explanation could be that in times of economic upswing, banks tend to provide more loans relative to other forms of business, which are valued in regulatory terms with higher risk (especially considering the STA approach). This could be manifested in the declining risk-adjusted metric of profits if elevated risk is not appropriately compensated for by profits. Another potential reason could be that, under favourable economic conditions, banks may approach profit-smoothing practices to under-report profits due to taxes or create reserves for economic slowdowns.

5 The long-run effect is estimated using the formula $\frac{\beta_0}{(1-\alpha_1)}$, where α_1 is the coefficient of the lagged dependent variable (known as the autoregressive coefficient), β_0 is the coefficient of the risk measure and $(1-\alpha_1)$ is the rate of convergence.

Table 1: Estimation results – baseline model

Dependent variable	RORWA	RAROC	rNIM
Independent variables	**1**	**2**	**3**
Dependent variable$_{t-1}$	0.546*** (0.132)	0.550*** (0.087)	0.670*** (0.090)
RWATA	−0.073* (0.038)	−0.683 (0.726)	−0.105* (0.056)
RWATA_sq	0.000 (0.000)	0.004 (0.006)	0.001 (0.000)
ln_TA	−3.023 (14.544)	−4.601 (217.025)	16.419 (10.181)
ln_TA_sq	0.036 (0.296)	−0.018 (4.386)	−0.354* (0.208)
LTA	−0.018* (0.009)	−0.415** (0.181)	−0.018* (0.01)
EAR	−0.003 (0.059)	−0.151 (0.723)	0.021 (0.055)
LDR	0.007 (0.010)	0.131 (0.118)	0.004 (0.008)
DER	−0.024 (0.027)	−0.252 (0.435)	−0.011 (0.037)
LATA	−0.005 (0.015)	−0.483** (0.214)	−0.006 (0.013)
NII	−0.011 (0.007)	−0.133 (0.099)	0.031*** (0.009)
NFCI	−0.002 (0.010)	−0.146 (0.172)	−0.002 (0.014)
CIR	−0.037*** (0.009)	−0.396*** (0.123)	−0.021* (0.011)
MS	0.107 (0.269)	−0.200 (3.181)	0.141 (0.214)
HHI	0.000 (0.002)	0.000 (0.017)	0.002 (0.001)
rGDP	−0.295*** (0.070)	−5.050*** (1.432)	−0.322*** (0.074)
DEF	0.172 (0.118)	0.999 (1.636)	0.375*** (0.146)
STR	0.383*** (0.093)	4.385*** (1.306)	0.411*** (0.095)
YCS	−0.057 (0.072)	1.102 (1.006)	−0.027 (0.057)
Bank fixed effects	YES	YES	YES
No. of banks	18	18	18
Observations	308	268	308
Hausman test	11.28	18.79	116.60***

Note: The table presents coefficients from the BCLSDV estimation of Equation (1). Bootstrapped standard errors in parentheses. Fixed effects not reported. Results of Hausman test for standard FE and RE estimation presented. ***, **, * denote significance at 1%, 5% and 10% levels.
Source: author

The negative effect of the risk on RORWA and rNIM might be further disintegrated into different types of financial risks. Table 2 summarizes the results of the baseline model estimation for different types of financial risks as the main independent variable – credit risk, market risk and operational risk. The results show that the link is driven by credit risk, which is not surprising given the fact that credit risk is the main component of the total risks of the Czech banks.

Table 2: Estimation results – baseline model with different financial risks

Dependent variable	RORWA	RAROC	rNIM
Independent variables			
RWACRTA	−0.070** (0.035)	−0.684 (0.729)	−0.106** (0.053)
RWAMRTA	−0.004 (0.300)	−0.430 (2.870)	−0.018 (0.201)
RWAORTA	−0.193 (0.410)	−2.609 (6.429)	−0.287 (0.492)
Bank fixed effects	YES	YES	YES
Bank-specific variables	YES	YES	YES
Sector-specific variables	YES	YES	YES
Macro-specific variables	YES	YES	YES
No. of banks	18	18	18
Observations	308	268	308

Note: The table presents coefficients from the BCLSDV estimation of Equation (1) with different risks. Bootstrapped standard errors in parentheses. Fixed effects not reported. Results of Hausman test for standard FE and RE estimation presented. ***, **, * denote significance at 1%, 5% and 10% levels. Complete results are available upon reasonable request.

