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Bank Risk-Taking and Deposit Price in Times of Low Economic Activity: Relevance or Irrelevance of Capital Requirements?

Abstract

This paper investigates the influence of bank capital regulation on their portfolio risk and deposit financing costs, assuming that the regulatory burden of capital requirements might trigger adverse effects on bank asset riskiness, regardless of the potentially positive impact on lowering deposit price. Data for the Croatian banking sector in the 2011-2019 time span served as an input for the dynamic panel analysis. The results confirm that banks with higher capital ratios do not have lower deposit financing costs, but tend to make risky investments to compensate their shareholders for the demand for additional funds. In addition, bank size, previous credit risk materialization, and higher economic growth reduce asset riskiness exposure, while bank profitability (net interest margin) is consistent with risk-taking behaviour. Deposit price is positively influenced by the interbank market conditions, while return on equity and portfolio risk have a negative impact. All in all, there is solid evidence that the capital requirements regulation significantly alters bank business indicators, more precisely bank asset riskiness. However, remarks about its counterproductive effects on banking stability require more convincing and comprehensive evidence against the capital buffer theory. The unavailability of data has prevented us from disaggregating bank riskiness by type and using composite measures such as the risk index. Nevertheless, this research is one of the few for the Croatian banking sector in the area of microeconomic consequences of the adjustment to capital requirements.

Keywords: capital requirements, banking regulation, risk-taking, deposit price, dynamic panel analysis

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1. INTRODUCTION

Banking stability is a public good. Thus, the prevention of bank failures and their spillover effects to the rest of the economy falls within the scope of public regulation. Nevertheless, they still occur more or less frequently in the banking market. According to Slattery and Nellis (2011), this could be the result of 1) insufficient regulation or a prevalence of the financial liberalization (known as the market failure approach) and 2) inadequate regulation due to bounded rationality of regulatory authorities and/or their focus on private, rather than public interests (known as the state failure approach). However, even appropriate levels of regulation, robust capacity and good intentions of regulators can lead to unintended evils, such as counterproductive regulatory instruments. In such a manner, this paper analyses the consequences of capital requirements regulation on the price of bank deposits and the riskiness of assets.

Since the late 1980s, when risk-based capital requirements for internationally active banks were first introduced, numerous attempts have been made to discredit their usefulness and effectiveness for the safety and soundness of the banking sector, both by academia and the representatives of the banking industry. Namely, in order to comply with the required capital ratios, banks generally have to raise additional equity, retain a certain portion of their earnings or/and change the structure and level of their risk exposures. In any case, regulatory compliance increases banks' costs, leads to missed opportunities, such as cheaper equity funding and more satisfied shareholders, and limits the risk-taking. Thus, regulatory struggle phenomenon occurs (Kane, 1977), and the behaviour of banks under regulatory pressures will be the most opportunistic. The interdependence of bank's capital position and risk profile remains the most studied area within this topic, usually upholding the conclusions of either the moral hazard theory or the capital buffer theory.

According to the moral hazard theory, banks will transfer increased regulatory costs to their clients by raising the credit price, which means that they accept riskier clients and increase the probability of their moral hazard (Koehn and Santomero, 1980; Kim and Santomero, 1988; Gennotte and Pyle, 1991; Rochet, 1992; Blum, 1999). Thus, rather than contributing to the stability of the banking sector, capital requirements could be counterproductive and undermine it, because although they reduce banks' financing risks by increasing their solvency, they could, at the same time, radically increase their credit and overall business risk. In contrast, the capital buffer theory (Marcus, 1984; Milne and Whalley, 2001) argues for the implementation of capital requirements and promotes conclusions about the prudent behaviour of banks under the regulatory pressure, as banks build up and consume their capital in a way that not only minimizes their potential regulatory compliance issues in the future, but also satisfies their shareholders' interests. According to the latter theoretical approach, the additional accumulation of risk should not be qualified as hazardous behaviour if there is a sufficient pledge against it in bank capital buffers, i.e. a surplus over the prescribed capital ratios.

The empirical results on the impact of bank capital regulation on risk-taking are mixed and vary depending on the banking sector and the observed time span, as usual. For some countries, they are still missing or are outdated. For example, the capital-to-risk relationship of Croatian banks for the 1999-2006 period was analysed by Kraft (2009), while some extended data evidence for the Croatian banking sector goes up to the year 2010, but is included in the cross-country analysis of the South-Eastern European economies provided by Kundid Novokmet (2021). To our best knowledge, this is the first empirical estimation of the impact of capital regulation on the risk exposure of the Croatian banking sector, which takes into account the period of low economic activity after the global financial crisis. Based on the capital buffer theory, we have established the first hypothesis – *H.1: Higher regulatory capital contributes to an increase in the asset riskiness of banks in Croatia.*

Furthermore, this paper contributes to the literature on the impact of capital requirements on the funding costs, more precisely on deposit prices. According to the market discipline hypothesis, higher levels of regulatory solvency should be associated with lower deposit financing costs, as financial and bankruptcy risks are lower. Fonseca, González and Pereira da Silva (2010) reached similar conclusions for more than 2,300 banks in 92 countries worldwide for the 1990-2007 period. Our research provides the first comparable evidence in the area of deposit financing costs for the Croatian banking sector, which is why the following hypothesis is established – *H.2: Higher regulatory capital contributes to a decrease in deposit prices of banks in Croatia.*

The remainder of the paper is organized as follows. Section 2 reviews the literature on capital requirements as a key determinant of banks' risk-taking behaviour and funding costs. The third section discusses the methodology used, the data and the empirical results, while section 4 concludes the paper.

