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Beyond compliance: Decoding the time effects of banking regulations on credit risk in the EEA banks

Przemysław Borkowski, Magdalena Markiewicz, Maria Spanou

ABSTRACT

Objective: The article aims to determine whether banks promptly react to risk-related regulatory changes or if there is a delayed response. Considering the complexities of the financial system, our study underscores the need to examine the time-sensitive impact of banking regulations on credit risk. Separating intricate dynamics, measuring responsiveness, and assessing compliance, we probe this research to find the assumptions for strengthening financial resilience in a dynamic landscape.

Research Design & Methods: The research design in this study is quantitative. We collected the initial data through desk research, sourcing information from regulatory documents, financial reports, and other relevant documents related to banking supervision rules. We used a dynamic panel data model to analyse the collected data, specifically examining the relationship between regulatory changes and banks' responses to these changes. The study's sample size involves quantitative data from multiple banks over time, allowing for an assessment of regulatory pressure's effects on credit risk and the tPime required for banks to achieve compliance.

Findings: The article sheds light on how alterations in regulatory policies for risk influence the responsiveness of systemically important banks (SIBs). We explored how long it takes for banks to comply fully with regulatory changes regarding risk. The results show that the effects of regulatory pressure may be delayed more than conventional models suggest, even as much as two years, with potential consequences for the efficacy of regulatory interventions.

Implications & Recommendations: The study results contribute to understanding the time dynamics of regulatory impacts on the banking sector, particularly concerning credit risk, and bring valuable insights into sustainable finance. It aids in identifying opportunities to align regulatory frameworks with sustainability objectives, and greater financial resilience. Policymakers and banks should invest in enhanced monitoring systems to track the time-sensitive responses of banks, primarily SIBs, to ensure regulatory interventions achieve their intended outcomes.

Contribution & Value Added: This research revealed the timing and progression of banks' responses to risk-related regulatory changes over time, offering valuable insights for policymakers and financial institutions. This alignment offers insights for fostering long-term financial stability and resilience.

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INTRODUCTION

The banking sector's role in the economy has expanded significantly, providing innovative financial products that enhance credit market flexibility and introduce risk. Given the sector's close ties to the real economy, adequate regulatory and supervisory frameworks are essential for financial stability. Historical crises, such as the 2008-2009 financial crisis and the Great Depression, demonstrate how

financial market risks can disrupt the broader economy, raising concerns over deposit security and liquidity (Anginer *et al.*, 2019; Arrigoni & Rivolti, 2022; Böhnke *et al.*, 2023). Early regulations aimed to reduce bankruptcy risks through portfolio management (Dothan & Williams, 1980; Sharpe, 1978). Financial crises have prompted government and industry self-regulation, with the Basel Committee on Banking Supervision offering guidelines for managing key risks (Ambrocio *et al.*, 2020; Barth *et al.*, 2013). However, the timing and implementation of regulations remain underexplored.

This study investigated how regulatory interventions influence liquidity creation and examined the relationship between regulatory pressure and credit risk, providing valuable insights for policy development. Key questions include whether strict regulation enhances or hinders efficiency (Barth *et al.*, 2004; Barth *et al.*, 2013). While swift interventions during crises aim to improve banking system safety and performance, concerns persist over supervisory involvement, particularly regarding potential political influences on credit allocation (Beck *et al.*, 2010). Regulators increasingly influence banks' operations, impacting financial reporting and oversight changes. Regulatory statements on credit risk prevention often prompt swift strategy adjustments. While regulations enforce strict credit risk standards to protect consumers and the economy, banks' readiness to implement these changes quickly is crucial. The article examines how regulations affect credit risk and capital reserves needed for sudden changes and explores whether banks adapt promptly to regulations or if delays undermine the policies' objectives.

While compliance is generally accepted, evidence from financial crises suggests that banks may implement measures selectively to minimise the impact on efficiency (Anginer *et al.*, 2019; Hellmann *et al.*, 2000; Kashyap *et al.*, 2020). This raises the question: Does regulatory pressure achieve its intended result? The existing research produces mixed results regarding the effects of regulatory pressure on risk. Some authors show that growth in value-maximising bank incentives decreases asset risk as capital increases (Furlong & Keeley, 1989). According to other studies, capital regulation stimulates banks to take excessive risks by allowing them to increase riskier investments with the increase of bank capital (Siddika & Haron, 2020). Taking prior empirical results into consideration and a testing sample of several banks from the European Economic Area (EEA), and concentrating on the systemically important banks (SIBs), our research aims to answer the questions how changes in capital and risk regulations affect the time of responsiveness of the banks concerning their size and capitalisation.