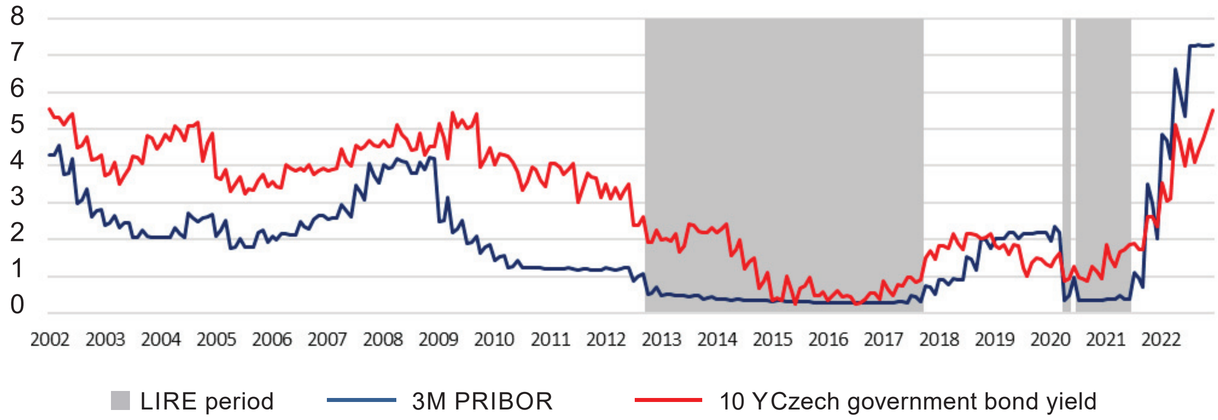
Source: author

The effects of a prolonged period of low interest rates (LIRE) on bank profitability and risk were described in Section 2. The Czech Republic experienced a LIRE[6] from 2012 to 2017 and then shortly after the outbreak of the COVID-19 pandemic until the first half of 2021

6 I consider the interest rate environment low when the short-term rate (PRIBOR 3M) equals or is lower than 0.50%.

(Figure 4), so I estimate a potentially different relationship between risk and the RAPMs during these periods. The estimation results are shown in Table 3.

Figure 4: LIRE in Czech Republic



Source: ARAD, author

The results show that, during the LIRE, the risk-adjusted profitability is generally lower compared to other times. Moreover, including the LIRE dummy resulted in finding a significant and negative relationship between risk and RAROC, contrary to the baseline model. However, the effect of risk on the RAPMs during the LIRE compared to other (normal) periods significantly differs only for RORWA. The coefficient of the interaction term *RWATA* × *LIRE* is positive and implies that during the LIRE, the negative effect is reduced to about one half on average compared to non-LIRE times. The effects and statistical significance of bank's asset structure, managerial effectiveness, real GDP growth and short-term interest rates from the baseline estimation were confirmed.

By the end of 2007, the five biggest banks started to use the IRB approach for the calculation of risk-weighted assets and capital requirements respectively (Figure 5). The IRB approach enables us to use the bank's own estimates of risk parameters such as probability of default, loss given default or exposure at default. Then, in 2014, the CRR came into effect. The regulation, among others, recalibrated risk weights used by banks in STA to better reflect the risk of the respective asset.