2. LITERATURE REVIEW

The methodological framework for examining the bank risk-taking behaviour under the capital requirements regulation was initially introduced in the seminal paper of Shrieves and Dahl (1992). Since then, numerous empirical estimations have replicated their research pattern. According to Shrieves and Dahl (1992), changes in the bank risk posture ($\Delta RISK_{j,t}$) are driven by endogenous, controllable or discretionary adjustments ($\Delta RISK^{M}_{jt}$) and exogenous factors ($\tilde{U}_{j,t}$) or

$$\Delta RISK_{j,t} = \Delta RISK^{M}_{j,t} + \tilde{U}_{j,t} \tag{1}$$

Discretionary changes in risk ($\Delta RISK^{M}_{j,t}$) are determined by the difference between the target risk ($RISK^{*}_{j,t}$) and the initial risk ($RISK_{j,t-1}$) or the risk level in the previous period:

$$\Delta RISK^{M}_{j,t} = \beta\left(RISK^{*}_{j,t} - RISK_{j,t-1}\right) \tag{2}$$

Finally, the following equation results:

$$\Delta RISK_{j,t} = \beta\left(RISK^{*}_{j,t} - RISK_{j,t-1}\right) + \tilde{U}_{j,t} \tag{3}$$

where β is the adjustment speed for the risk.

Using the data sample of almost 1,800 large and insured US commercial banks in the pre-Basel I period, from 1983 to 1987 to be precise, Shrieves and Dahl (1992) documented that an increase in the equity to assets ratio enhances the risk-weighted assets to total assets ratio, for both adequately and insufficiently capitalized banks. Rime (2001) considered around 150 Swiss banks in the 1989-1995 period, and found no evidence about capital requirements and bank risk-seeking behaviour. Similarly, Van Roy (2008) demonstrated limited effects of capital requirements on the credit risk level for the majority of observed G-10 countries from 1988 to 1995. In contrast, Cannata and Quagliariello (2006) again reported on the importance of capital requirements for asset riskiness of 500 Italian banks in the 1994-2003 period, especially for the well-capitalized banks, which reduced their business risk faster than the low-capitalized banks. In order to increase their regulatory solvency ratios and comply with regulatory requirements, low-capitalized banks relied more on capital build-up and less on risk reduction. However, based on the evidence for 570 savings banks in Germany in the 1993-2004 period, it was found that low-capitalized banks simultaneously reduced their asset risk and increased their capital, while well-capitalized banks used their excess capital for risk accumulation (Stolz, 2007). An analysis of the Croatian banking sector in the 1999-2006 period conducted by Kraft (2009) revealed that only moderately capitalized large banks increased their portfolio risk, while low and well-capitalized banks did not engage in such a behaviour. In summary, it can be said that the initial level of bank capital can lead to risk-averse (usually for low-capitalized banks) or risk-taking behaviour (usually for adequately and well-capitalized banks) or that there are no notable changes in risk levels at all.

Apparently, the differences among banks in terms of the risk-taking practice under the regulatory capital regime might be context-driven. For example, banks in the EU-15 are more conservative in assuming credit risk after complying with capital requirements than US banks in the period 2000-2005, as compared by Matejašák, Teplý and Černohorský (2009). A more recent study covering almost 600 banks in the

EU-27 from 2006 to 2011 (Šútorová and Teplý, 2014) shows that banks have not increased their asset riskiness in parallel with their capital increase. On the other hand, monetary instability, excessive economic growth and poor quality of regulatory enforcement contribute to bank risk-taking behaviour, regardless of the capital requirements regulation (Delis, Tran and Tsionas, 2012).

With regard to bank-specific factors, Camara, Lepetit and Tarazi (2013) evidenced that it is not the level of a bank's regulatory solvency but its composition, i.e. its structure, that plays a pivotal role in shaping the bank portfolio risk. By observing more than 1,400 commercial, cooperative, mutual and savings banks in 17 European countries in the 1992-2006 period, they found that banks with lower core capital and higher subordinated debt exhibit riskier behaviour. Li (2021) came to the same conclusions for more than 7,600 banks in 118 countries in the period from 2001 to 2016, according to which banks with a higher core capital ratio were more risk-averse, and those with a higher subordinated debt ratio were risk-takers, which was especially highlighted in a more competitive conditions as well as during the global financial crisis. Kundid Novokmet (2021), in a cross-country analysis for South-Eastern Europe from 2000 to 2010, concluded that capital buffers (a surplus in the regulatory capitalization ratio) are more important than a certain level and structure of regulatory capital to increase bank asset riskiness and to reduce the overall risk.

Overall, there is solid empirical evidence that a higher regulatory capital might encourage risk-taking behaviour of retail (commercial) banks. However, this should not be considered necessarily as a hazardous behaviour, nor speak in favour of this regulatory instrument counterproductivness. Rather, it could support the conclusions of the capital buffer theory, according to which regulatory capital is built up to be employed for the subsequent asset growth and as an adequate collateral for the associated asset risks. Furthermore, higher asset riskiness should be compensated by a higher return, making the banking business more profitable. In this context, the impact of capital requirements on bank profitability and in particular on its net interest margin were estimated several times (e.g. Naceur and Kandil, 2009; Bitar, Saad and Benlemlih, 2016; Boubakri, Mirzaei and Samet, 2017), but differentiation between the loan and deposit price (which largely contribute to the bank net interest margin) is less common. This is important because one of the expected benefits of adopting capital requirements is higher solvency, which should lower bank risks associated with debt financing. Although the cost of equity is expected to increase, other financial sources have a better chance of repayment if the bank's shareholders put more of their "skin in the game".

Toader (2015), for example, demonstrated a positive impact of core capital on the reduction of average funding costs for 65 publicly listed commercial, universal and investment banks in Europe between 1997 and 2011. However, most retail bank deposits are covered by the deposit insurance scheme, which is why the market discipline of these depositors is usually inconspicuous. Thus, although it would be reasonable to presuppose that higher capital requirements reduce deposit financing costs, this may not be the case if there are dormant depositors and/or disrupted conditions in the interbank market, which usually have a huge impact on deposit interest rates, i.e. on their repricing policies (for further discussion see e.g. Männasoo, 2013 and Verga and Vasilcovschi, 2019). Nevertheless, there is some empirical evidence that the declining deposit price is one of the benefits of enforcing capital regulations. Fonseca et al. (2010) reported on the positive impact of capital requirements on lowering deposit prices in the pre-Basel II period for more than 2,300 banks worldwide. In contrast, Ehrenbergerová, Hodula and Gric (2022) found no conclusive evidence that banks in the Czech Republic changed their pricing policies due to compliance with capital requirements in the period 2004–2019. A weak effect was only found for household deposits, as a one-point increase in capital requirements was accompanied by a 7-basis point decrease in deposit rates for households. Surprisingly, this result was not confirmed for the deposit rates for non-financial corporations, which are expected to impose greater market discipline.