We hypothesised that regulatory pressure effects are delayed far longer than conventional models assume. If true, this suggests that consistent, less restrictive regulation is more effective than reactive, one-time interventions. We propose that while regulatory changes significantly affect the responsiveness of SIBs, their timing and extent vary widely. In the EEA, SIBs show differing adaptation speeds due to regulatory complexity and internal risk management capabilities. These delays highlight a gap between expected and actual outcomes, suggesting potential inefficiencies in regulatory interventions.

From a policy perspective, constant and predictable oversight may foster sustainable risk management practices rather than sporadic restrictive measures, allowing banks to adapt gradually.

The article is structured as follows. The first part reviews current research on banking supervision rules and presents the hypotheses and research questions. The following section formulates methods for data collection, modelling, and analysis. A discussion of the results follows this. The article ends with conclusions, limitations and directions for future research.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The regulatory framework is built to create a financial stability architecture and network, evaluated in the context of the bank's size, performance, and willingness to adopt the regulations. Commercial banks' goals include maximising profits and operating efficiently, with a positive attitude toward regulations due to the perception of stability. On the other hand, it is impossible to maintain relative efficiency and improve the economic position of an entity with stricter buffers and reserves. Scholars widely analysed the evolution in bank capital regulations and bank risk after the global financial crisis in search of the factors ensuring the quality of capital and reducing bank risk (Kashyap *et al.*, 2020; Repullo, 2004; Sharpe, 1964). Surveys on bank regulation and supervision try to give evidence on

whether bank regulatory and supervisory requirements enhance or impede the banks' ability to create liquidity (Barth *et al.*, 2013; Mendicino *et al.*, 2021).

Empirical evidence on the impact of regulation and supervision on bank performance and risk-taking remains inconclusive, showing that tighter rules are not always beneficial (Barth *et al.*, 2004; Barth *et al.*, 2013; Chen, 2007). Some research distinguishes between regulatory intent and supervisory effects, with regulations imposing strict rules and enabling tailored interventions to prevent crises (Cihak *et al.*, 2013). Enhanced supervision has yielded valuable insights into the efficiency of post-crisis regulations. Following the 2008 financial crisis, policymakers introduced stricter capital regulations regarding capital level and quality (Anginer *et al.*, 2019). The impact of these regulations on banks' operations and liquidity creation remains uncertain, with empirical and theoretical analyses yielding conflicting results. Some researchers argue that activity restrictions promote bank stability (Agoraki *et al.*, 2011; Buckmann *et al.*, 2023; Kashyap *et al.*, 2020), while others declare the opposite opinion (Ahnert *et al.*, 2021; Demirgüç-Kunt *et al.*, 2004), which is in line with the assessment of anticipatory effects of regulatory proposals within Basel III (Hendricks *et al.*, 2023; Laeven & Levine, 2009; Mirzaei & Samet, 2022). Regulatory and supervisory policies are vital for safeguarding the financial sector, particularly in managing credit risk, which often underpins economic crises. Regulations aim to prevent past mistakes linked to credit product failures, but their effectiveness varies depending on the type of regulation and a bank's market power. Capital requirements generally lower risk, though this effect diminishes for banks with significant market power (Agoraki *et al.*, 2011). Restrictions on activities, when paired with market power, can reduce credit and default risks, with supervisory capacity influencing risk levels (Klomp & De Haan, 2015). In the EU, deregulation has improved loan quality and lowered credit risk by encouraging better borrower screening amid competition (Chen, 2007) and supervisory monitoring of bank risks during crises (Hoque *et al.*, 2015). Regulations significantly impact high-risk banks but have limited influence on low-risk institutions (Klomp & De Haan, 2015; Klomp & Haan, 2012).

The above analysis leads us to formulate a research question **(RQ1)**: Do changes in capital and risk regulation affect banks' responsiveness to risk? The hypotheses corresponding to RQ1 are:

H1a: Regulatory pressure does not significantly influence banks' responsiveness to risk-related regulations.

H1b: Larger banks take on more risk, affecting regulatory response by maintaining risky assets in their portfolios.

Modern banks operate in a globalised, complex environment with easy financial access, intense competition, and rigorous regulations focused on risk management and capital requirements. While the measures strengthen central supervisory bodies, they can threaten banking stability. Research on the credit and sovereign debt crises suggests that deposit insurance schemes increased moral hazard, leading banks to take significant risks and underperform during the crises (Hoque *et al.*, 2015). Some studies explored factors affecting default distance and systemic risk, finding that regulatory restrictions and monitoring influenced bank risk (Acharya, 2009; Barth *et al.*, 2004; Laeven & Levine, 2009). Intense supervision and monitoring help reduce systemic fragility in the banking sector (Anginer *et al.*, 2019; Cihak *et al.*, 2013; Demirgüç-Kunt *et al.*, 2004). In-depth research using the database on bank regulation and supervision in 107 countries showed the existing relationship between specific regulatory, supervisory practices and banking-sector development, efficiency, and fragility (Hellmann *et al.*, 2000). It examined factors such as regulatory restrictions, capital adequacy, supervisory power, loan classification, diversification standards, deposit insurance systems, and information disclosure. The findings suggest that accurate information disclosure and the empowerment of private-sector governance improve bank performance and stability. The interconnectedness of banking and the real economy underscores the need for effective regulation. The sector's growing role and innovative but riskier financial products highlight the importance of ensuring deposit security and liquidity during crises. Basel III addresses these issues, providing guidelines for capital management, particularly for major banks (Chaikovska, 2021; Gržeta *et al.*, 2023).