Table 3: Estimation results – effect during LIRE

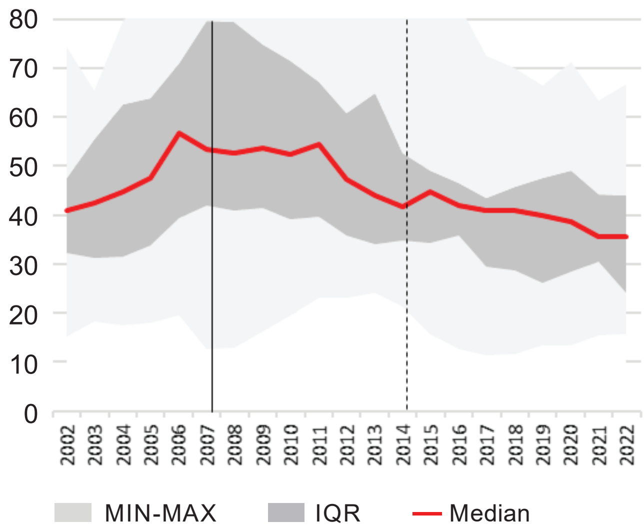
Dependent variable	RORWA	RAROC	rNIM
Independent variables	13	14	15
Dependent variable$_{t-1}$	0.460*** (0.123)	0.520*** (0.091)	0.647*** (0.073)
RWATA	−0.040*** (0.013)	−0.304* (0.166)	−0.042*** (0.016)
LIRE	−1.785*** (0.581)	−13.548** (6.170)	−1.396** (0.567)
RWATA × LIRE	0.020* (0.011)	0.197 (0.140)	0.015 (0.011)
ln_TA	−12.616 (11.325)	−11.670 (195.816)	10.534 (9.883)
ln_TA_sq	0.234 (0.232)	0.179 (3.987)	−0.232 (0.204)
LTA	−0.026** (0.010)	−0.444** (0.197)	−0.025** (0.012)
EAR	0.068 (0.061)	0.300 (0.783)	0.104 (0.068)
LDR	0.014 (0.009)	0.181* (0.100)	0.011 (0.008)
DER	−0.019 (0.021)	−0.112 (0.373)	0.010 (0.027)
LATA	−0.005 (0.013)	−0.431** (0.218)	−0.009 (0.012)
NII	−0.007 (0.007)	−0.084 (0.103)	0.036*** (0.009)
NFCI	−0.014 (0.011)	−0.186 (0.156)	−0.013 (0.011)
CIR	−0.040*** (0.008)	−0.436*** (0.128)	−0.022** (0.010)
MS	0.015 (0.255)	−0.515 (3.743)	0.095 (0.241)
HHI	0.000 (0.001)	−0.001 (0.017)	0.002 (0.002)
rGDP	−0.143** (0.061)	−3.86*** (1.343)	−0.209** (0.084)
DEF	0.087 (0.111)	0.484 (1.513)	0.294* (0.154)
STR	0.091 (0.064)	2.631** (1.307)	0.199** (0.098)
YCS	−0.184 (0.062)	0.402 (1.201)	−0.122 (0.047)
Bank fixed effects	YES	YES	YES
No. of banks	18	18	18
Observations	308	268	308
Hausman test	68.77***	27.72**	90.16***

Note: The table presents coefficients from the BCLSDV estimation of Equation (2). Bootstrapped standard errors in parentheses. Fixed effects not reported. Results of Hausman test for standard FE and RE estimation presented. ***, **, * denote significance at 1%, 5% and 10% levels.

Source: author

These regulatory changes should have made the risk estimation more precise, which in turn should allow us to track the risk-return link more accurately. On the other hand, the IRB estimates are still subject to a number of issues that make it difficult to properly capture the risk level (refer to Section 2), while standardized risk weights are not granular enough to do it either. Thus, I estimate Equation (3) to verify whether the risk-return link changed once these regulatory changes were introduced. The results are presented in Table 4.

Figure 5: Risk weights (risk density) of Czech banks



Note: Solid line marks IRB enabling; dashed line marks CRR application.

Source: Annual reports, Amadeus, Orbis Europe, author

The results show that including any of the dummies, the risk-RAPM link becomes significant for all three measures. Nevertheless, apart from RAROC in the case of the CRR, the relationship between risk and the RAPMs did not differ significantly once the regulatory changes were introduced. The majority of the other statistically significant results from the baseline estimation were confirmed.