3. DATA, METHODOLOGY AND RESULTS

The empirical estimation of the impact of capital regulation on the bank risk-taking and deposit prices was carried out on the data sample consisting of 20 retail/commercial banks in the Croatian banking sector in the period from 2011 to 2019. We only considered banks that were operating continuously during the observed period. This means that we excluded four banks that were closed due to insolvency in the period from 2012 to 2016, as well as several small banks that were taken over by large banking groups. Namely, banks that go bankrupt usually hide their losses, underestimate risks, collect deposits at high interest rates to gamble for resurrection, and give false impression of being solvent for a period of time. Since this paper deals with the relationships between solvency – risk and deposit prices, it was necessary to exclude bankrupt banks due to potential data inaccuracy and outliers in the data for the year of bankruptcy, i.e. simultaneous insolvency followed by high risk of assets and deposit price. In addition to the failed banks, we also deliberately excluded the acquired banks in order to obtain a balanced panel data set. Finally, business data continuity was also important from the perspective of using lagged variables. Due to the COVID-19 outbreak in 2020 and pandemic business circumstances in the following two years, we ended our data set with the year 2019. As in other countries, the Croatian National Bank granted the banking sector additional liquidity support and at the same time relaxed or even suspended some of the usual supervisory measures. For example, it allowed moratoria on loan repayments, extended the possibilities for loan restructuring and restricted the banks' dividend policy (mandatory retention of net income), to mention just a few, examples that could lead to biased results overall.

Bank-specific variables were calculated from the banks' annual financial reports, published on their official websites (Table 1). Bloomberg served as the data source for calculating an annual average of the 6-month LIBOR rates in euros, while the GDP growth rates were taken from the Croatian National Bank's website. We used the 6-month LIBOR rate in euros as the reference, as interbank deposits in the Croatian banking sector are predominantly agreed in euros, with a 6-month repricing period (Ercegovac and Kundid, 2011).

Risk-weighted assets to total assets ratio (RWA) was used as the dependent variable in the models, which estimated the effect of capital regulation on bank asset riskiness with regard to the H-1 hypothesis. Interest expenses over total deposits indicator (DEPPRICE) was used in the models measuring the impact of bank solvency on its deposit price, which is related to the H-2 hypothesis. Capital regulation (SOLV) was measured using the following variables: 1) equity to assets ratio (CAP), 2) capital adequacy ratio (ADEQ), 3) tier 1 ratio (TIER1ADEQ), and 4) capital quality ratio (CAPQUAL). Measuring asset riskiness, deposit price and bank capital in this way is almost a standard in the empirical literature on capital requirements, and we have simply followed this practice. The list of control variables included bank size (ASSETS), profitability indicators (NIM and ROE), asset quality/credit risk ratio (NCO), money market conditions (LIBOR), and the macroeconomic environment (GDPG). The latter were selected parsimoniously by taking into account the sample size and data availability, whereby most of the reviewed articles were taken into account.

According to the descriptive statistics (Table 2), the mean value of the asset riskiness indicator was around 63%, with a standard deviation of almost 11 percentage points. The average value of Tier 1 ratio (16.4%) is close to the average value of the capital adequacy ratio (18.2%), with minimal differences in the standard deviation. From this, it can be concluded that the regulatory capital requirements for banks in Croatia are largely met by core equity capital and are significantly above the minimum standard of the EU regulation. Similarly, the mean values of the equity to assets ratio (11.2%) and the capital quality ratio (10.2%) correspond to each other. With regard to bank profitability, the net interest margin was on average 2.6% in the 2011-2019 period, while the mean value of the return on equity was -1.38%. The latter is a result of the global financial crisis and the losses of smaller banks in particular, although some years were unprofitable even for some large banks. Loan

Table 1. Definition of the variables used in the regression models

Variable	Definition	Group of variables
RWA	Risk-weighted assets / Total assets	Asset riskiness indicator
DEPPRICE	Interest expense / Total deposits	Deposit price
CAP	Equity / Total assets	Capital structure indicator
ADEQ	Capital adequacy ratio = Regulatory capital / Risk-weighted assets	Regulatory capital ratio
TIER1ADEQ	Tier 1 ratio = Core equity capital / Risk-weighted assets	Regulatory capital ratio
CAPQUAL	Capital quality ratio = Core equity capital / Total assets	Regulatory capital ratio
ASSETS	Ln (Total assets)	Bank size indicator
NIM	Net interest margin = (Interest income – Interest expense) / Total assets	Bank profitability indicator / Cost of banking intermediation
NCO	Loan charge offs / Total loans	Asset quality indicator
ROE	Return on equity = Net income / Total equity	Bank profitability indicator / Shareholders' profitability
GDPG	Real annual GDP growth rate	Macroeconomic indicator
LIBOR	London Interbank Offered Rate (average annual)	Benchmark interest rate on the interbank market / Market conditions indicator

Notes: All variables are expressed in percentage (%), except for the ASSETS variable, which is a natural logarithm of total assets in Croatian kuna. Capital regulation is labelled as SOLV variable in the basic model formula, where RWA and DEPPRICE appear as dependent variables. CAP, ADEQ, TIER1ADEQ and CAPQUAL are used interchangeably as SOLV variable in the models.

Source: Authors' calculation

charge-offs were on average 2%. GDP growth was negative in the 2011-2014 period, with the highest decline of -2.4% in 2012. It started to recover in 2015 and peaked at 3.5% in 2016. The deposit price was approximately 2.64% for the observed data set, although the discrepancy between the minimum value (0.1977%) and the maximum value (6.52%) was still very large. LIBOR was on average 0.21%, but with enormous volatility of 1.59% in 2011, which was followed by its continuous decline to even negative values from 2016 to 2019. The mean value of the 6-month LIBOR rates in euros was -0.36% in 2019. Graph 1 depicts the mean values of the indicators for asset riskiness, deposit price and solvency for the period under review.