Table 4: Estimation results – effect after IRB and CRR introduction

Dependent variable	RORWA	RAROC	rNIM	RORWA	RAROC	rNIM
Independent variables	**16**	**17**	**18**	**19**	**20**	**21**
Dependent variablet–1	0.387*** (0.109)	0.442*** (0.096)	0.618*** (0.098)	0.503*** (0.136)	0.420*** (0.087)	0.636*** (0.066)
RWATA	−0.054*** (0.014)	−0.655*** (0.228)	−0.057** (0.022)	−0.037*** (0.014)	−0.551*** (0.153)	−0.045*** (0.016)
IRB	−2.302*** (0.773)	−28.771*** (10.537)	−2.187** (0.882)			
RWATA × IRB	0.010 (0.010)	0.126 (0.123)	0.017 (0.011)			
CRR				−0.927** (0.372)	−23.883*** (3.718)	−0.806** (0.366)
RWATA × CRR				−0.001 (0.009)	0.171** (0.080)	−0.004 (0.009)
ln_TA	−21.075 (13.707)	−91.045 (210.334)	5.295 (15.899)	−6.941 (13.609)	−74.659 (192.344)	12.966 (8.538)
ln_TA_sq	0.396 (0.282)	1.683 (4.285)	−0.132 (0.324)	0.102 (0.276)	1.211 (3.875)	−0.298* (0.175)
LTA	−0.013 (0.009)	−0.312* (0.188)	−0.012 (0.008)	−0.008 (0.009)	−0.184 (0.172)	−0.009 (0.010)
EAR	0.068 (0.044)	0.696 (0.470)	0.098 (0.060)	0.056 (0.056)	0.690 (0.651)	0.098 (0.062)
LDR	0.013* (0.008)	0.182* (0.095)	0.010 (0.009)	−0.001 (0.010)	0.026 (0.106)	−0.003 (0.009)
DER	−0.052** (0.025)	−0.550 (0.357)	−0.013 (0.035)	−0.027 (0.023)	−0.442 (0.305)	−0.004 (0.030)
LATA	−0.020 (0.012)	−0.448** (0.217)	−0.017 (0.010)	−0.005 (0.014)	−0.283 (0.193)	−0.010 (0.011)
NII	0.001 (0.007)	−0.033 (0.097)	0.041*** (0.011)	−0.012 (0.007)	−0.114 (0.099)	0.032*** (0.008)
NFCI	−0.019* (0.010)	−0.197 (0.181)	−0.019 (0.013)	−0.009 (0.010)	−0.277* (0.150)	−0.009 (0.012)
CIR	−0.045*** (0.009)	−0.453*** (0.123)	−0.025 (0.016)	−0.035*** (0.008)	−0.400*** (0.102)	−0.019* (0.010)
MS	0.023 (0.222)	−0.440 (3.495)	0.103 (0.220)	0.158 (0.264)	0.099 (3.060)	0.200 (0.184)
HHI	0.000 (0.001)	−0.036** (0.018)	0.002 (0.002)	0.002 (0.002)	0.031 (0.019)	0.004** (0.002)
rGDP	−0.593*** (0.114)	−8.622*** (2.421)	−0.523*** (0.089)	−0.239*** (0.065)	−3.539** (1.373)	−0.266*** (0.064)

DEF	0.232* (0.121)	3.116* (1.862)	0.392*** (0.139)	0.038 (0.117)	–1.036 (1.417)	0.227 (0.153)
STR	0.441*** (0.096)	4.920*** (–1.400)	0.466*** (0.095)	0.410*** (–0.090)	4.220*** (1.243)	0.441*** (0.089)
YCS	–0.051 (0.069)	1.612 (1.199)	–0.025 (0.061)	(–0.069) (0.065)	0.543 (1.222)	–0.032 (0.055)
Bank fixed effects	YES	YES	YES	YES	YES	YES
No. of banks	18	18	18	18	18	18
Observations	308	268	308	308	268	308
Hausman test	50.89***	48.27***	94.65***	36.82***	27.18*	44.45***

Note: The table presents coefficients from the BCLSDV estimation of Equation (3). Bootstrapped standard errors in parentheses. Fixed effects not reported. Results of Hausman test for standard FE and RE estimation presented. ***, **, * denote significance at 1%, 5% and 10% levels.

Source: author

Robustness and additional estimations

I perform several robustness or additional checks. The sample includes five building societies, whose business model differs from that of conventional banks. On average, the building societies achieved profitability comparable to that of the banks' during the respective period, but their risk was on average significantly lower (refer to Table A1 in Appendix). This can influence the results of the baseline model. Thus, I re-perform the baseline model only for the banks. The results, presented in Table 5, indicate that the effect (coefficient) is almost the same; however, its statistical significance was not confirmed.

As indicated in the previous sections, RWATA does not have to be the ideal risk measure for a number of reasons such as pro-cyclicality, risk insensitivity or notorious risk underestimation in the case of the IRB. To underpin the results, I estimate the baseline model using the Z-score as a risk proxy. Note that the higher the Z-score, the lower the risk. As shown in Table 5, the negative relationship between risk and risk-adjusted return was not confirmed for RORWA; however, a statistically significant negative link was found for RAROC and rNIM. The findings suggest that that less solvent banks (i.e., more risky banks with lower Z-scores) are more profitable on average, which points to at least partial validity of the risk-return trade-off in the case of the RAROC and rNIM measures.

While a number of RAPMs were used already in the baseline specification, I estimate the baseline model (given by Equation (1)) using two additional measures as a robustness check – RAROA and RAROE (see definitions in Table A2). Estimates in Table 5 show no significant relationship between risk and these two additional measures, pointing to potential validity of the risk-return trade-off.

Table 5: Estimation results – robustness and other estimations

Dependent variable	**RORWA**	**RAROC**	**rNIM**
Baseline model	**1**	**2**	**3**
Dependent variable$_{t-1}$	0.546*** (0.132)	0.550*** (0.087)	0.670*** (0.090)
RWATA	−0.073* (0.038)	−0.683 (0.726)	−0.105* (0.056)
RWATA_sq	0.000 (0.000)	0.004 (0.006)	0.001 (0.000)
Banks only	**22**	**23**	**24**
Dependent variable$_{t-1}$	0.396** (0.181)	0.357*** (0.076)	0.756*** (0.135)
RWATA	−0.071 (0.053)	−0.186 (0.474)	−0.048 (0.040)
RWATA_sq	0.000 (0.000)	0.001 (0.004)	0.000 (0.000)
Z-score as risk measure	**25**	**26**	**27**
Dependent variable$_{t-1}$	0.614*** (0.147)	0.560*** (0.085)	0.788*** (0.066)
Z-score	−0.009 (0.007)	−0.278** (0.111)	−0.012* (0.007)
Z-score_sq	0.000 (0.000)	0.001* (0.001)	0.000 (0.000)
Other risk adjusted profitability measures	**RAROA** **28**	**RAROE** **29**	
Dependent variable$_{t-1}$	0.572*** (0.098)	0.518*** (0.065)	
RWATA	0.032 (0.067)	0.005 (0.051)	
RWATA_sq	0.000 (0.001)	0.000 (0.000)	
Bank fixed effects	YES	YES	YES
Bank-specific variables	YES	YES	YES
Sector-specific variables	YES	YES	YES
Macro-specific variables	YES	YES	YES

Note: The table presents coefficients from the BCLSDV baseline estimation of Equation (1), the estimation of Equation (1) for banks only, the estimation of Equation (1) with Z-score used as a risk proxy and the estimation of Equation (1) using additional risk-adjusted profitability measures – RAROA and RAROE. Bootstrapped standard errors in parentheses. Fixed effects not reported. Results of Hausman test for standard FE and RE estimation presented. ***, **, * denote significance at 1%, 5% and 10% levels. Complete results are available upon reasonable request.
Source: author

4.3 Summary of results, discussion and further research opportunities

Returning to the research hypotheses, although there is some indication that the Czech banks with higher risk achieve higher returns, which would point to validity of the risk-return trade-off, I find evidence that the compensation that the Czech banks receive in return for the level of the undertaken risk might not be adequate or complete. This is supported by the finding of a statistically significant negative link between risk – measured by average risk weight – and the risk-adjusted profitability measures RORWA and rNIM. I show that a 1 pp increase in risk results in a decrease in RORWA by approximately 7 bps and a decrease in rNIM by 11 bps, when the short-term effect is considered. This equals to 3% and 2% of their average value across the sample and respective period. In the long-term, the effect is more than double for RORWA and almost triple for rNIM. Note that the absence of such a link would indicate absolute or complete validity of the risk-return trade-off. Further investigation showed that the results were primarily driven by credit risk. Although the link was not found for RAROC in the baseline model, I reject Hypothesis 1 that the risk-return trade-off was valid in full for the Czech banks in the considered period.

With respect to Hypothesis 2, I found a statistically significant effect of risk during the LIRE period that differs from the effect in normal times only for RORWA. The effect was lower approximately by a half during the LIRE period, though it was still negative. Therefore, I reject Hypothesis 2 of no effect of accommodative monetary policy on the Czech banks' risk-return relationship.

I also reject Hypothesis 3, although it was statistically confirmed that only in the case of RAROC did the link between risk and risk-adjusted profits differ after the CRR application.

As a by-product of the estimation, managerial or operational effectiveness (measured by the cost-to-income ratio) of the banks proved to be an essential bank-specific factor for the banks' risk-adjusted performance. A statistically significant negative link between the cost-to-income ratio and the RAPM was confirmed in almost all the model specifications, which means that with increasing managerial effectiveness, the risk-adjusted profitability increases.