The dynamic panel data methodology is often used to obtain answers to the research topic presented. Indeed, the problem of the autoregressive process, which is typical for financial indicators, can be solved using the dynamic panel models, since they contain the dependent variable, which is lagged by one or more periods. The dynamic panel model is given by the equation:

$$y_{i,t} = \alpha + \gamma y_{i,t} \beta + \varepsilon_{i,t} \quad (4)$$

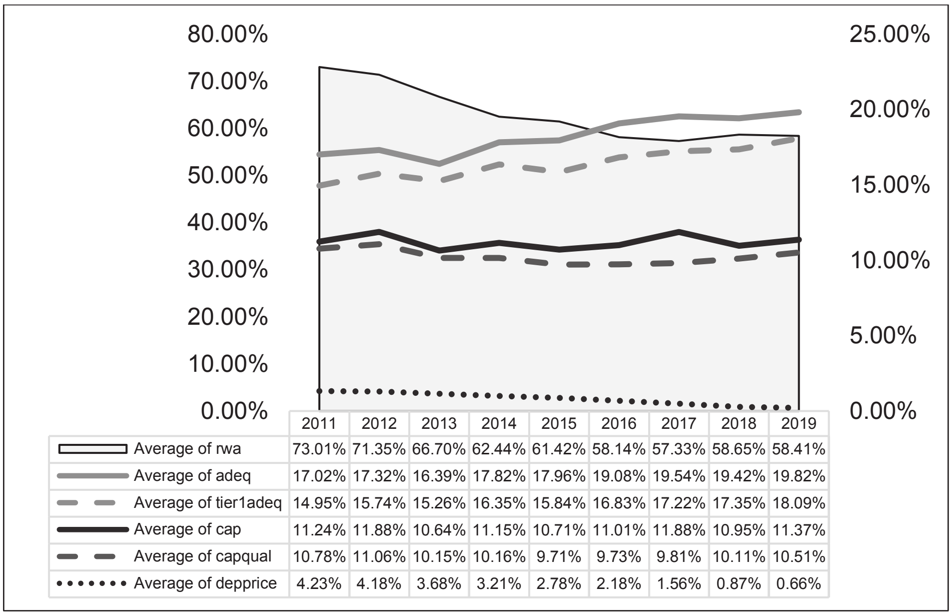
It is assumed that $\varepsilon_{i,t}$ are IID(0,σ_ε^2; identically and independently distributed error terms, where the dependent variable $y_{i,t}$ is asset riskiness (RWA) or deposit price (DEPPRICE) indicator, while $y_{i,t-1}$ stands for the lagged dependent

Table 2. Descriptive statistics

Variable	Mean	St. deviation	Minimum	Maximum	Number of observations
RWA	63.18815	10.92482	33.06586	98.68634	175
DEPPRICE	2.6416106	1.4488885	0.1977246	6.5227018	175
CAP	11.20134	3.56674	-0.3919	25.59353	175
ADEQ	18.22313	4.63394	-4.18	32.79	175
TIER1ADEQ	16.3678	4.76965	-1.12	28.6	175
CAPQUAL	10.22703	3.12228	-0.66239	20.85839	175
ASSETS	22.60973	1.520205	20.08635	25.49084	175
NIM	2.61057	0.5925	0.88844	4.95437	175
NCO	1.97312	1.99793	-0.41053	14.6498	175
ROE	-1.38034	16.11863	-98.79886	15.73976	173
GDPG	1.252571	2.032461	-2.4	3.5	175
LIBOR	0.2119959	0.6033319	-0.3620749	1.593603	175

Source: Authors' calculation

Graph 1. The mean values of the indicators for asset risk, deposit price and solvency



Source: Authors' calculation

variable, $X'_{i,t}$ is K × 1 matrix of the explanatory variables (K – the total number of explanatory variables), $\beta = [\beta_1, \beta_2, \ldots, \beta_K]^T$ is the vector K × 1 of all the coefficients of the independent variables. Thus, all the $\beta_1, \beta_2, \ldots, \beta_K$ coefficients represent the short-term effects.

The basic model, when the asset riskiness is set as the dependent variable, is as follows:

$$RWA_{i,t} = \mu + \gamma \cdot RWA_{i,t-1} + \beta_1 \cdot SOLV_{i,t-1} + \beta_2 \cdot ASSETS_{i,t} + \beta_3 \cdot NIM_{i,t} + \beta_4 \cdot NCO_{i,t-1} + \beta_5 \cdot ROE_{i,t-1} + \beta_6 \cdot GDPG_{i,t} + \alpha_i + \varepsilon_{i,t},\ i = 1, \ldots N,\ t = 1, \ldots T \quad (5)$$

where i denotes an individual and t denotes time, μ is an intercept, γ is the parameter of the lagged dependent variable, $\beta_1, \beta_2, \ldots, \beta_K$ are the parameters of the exogenous variables, α_i is an individual-specific effect and $\varepsilon_{i,t}$ is the error term.

We used the lagged values of all solvency variables, the asset quality indicator and the shareholder profitability ratio to avoid the endogeneity problem. Namely, due to a small number of groups, those variables could not be treated as endogenous ones to solve the problem of reverse causality. Namely, risk-weighted assets are already part of certain regulatory capital ratios (ADEQ, TIER1ADEQ). If we want to capture some dynamics and the spillover effect of capital requirements (SOLV) on the asset riskiness in the following period, then using lagged values seems to be a reasonable solution. Materialization of credit risk (NCO) in the previous period will certainly have an impact on the bank's risk-posture in the following year, as will the shareholders' profitability (ROE), which is a factor in pricing loans as the main risky asset of retail banks. In order to draw conclusions about whether and how bank managers adjust asset riskiness based on the capital employed, its profitability and underlying credit risk, it was therefore necessary to track required lagging the values of those indicators.