Statistical significance in almost all the models was also confirmed for real GDP growth and short-term interest rate proxied by PRIBOR 3M. While increasing short-term rates tends to positively influence the RAPMs, the RAPMs seem to be rather countercyclical.

The results of the baseline model might be surprising given the historical profitability of the Czech banks at relatively low risk levels compared to their peers in other European countries. On the other hand, the Czech banking sector is quite concentrated with five largest banks accounting for over 60% of the total sector assets, while the rest of the sector is rather fragmented with a relatively large number of banks with heterogeneous business models and other credit institutions such as building societies, credit unions and foreign branches. High competition for the market share among the top market players may put some pressure on the price (interest rates charged on loans) and on undertaking more risks, influencing the risk-return relationship in the process. The same may apply to other banks as they strive to increase their market share. The business model heterogeneity of other banks can also result in varying risk exposure, which contributes to the complexity of the risk-return dynamics in the Czech conditions.

It is also important to keep in mind that used regulatory measure of risk does not have to precisely reflect the implicit risk level of the financial asset. It could still be the case that the risk measured by regulatory standards overestimates the implicit risk faced by the Czech banks (especially those that use the STA approach, which prevail in numbers on the Czech banking market), and thus the returns in the face of regulatory-measured risk might seem to be insufficient. In this sense, the result could be interpreted that the Czech banks' returns do not fully compensate for the regulatory-measured risk.

The risk-return trade-off can still hold for the Czech banks once the implicit value of risk is taken. The robustness and control checks, which did not use the regulatory measure of risk or use different RAPMs that are not adjusted by the risk measured in regulatory terms, support this view as they did not fully confirm the results of the baseline model.

There are several ways for further research to bring more clarity on the issue. Firstly, as suggested above, other measures of risk, together with other RAPMs could be used to make a more precise estimation. Regulatory measures of risk – standardized to some extent[7] – may prove to be less risk-sensitive. In practice, banks commonly use other metrics such as value at risk (VaR) or expected shortfall (ES) to estimate the risk of an individual transaction or portfolio that enable reflection of the bank's specifics. Besides, RAROC in this paper is based on a regulatory capital requirement instead of economic capital due to data unavailability. Use of banks' economic capital value could further contribute to the accuracy of the estimates.

Secondly, the risk and profitability measures are used at the level of the bank's whole portfolio. This approach is easy to implement as necessary data are available; however, at a portfolio level, some risks can be offset through diversification while others can be double-counted and

7 Even in the case of IRB approach, there is some kind of standardization, e.g., in the form of input floors on the risk parameters.

thus overestimated. Ideally, the banks estimate the risk and returns for each individual transaction (e.g., loan), whereby each new transaction should be, in terms of risk, viewed as an addition to the current risk level. The expected or required return of each transaction should then reflect the extent to which the new transaction contributes to the risk of the whole portfolio. Analysis at a more granular (transactional) level could thus yield more precise results.

Although a number of control variables were used for the estimation, other factors play a role in a bank's profitability that were not considered such as reputation, brand, customer experience and loyalty, management quality, corporate culture, and so on. Unfortunately, these are hard to objectively measure and to obtain, yet they can have a significant impact on the bank's performance. Including such variables in some form could enhance the estimation as well.

Lastly, the analysis could be extended to other markets and banking sectors as well. Such an analysis could bring additional clarity about potential cross-country differences or variances between different types of bank business models and/or different bank sector institutional settings.

Conclusion

Profitable banks are essential for a sound and resilient financial system. It is thus of great importance to various stakeholders. Banks take risks in the course of their business and, in order to sustain their profitability, they need to be adequately compensated for that risk.

In this paper, I examined whether the risk taken by the Czech banks during the period from 2002 to 2022 had paid off. I used various RAPMs and risk measures to estimate the link between the two. The absence of a relationship would imply that risks are properly reflected in the banks' returns. I further focused on potentially different effects during the LIRE periods and after major regulatory changes.

I found evidence that after controlling for a number of bank-specific, sector-specific and macroeconomic variables, the risk-adjusted profitability is significantly and negatively associated with the regulatory measure of risk, which points to invalidity of the risk-return trade-off. During the LIRE period, the effect was about a half lower, albeit still negative. However, when other (non-regulatory) measures of risk or risk-adjusted profitability were used, the association from the baseline model was not fully confirmed, suggesting that banks may still be adequately compensated in terms of the market measures of bank risk.