In line with H-1, we assume that higher solvency ratios in the previous year will have a positive impact on the asset riskiness in the following year. Bank size (ASSETS) is expected to be inversely related to asset riskiness, as large banks have various risk management strategies and tools at disposal, such as better diversification opportunities, selection of prime clients, loan sales, use of derivatives, etc. In this context, Nguyen and Nghiem (2015) found an inverse U-shaped relationship between size and risk of Indian banks during the period 1994-2011. Large banks might accumulate more risk in the expansion phase, as they are also too-big-to-fail, but they can also get rid of the risk surplus faster than others in the economic downturn. Furthermore, there is solid empirical evidence of a positive influence of capital requirements on the net interest margin (e.g. Naceur and Kandil, 2009; Bitar et al., 2016; Boubakri et al., 2017), even for the Croatian banking sector (Kundid Novokmet and Pavić, 2021). If capital requirements increase both the banks' net interest margin and asset riskiness, then a positive relationship between net interest margin and asset riskiness is also presumed. A higher net interest margin will be reflected in a higher asset riskiness, especially if we expect the deposit price, i.e. interest expenses in relation to total deposits, to fall (H-2). If the net interest margin also increases as a result of the interest income segment, the bank will choose riskier and thus more interest-bearing assets. The opposite holds for the return on equity, as lower shareholders' profitability (due to higher equity financing) in one year should be compensated for by a higher asset riskiness in the following year and *vice versa*. Simply put, risk and return are mutually dependent when the higher costs of equity financing are transferred to bank clients i.e. to the net interest margin (NIM). We therefore expect an inverse relationship between shareholders' profitability and asset riskiness. NCOs represent an *ex-post* measure of bank credit risk as they reflect the materialization of credit risk. They are expected to be inversely related to asset riskiness because when NCOs are low, bank managers are relaxed and take more risks. A more cautious approach is required when NCOs are high. In this case, it is most logical to reduce asset riskiness and slow down credit growth, especially if the bank's capital ratios are close to the prescribed minimum and equity financing is proving less available and costly. Finally, poor macroeconomic achievement is likely to

Table 3. Correlation matrix for the asset riskiness model

	CAP	ADEQ	TIER1 ADEQ	CAP QUAL	ASSETS	NIM	NCO	ROE	GDPG
CAP	1.0000								
ADEQ	0.7251*	1.0000							
TIER1 ADEQ	0.8023*	0.8677*	1.0000						
CAP QUAL	0.9193*	0.7700*	0.8508*	1.0000					
ASSETS	0.5594*	0.5723*	0.6433*	0.5237*	1.0000				
NIM	0.2154*	-0.0311	0.0269	0.2264*	0.0051	1.0000			
NCO	-0.1788*	-0.2808*	-0.2454*	-0.1838*	-0.1389	0.0675	1.0000		
ROE	0.3229*	0.2970*	0.4006*	0.3297*	0.2708*	0.1684*	-0.6216*	1.0000	
GDPG	-0.0198	0.2078*	0.1458	-0.1073	0.0142	-0.0226	-0.1565*	0.1903*	1.0000

Notes: * indicate significance at 5%.

Source: Authors' calculation

discourage risk-seeking behaviour, while higher GDP growth rates should speed up asset risk accumulation. However, risks are usually underestimated in the period of economic expansion and overestimated in the recession. Therefore, the negative relationship between GDP growth and asset riskiness is also possible.

According to the correlation matrix (Table 3), there is no multicollinearity problem between the independent variables in the model specifications for asset riskiness, with the exception of the solvency ratios, which are thus introduced individually into the different models. All calculations were performed in STATA 17.

The differenced GMM estimator was used to fulfil the condition that the number of groups must be higher than the number of instruments, as the estimations could be biased in the opposite case. Table 4 shows the results of panel data estimations with the Arellano-Bond two-step estimator and one maximum lag. Nevertheless, panel data estimations using the system GMM estimator are also shown in the Appendix, although the basic model and the results differ slightly. Namely, when using the Blundell-Bond estimator, we did not lag any of the independent variables, as the system GMM already captures the first differences and levels of the model variables. Therefore, it was not necessary to lag the variables to reduce the endogeneity problem. In addition, the system GMM estimator (Blundell and Bond, 1998) can improve the performance of the usual Arellano-Bond estimator when the autoregressive parameter is moderately high (as in our case) and the number of time series observations is moderately small. Despite slight model differences and a barely larger number of instruments (21) than in the groups (20), the Blundell-Bond results are comparable to the Arellano-Bond estimations, with the exception of bank size and asset quality, which are no longer significant. Thus, we base our discussion on the Arellano-Bond estimations. Sargan tests for endogeneity and two autocorrelation tests AR(1) and AR(2) confirm that all the disclosed models are well specified. Most of the results obtained are in line with our expectations.

Table 4. Panel data estimations of the asset riskiness model with the differenced GMM estimator

Explanatory variable	Asset riskiness (RWA)			
L.RWA	0.528*** (0.0902)	0.629*** (0.0944)	0.591*** (0.0914)	0.543*** (0.0958)
L.CAP	0.00183 (0.166)	-	-	-
L.ADEQ	-	0.558*** (0.155)	-	-
L.TIER1ADEQ	-	-	0.301*** (0.0798)	-
L.CAPQUAL	-	-	-	-0.221 (0.307)
ASSETS	-0.146*** (0.0223)	-0.166*** (0.0246)	-0.163*** (0.0209)	-0.136*** (0.0247)
NIM	4.820*** (1.163)	4.784*** (1.250)	4.844*** (1.218)	4.748*** (1.151)
L.NCO	-0.195*** (0.0727)	-0.125** (0.0615)	-0.192*** (0.0554)	-0.196** (0.0928)
L.ROE	-0.00137* (0.000719)	0.00352** (0.00137)	0.000443 (0.000560)	-0.00215** (0.00108)
$GDPG_{i,t}$	-0.00511* (0.00262)	-0.00423* (0.00244)	-0.00407* (0.00236)	-0.00585** (0.00257)
constant	3.440*** (0.498)	3.733*** (0.522)	3.732*** (0.473)	3.234*** (0.554)
Number of observations	135	135	135	135
Number of banks	20	20	20	20
Number of instruments	14	14	14	14
Sargan test (p-value)	0.2719	0.3536	0.3566	0.2375
AR(1)	0.0589	0.0478	0.0469	0.0616
AR(2)	0.6051	0.8913	0.6098	0.6110

Notes: Standard errors in parentheses, significance levels at 10%, 5% and 1% are denoted by *, **, *** respectively.