The presented findings contribute to the literature in a number of ways. They add to the literature on the determinants of risk-adjusted profitability, a neglected area of research, and also to the literature focusing on the validity of the risk-return trade-off for banks. The paper also adds to the literature on the impacts of accommodative monetary policy on bank profitability. Using different risk and return measures and a different time period, the paper complements the research into performance of Czech banks. The presented result on the risk-return trade-off might be of interest to supervisors when assessing the financial stability and sustainability of individual banks and the banking sector as a whole.

Further research opportunities lie in the use of more risk-return sensitive measures, which could be accompanied with a more granular approach to the analysis, ideally at the level of individual bank transactions. A wider demographic scope could also yield interesting results and bring more clarity on the issue.

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Appendix

Table A1: Sample overview

Bank			Average profitability over 2002–2022			Average risk over 2002–2022	
	Type	Total assets as at end 2022	ROA	ROE	NIM	RWATA	Z-score
		million CZK	%	%	%	%	-
Česká spořitelna	Bank	1 565 461	1.51	18.07	2.98	48.80	48.80
Československá obchodní banka	Bank	1 680 075	1.33	20.03	1.99	36.79	36.79
Komerční banka	Bank	1 228 892	1.60	17.05	2.58	45.74	45.74
UniCredit Bank	Bank	756 090	1.02	10.76	1.92	65.12	65.12
Fio banka	Bank	229 428	0.56	15.14	0.61	21.73	21.73
J&T Banka	Bank	220 172	1.48	12.50	2.43	73.12	73.12
MONETA Money Bank	Bank	370 175	2.74	14.47	5.60	77.72	77.72
PPF banka	Bank	288 650	1.65	23.45	1.95	40.26	40.26
Raiffeisenbank	Bank	601 326	0.80	10.29	2.63	55.59	55.59
Air Bank	Bank	152 004	–0.39	2.75	1.17	44.81	44.81
Banka CREDITAS	Bank	95 012	0.12	1.66	0.46	39.35	39.35
Max banka	Bank	33 077	0.15	1.40	2.01	60.11	60.11
TRINITY BANK	Bank	63 965	0.10	1.37	0.36	42.14	42.14
ČSOB stavební spořitelna	Building society	137 368	0.85	16.32	1.59	26.72	26.72
Modrá pyramida stavební spořitelna	Building society	101 687	0.89	14.96	1.70	32.55	32.55
MONETA stavební spořitelna	Building society	33 662	0.85	14.61	1.94	43.57	43.57
Raiffeisen stavební spořitelna	Building society	77 286	0.66	13.69	1.37	30.78	30.78
Stavební spořitelna České spořitelny	Building society	71 495	0.99	19.10	1.54	24.15	24.15
Total		**7 705 824**	**0.94**	**12.65**	**1.94**	**45.94**	**44.36**

Note**:** Air Bank ROA and ROE influenced by the losses at incorporation of the bank in 2011. Average ROA and ROE for PPF banka influenced by high dividend income in 2003.

Source**:** Annual reports, Amadeus, Orbis Europe, author

Table A2: Variables – definitions

Variable	Measure	Notation
Dependent variables		
Risk-adjusted return on assets	Refer to Equation (4).	RORWA
Risk-adjusted return on capital	Refer to Equation (5)–(7).	RAROC
Risk-adjusted net interest margin	Refer to Equation (8).	rNIM
Operating return on risk weighted assets	Operating profit for the period to average volume of risk weighted assets for the period, where average is calculated as sum of start and end balance divided by 2.	ORORWA
Risk-adjusted return on assets	ROA divided by standard deviation of ROA over preceding 3 years (i.e., 12 quarterly observations), where ROA equals net profit for the period to average volume of total assets calculated as sum of start and end balance divided by 2.	RAROA
Risk-adjusted return on equity	ROE divided by standard deviation of ROE over preceding 3 years (i.e., 12 quarterly observations), where ROE equals net profit for the period to average volume of total capital calculated as sum of start and end balance divided by 2.	RAROE
Independent variables		
Bank-specific		
Total risk	Total risk-weighted assets to total assets at end of period.	RWATA
Total risk	RWATA squared to test for potential non-linearity.	RWATA_sq
Credit risk	Total risk-weighted assets for credit risk to total assets at end of period.	RWACRTA
Market risk	Total risk-weighted assets for market risk to total assets at end of period.	RWAMRTA
Operational risk	Total risk-weighted assets for operational risk to total assets at end of period.	RWAORTA
Solvency	Refer to Equation (9).	Z-score
Solvency	Z-score squared to test for potential non-linearity.	Z-score_sq
Size	Natural logarithm of total assets at end of period.	ln_TA
Size	ln_TA to test for potential non-linearity.	ln_TA_sq
Asset structure	Total loans to total assets at end of period.	LTA
Capitalization	Total capital to total assets at end of period.	EAR
Maturity transformation	Total loans to total deposits at end of period.	LDR
Liability/funding structure	Total debt to total equity at end of period, where debt are bank's total liabilities.	DER
Liquidity	Liquid assets to total assets at end of period, where liquid assets comprise cash and cash equivalents, deposits at central banks, other on-demand deposits, and financial assets held for trading.	LATA