Source: Authors' calculation

First, there is a high persistency in the asset riskiness (RWA) in the Croatian banking sector, as the estimated parameters of the lagged dependent variable are always positive and higher than 0.5. This indicates that the asset risk of banks cannot be adjusted easily or quickly and that it is highly dependent on the asset risk recorded in the previous year. The same was explained with high adjustment costs of a risk posture modification in some previous studies such as Rime (2001), Cannata and Quagliariello (2006) and Stolz (2007). In countries without securitization possibilities and a developing loan sales market, such as Croatia, this is even more pronounced. Secondly, regulatory capital (ADEQ and TIER1ADEQ) is positively related to asset riskiness of Croatian banks. Thus, we accept the H-1 hypothesis, as capital requirements contribute to asset risk accumulation. In short, higher capital requirements are likely to reduce financing risks and consequently the cost of debt financing. On the other hand, if equity financing costs increase, i.e. shareholder return on equity (ROE) decreases, they could encourage the risk-taking behaviour of bank managers when selecting portfolios in order to compensate for a fall in ROE. Furthermore, according to the capital buffer theory (Marcus, 1984; Milne and Whalley, 2001), regulatory capital surpluses are built up to allow for both asset and asset riskiness growth. For this reason, the obtained results should not be perceived as imprudent or hazardous behaviour, especially bearing in mind good regulatory solvency of Croatian banks. Normally, higher level of bank capital should serve as collateral for risk-taking behaviour and *vice versa*. If regulatory solvency gets close to the required minimum, banks must reduce their risk appetites. If they fail to do so, we can speak of the moral hazard behaviour.

Lower asset riskiness in associated with larger banks (ASSETS). This is in line with large banks having more opportunities within the financial risk management and attracting clients with a better credit capacity. They also tend to minimize their capital surpluses, which further limits their *ad hoc* risk-taking, especially in times of economic downturn. The opposite result was found for the South-Eastern European banks in the 2000-2010 period, when larger banks significantly increased their portfolio risk (Kundid Novokmet, 2021).

Next, there is a positive effect of the net interest margin (NIM) on RWA. Croatian banks embrace a traditional business model and the net interest margin is crucial for their profitability. When the net interest margin is rather high, credit price significantly exceeds the deposit price. Since the credit price reflects the clients' risk, it is clear why a higher net interest margin is associated with a higher asset riskiness. In short, banks which transfer regulatory burden on their clients (via higher interest rates on loans and lower interest rates on deposits), undertake higher risks (RWA). On the other hand, higher shareholder profitability (ROE) reduces asset risk, as their profitability increases *ceteris paribus* with a lower share of banking business. Thus, only by recapitalization (internal or external) shareholders can be in a position to embrace more risks and in that case return on equity drops. The latter explains the negative relationship between ROE and RWA. It is also consistent with the results for the solvency ratios. Materialized credit risk (NCO) reduces the risk-weighted assets (RWA) as charged-off loans are no longer included in the asset riskiness and bank capital (Leung, Taylor and Evans, 2015). In addition, higher NCOs in the previous year are a clear sign of increased credit risks, which reduces risk appetites, and makes bank managers more cautious and risk averse in the following period. In contrast, a decrease in the NCOs encourages bank managers to adopt risk-taking behaviour. Finally, a decline in the GDP growth increases the perception of risk and thus the RWA also increases. For this reason, GDPG and RWA are inversely related.

To illustrate the effect of regulatory capital on the deposit price we have set up the following model:

$$DEPRICE_{i,t} = \mu + \gamma \cdot DEPRICE_{i,t-1} + \beta_1 \cdot SOLV_{i,t} + \beta_2 \cdot ASSETS_{i,t} + \beta_3 \cdot ROE_{i,t} + \beta_4 \cdot RWA_{i,t} + \beta_5 \cdot LIBOR_{i,t} + \alpha_i + \varepsilon_{i,t},\ i = 1, \dots N,\ t = 1, \dots T \quad (6)$$

where i denotes an individual and t denotes time, μ is an intercept, γ is the parameter of the lagged dependent variable, $\beta_1, \beta_2, \dots, \beta_K$ are the parameters of the exogenous variables, α_i is an individual-specific effect and $\varepsilon_{i,t}$ is the error term.

Based on the theory of capital structure, higher solvency (SOLV) should be seen as a sign of the bank's safety and soundness and thus lower the interest rates on deposits (H-2). However, if there is no sufficient market discipline on the

Table 5. Correlation matrix for the deposit price model

	CAP	ADEQ	TIER1 ADEQ	CAP QUAL	ASSETS	ROE	RWA	LIBOR
CAP	1.0000							
ADEQ	0.7251*	1.0000						
TIER1 ADEQ	0.8023*	0.8677*	1.0000					
CAP QUAL	0.9193*	0.7700*	0.8508*	1.0000				
ASSETS	0.5594*	0.5723*	0.6433*	0.5237*	1.0000			
ROE	0.3229*	0.2970*	0.4006*	0.3297*	0.2708*	1.0000		
RWA	0.2482*	-0.1215	-0.2229*	0.3018*	-0.1772*	-0.1191	1.0000	
LIBOR	0.0141	-0.1871*	-0.1676*	0.0968	-0.0178	-0.1490	0.4833*	1.0000

Notes: * indicate significance at 5%.

Source: Authors' calculation

part of depositors due to a generous and explicit deposit guarantee scheme, we may fail to reach such conclusions. Next, we assume that larger banks (ASSETS), as they are too-big-too-fail, will have a lower deposit price (DEPPRICE), as will banks with a higher shareholders' profitability (ROE), which are perceived to be more stable. Higher asset riskiness (RWA) is expected to be covered by a higher regulatory capital and boost bank profitability, which should lower the overall risk premium demanded by depositors. In addition, higher asset riskiness is usually recorded in economic downturns, when central banks try to reverse the trend by lowering interest rates. In short, we expect a negative impact of bank size, return on equity and asset riskiness on the deposit price. Finally, the relationship between retail bank interest rates and market interest rates (LIBOR) should be positive. Namely, conditions in the interbank market normally have a direct and *ad hoc* impact on bank interest rates (Verga and Vasilcovschi, 2019), especially on interest rates on deposits, which in retail banking are usually short-term or one-year maturities and are therefore frequently repriced.