Profit and loss structure	Net interest income for the period to total operating income for the period.	NII
Profit and loss structure	Net fee and commission income for the period to total operating income for the period.	NFCI
Operational (managerial) effectiveness	Cost to income ratio as administrative and depreciation expenses for the period to total operating income for the period.	CIR
Sector-specific		
Market share	Total assets of a bank at end of period to total assets of banking sector at end of period.	MS
Concentration	Herfindahl–Hirschman index.	HHI
Macro specific		
Business cycle	Real GDP growth rate deflated by GDP deflator, seasonally adjusted.	rGDP
Price level	GDP deflator.	DEF
Financial cycle	Bank credit to GDP gap. Difference between credit-to-GDP ratio and its long-run trend. Credit from all sectors to private non-financial sector.	CGDP
Short term interest rate	PRIBOR 3M.	STR
Slope of the yield curve	Difference between interest rate on long-term and short-term debt approximated by spread between PRIBOR 3M and 10y Czech government bond yield.	YCS

Note: Dummy variables not included.

Table A3: Variables – summary statistics

Variable	Units	Min.	Average	Median	Max.	St. dev.	No. of obs.
Dependent variables							
RORWA	%	–3.66	2.49	2.36	12.33	1.8	327
RAROC	%	–27.42	35.40	30.90	190.91	24.1	286
rNIM	%	0.68	4.85	4.74	16.27	2.0	327
ORORWA	%	1.76	6.90	6.59	20.91	2.8	327
RAROA	%	–2.24	4.87	3.89	28.47	4.1	300
RAROE	%	–2.71	4.48	3.78	19.20	3.3	300
Independent variables							
Bank-specific							
RWATA	%	11.40	45.94	42.96	102.56	19.62	327
RWACRTA	%	9.30	41.44	38.86	97.65	18.52	327
RWAMRTA	%	0.00	1.24	0.34	14.31	1.92	327
RWAORTA	%	0.40	4.07	3.67	11.52	1.88	327
Z-score	-	0.50	44.36	35.05	235.61	34.09	300
TA	bn. CZK	3.35	269.55	103.71	1 680.07	353.29	327
LTA	%	22.93	64.91	66.70	93.75	17.66	327
EAR	%	1.54	8.42	7.72	28.67	4.22	327
LDR	%	12.68	66.47	68.04	123.30	23.76	327
DER	%	2.49	13.96	11.95	63.84	8.34	327
LATA	%	0.17	11.83	5.91	56.23	12.22	327
NII	%	13.99	72.24	70.92	133.24	15.30	327
NFCI	%	-14.25	19.52	18.71	75.35	10.79	327
CIR	%	16.15	52.31	47.58	212.40	20.74	327
Sector-specific							
MS	%	0.20	5.41	2.30	22.11	6.44	327
HHI	%	1 366.96	1 551.26	1 521.55	1 867.51	116.77	376
Macro specific							
rGDP	%	–1.05	1.26	1.40	3.70	1.19	376
DEF	%	–1.40	0.20	0.30	1.60	0.69	376
CGDP	%	–4.40	6.11	2.90	18.00	7.60	376
STR	%	0.29	1.97	1.92	7.27	1.64	376
YCS	%	–2.16	0.94	0.89	2.61	1.16	376

Source: Annual reports, Amadeus, Orbis Europe, ARAD, BIS Data Portal, author