According to the correlation matrix (Table 5), there is no multicollinearity problem between the independent variables in the model specifications for the deposit price, with the exception of the solvency coefficients, which are thus included interchangeably in the different models. The differenced GMM estimator was used to satisfy the condition that the number of groups must be higher than the number of instruments, as the results could be biased in the opposite case. Table 6 contains the results of the panel data estimations with the Arellano-Bond two-step estimator and one maximum lag, while the panel data estimations with the system GMM estimator are presented in the Appendix. The Blundell-Bond estimations indicate an equal number of instruments and groups and minor differences in the estimated parameters (bank size is now significant). Diagnostic tests confirm a good specification of all the models presented. As before, our explanations for the Arellano-Bond estimations are given.

The lagged dependent variable is also highly persistent here, as the estimated parameters of the deposit price (DEPPRICE) are always positive and lie at around 0.7. This indicates that banks' deposits volume and their expenses are stable or change gradually over the years. The estimated parameters for the control variables

Table 6. Panel data estimations of the deposit price model with the differenced GMM estimator

Explanatory variable	Deposit price (DEPPRICE)			
L.DEPPRICE	0.705*** (0.0350)	0.716*** (0.0372)	0.705*** (0.0387)	0.711*** (0.0376)
CAP	-0.000763 (0.0113)	-	-	-
ADEQ	-	0.0161 (0.0222)	-	-
TIER1ADEQ	-	-	-0.00399 (0.0202)	-
CAPQUAL	-	-	-	0.0176 (0.0358)
ASSETS	0.000840 (0.00192)	0.00122 (0.00127)	0.0000932 (0.00136)	0.000840 (0.00128)
ROE	-0.00340** (0.00166)	-0.00469** (0.00238)	-0.00310 (0.00248)	-0.00437* (0.00257)
RWA	-0.0197*** (0.00533)	-0.0186*** (0.00515)	-0.0204*** (0.00553)	-0.0223*** (0.00658)
LIBOR	0.0127*** (0.00154)	0.0124*** (0.00155)	0.0125*** (0.00166)	0.0124*** (0.00159)
constant	-0.00380 (0.0438)	-0.0161 (0.0266)	0.0141 (0.0297)	-0.00415 (0.0283)
Number of observations	131	131	131	131
Number of banks	20	20	20	20
Number of instruments	13	13	13	13
Sargan test (p-value)	0.0582	0.0595	0.0559	0.0575
AR(1)	0.0024	0.0027	0.0025	0.0030
AR(2)	0.9799	0.9459	0.9695	0.9026

Notes: Standard errors in parentheses, significance levels at 10%, 5% and 1% are denoted by *, **, *** respectively.

Source: Authors' calculation

are consistent with our assumptions. LIBOR is positively related to the deposit price, while asset riskiness (RWA) and return on equity (ROE) are negatively related with it (DEPPRICE). It is obvious that banks' interest rates and repricing policies must be in line with market conditions. In addition, banks with a higher shareholders' profitability (ROE) are usually large banks with lower regulatory capital and are considered more stable, not only because of their profitability, but also because of their size. Thus, more profitable and larger banks can attract their depositors with lower interest rates, especially in oligopolistic banking markets like the Croatian one, when if they can act as market makers. The opposite is true for small banks.

In fact, bank size (ASSETS) was insignificant in the Arellano-Bond estimations, but it had recorded a negative impact on deposit price in the Blundell-Bond estimations. The asset riskiness (RWA) led to a decline in the deposit price, probably due to coinciding with an increase in risk perceptions and expansionary monetary policy during the recession period. Finally, bank solvency was completely irrelevant for the deposit price. Thus, a conclusion can be drawn about the insufficient market discipline of Croatian depositors and hypothesis H-2 is rejected, as capital requirements do not contribute to a reduction in the cost of deposit financing.

4. CONCLUSION

Numerous regulatory measures are often criticized in the sense that they have good intentions and unintended evils. This is also true of prudential regulation which forces banks to hold their shareholders more accountable for risk-taking and financial performance. Thus, instead of contributing to banking stability, capital requirements might undermine it by encouraging bank shareholders to engage in risk-seeking behaviour to compensate for their higher stake in the game. On the other hand, better solvency reduces banks' refinancing risks and bankruptcy costs, which in turn should lower the costs of debt financing. Considering the Croatian banking sector in the post-global financial crisis period, we seek an empirical answer to the following research questions: first, whether bank capital regulation imposes higher asset riskiness, and second, does it matter for the deposit price?

The panel data estimations show that higher regulatory solvency increases the bank asset riskiness. Thus, banks with higher regulatory capital ratios increase their risk-weighted assets. However, this is by no means a proof of the counterproductivness of capital requirements regulation, as banks normally build up capital in order to bear higher asset risks. Conversely, lower regulatory capital or the inability to increase it leads to a reduction in risk-weighted assets. The aforementioned is in line with the capital buffer theory. We also confirm that larger banks and those with higher loan charge-offs have lower asset riskiness. The net interest margin is positively related to risk-weighted assets, while the opposite is true for the return on equity. Finally, there is an inverse relationship between GDP growth and risk-taking. This is because risks are usually underestimated and tend to accumulate in times of economic expansion, while they materialise and are overestimated in times of economic downturn.

Concerning the results for the deposit price, capital regulation turns out to be completely irrelevant, as the deposit price primarily reflects interbank interest rates. In addition, asset riskiness and return on equity have a negative impact on the deposit price. Banks with higher profitability are perceived as more stable, while banks with a lower return on equity have to attract depositors with competitive interest rates. Higher asset riskiness is usually revealed in economic downturn, which coincides with attempts by monetary authorities to reverse this trend by lowering interest rates. In short, we miss evidence of the market discipline of bank depositors in Croatia as well as evidence of the importance of bank capital in lowering the cost of deposit funding.

Complying with capital requirements regulation has a tremendous impact on the business of banking, and should be continuously analysed in light of the latest regulatory improvements (Basel III and IV). Therefore, a replication of this or any further research that could deepen the knowledge in this area is strongly recommended, especially for the banking sectors for which there is scarce evidence about this topic. In addition, subsequent studies on the impact of capital requirements on banks' risk appetite should provide both a breakdown of risk appetite by type and aggregation into composite measures such as the risk index. Insufficient data prevented us from doing this for the observed banking sector.

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Appendix

Table 1. Panel data estimations of the asset riskiness model with the system GMM estimator

Explanatory variable	Asset riskiness (RWA)			
L.RWA	0.639*** (0.0255)	0.665*** (0.0536)	0.695*** (0.0467)	0.591*** (0.0248)
CAP	0.975*** (0.189)			
ADEQ		0.296** (0.151)		
TIER1ADEQ			0.135 (0.119)	
CAPQUAL				1.930*** (0.237)
ASSETS	-0.00535 (0.00708)	-0.00519 (0.00912)	-0.00401 (0.00811)	-0.0146*** (0.00467)
NIM	6.302*** (0.741)	7.582*** (0.853)	6.782*** (1.016)	3.563** (1.425)
NCO	-0.348* (0.190)	-0.291 (0.242)	-0.280 (0.263)	-0.186 (0.176)
ROE	-0.130*** (0.0358)	-0.0898** (0.0373)	-0.102*** (0.0372)	-0.117*** (0.0353)
$GDPG_{i,t}$	-0.00416*** (0.000917)	-0.00559*** (0.00121)	-0.00378*** (0.00102)	-0.00214** (0.000848)
constant	0.0773 (0.152)	0.0774 (0.221)	0.0894 (0.177)	0.289*** (0.0981)
Number of observations	153	153	153	153
Number of banks	20	20	20	20
Number of instruments	21	21	21	21
Sargan test (p-value)	0.6493	0.4435	0.3846	0.5259
AR(1)	0.0370	0.0475	0.0359	0.0055
AR(2)	0.5291	0.4333	0.5082	0.4497

Notes: Standard errors in parentheses, significance levels at 10%, 5% and 1% are denoted by *, **, *** respectively.

Source: Authors' calculation

Table 2. Panel data estimations of the deposit price model with the system GMM estimator

Explanatory variable	Deposit price (DEPPRICE)			
L.DEPPRICE	0.695*** (0.0185)	0.701*** (0.0193)	0.695*** (0.0144)	0.711*** (0.0198)
CAP	-0.000911 (0.00442)	-	-	-
ADEQ	-	0.0101 (0.0134)	-	-
TIER1ADEQ	-	-	-0.00413 (0.0105)	-
CAPQUAL	-	-	-	0.00810 (0.0189)
ASSETS	-0.000394* (0.000202)	-0.000467** (0.000182)	-0.000385 (0.000274)	-0.000468* (0.000276)
ROE	-0.00374*** (0.00116)	-0.00518*** (0.000975)	-0.00334*** (0.00129)	-0.00412*** (0.00124)
RWA	-0.0198*** (0.00310)	-0.0167*** (0.00188)	-0.0180*** (0.00269)	-0.0184*** (0.00348)
LIBOR	0.0127*** (0.00105)	0.0124*** (0.000956)	0.0126*** (0.000946)	0.0122*** (0.00117)
constant	0.0245*** (0.00530)	0.0221*** (0.00640)	0.0238*** (0.00644)	0.0238*** (0.00611)
Number of observations	153	153	153	153
Number of banks	20	20	20	20
Number of instruments	20	20	20	20
Sargan test (p-value)	0.4076	0.3797	0.4020	0.3417
AR(1)	0.0032	0.0041	0.0030	0.0036
AR(2)	0.9830	0.9897	0.9516	0.9374

Notes: Standard errors in parentheses, significance levels at 10%, 5% and 1% are denoted by *, **, *** respectively.

Source: Authors' calculation

Preuzimanje rizika i cijena depozita banaka u vremenima niske ekonomske aktivnosti: relevantnost ili irelevantnost kapitalnih zahtjeva?

Sažetak

Ovaj rad istražuje utjecaj regulacije kapitala na rizičnost portfelja i troškove depozitnog financiranja banaka, polazeći od pretpostavke da bi teret regulacije kroz kapitalne zahtjeve mogao potaknuti nepovoljne efekte na rizičnost bankovnih aktiva, usprkos potencijalno blagotvornim učincima na snižavanje cijene depozita. Podaci za hrvatski bankarski sektor za razdoblje od 2011. do 2019. godine obrađeni su dinamičkom panel analizom. Rezultati potvrđuju da banke s većim pokazateljima kapitaliziranosti nemaju niže troškove depozitnog financiranja, ali poduzimaju rizičnija ulaganja kako bi se iskupile dioničarima za dodatno zahtijevana sredstva. Dodatno, veličina banke, materijalizacija kreditnog rizika u prethodnom razdoblju i veći ekonomski rast umanjuju izloženost prema rizicima u aktivi, pri čemu je bankovna profitabilnost (neto kamatna marža) sukladna preuzetim rizicima. Cijena depozita je pozitivno određena uvjetima međubankovnog tržišta, a negativno prinosom na vlastiti kapital i rizikom portfelja. Sve u svemu, postoji solidan dokaz da regulacija kroz kapitalne zahtjeve značajno mijenja pokazatelje poslovanja banaka, preciznije rizičnost bankovnih aktiva. Ipak ocjene o kontraproduktivnosti za stabilnost bankarskog sektora zahtijevaju uvjerljivije i sveobuhvatnije dokaze na štetu teorije kapitala kao zaštite. Nedostupnost podataka ograničila nas je u dekompoziciji rizika banaka prema vrstama i korištenju kompozitne mjere poput indeksa rizika. Usprkos tome, ovo istraživanje jedno je od malobrojnih za hrvatski bankarski sektor u području mikroekonomskih posljedica od usklađivanja s kapitalnim zahtjevima.

Ključne riječi: kapitalni zahtjevi, bankovna regulacija, preuzimanje rizika, cijena depozita, dinamička panel analiza