Some studies suggest that as a bank's capital increases, its incentives to take on higher asset risk decrease (Kim & Santomero, 1988; McKeever, 2023). Others argue that capital regulation can encourage excessive risk-taking by allowing banks to make riskier investments with more capital (Furlong &

Keeley, 1989). The pressure of regulation forces banks to impose rules and mechanisms speedily regarding compliance management, processes, and systems. The question arises whether this is an antidote to the financial crisis. Financial regulation, particularly capital requirements, aims to reduce credit risk, making banks less prone to fast implementation and enabling different supervisory approaches. Recent studies explore how these reforms impact risk-taking. Chen *et al.* (2024) analysed the effect of liquidity regulation on risk-taking and shadow banking in China, while Xiao *et al.* (2023) examined cross-holdings and systemic risk. Other research showed improvements in capital ratios and a decline in non-performing loans after regulatory reforms (Alley *et al.*, 2023). The studies in the UAE found that innovative technologies facilitate efficient service delivery, but the complexity of implementing regulations remains unclear (Oudat *et al.*, 2023). The evidence from the Middle East and North Africa (MENA) regions examining the determinants of capital structure decisions for banks found that profitability, bank size, and macroeconomic and institutional factors as key drivers of bank leverage (Khan *et al.*, 2023).

While there are different regulatory frameworks across world economies, the Bank for International Settlements (BIS) regulations seem universally accepted by the banking industry. It has issued a series of influential international banking standards known as the Basel Accords: Basel I (1988), Basel II (2004), Basel III (2010), and the revisions of Basel III, called Basel IV (Basel Committee on Banking Supervision, 2017). The Basel III framework introduced high-quality assessment and liquidity standards, raising questions about whether regulation is a long-term solution to financial crises or merely delays future risks (Hendricks *et al.*, 2023). Basel III responded to stringent capital requirements, including a standard equity tier 1 capital ratio and the quality of capital. The influence of BIS regulations extends beyond individual jurisdictions, creating a harmonised approach to banking supervision and reducing the risk of regulatory arbitrage. The comprehensive Basel risk assessment focus has led banks to develop sophisticated risk measurement models and frameworks with substantial capital buffers and risk management practices. Not all countries adopt these standards in the same way or at the same pace. Some jurisdictions modify certain aspects to suit their specific circumstances better, leading to variations in implementation.

Based on these assumptions, we proposed the second research question **(RQ2):** Do banks tend to take more time to respond to regulatory changes relating to risk and delay implementing regulations? The hypothesis corresponding to RQ2 was:

H2: The effects of regulatory pressure on banks' risk levels are delayed and do not produce immediate responses.

Analysing the EU banking sector, some research showed that banking deregulation may improve loan quality and lower credit risk as banks invest resources in screening borrowers when there is an entry threat (Chen, 2007). Modern banks function in a globalised and complex environment marked by easy financial access, increased market competition, and a regulatory focus on risk management and capital requirements. Some researchers analysed whether regulation reduced risk during the credit and sovereign debt crises for a cross-section of global banks (Hoque *et al.*, 2015), finding that deposit insurance schemes enhanced default risk and moral hazard in the banks (Acharya, 2009; Barth *et al.*, 2004; Laeven & Levine, 2009). Large banks create liquidity using a solid position as intermediaries in the market, referring to depositors and borrowers. The effect of liquidity creation on actual economic output may be beneficial, particularly in bank-dependent industries (Berger *et al.*, 2023) or negatively charged (Acharya & Yorulmazer, 2007). When there is little regulatory pressure and banks experience lower supervision, they are likely to experience a faster implementation of credit risk requirements, complying with supervisory standards, which creates a significant regulatory gap (Acharya, 2009). Regulatory standards for reporting credit risk are established in a self-regulatory system to avoid confusion during financial crises and to promote good practices. Many authors have analysed the context of liquidity creation (Bauer *et al.*, 1998; Kladakis *et al.*, 2022; Saar *et al.*, 2023). Their critical observation is that banks with a high conditional accounting conservatism in the pre-adoption period significantly increased risk-taking in the post-adoption period.

These expectations gave us the input to the following research question **(RQ3):** Does a bank's size affect responsiveness to an imposed regulatory change? The hypotheses corresponding to RQ3 are:

H3a: Banks of larger total asset size tend not to respond directly to a regulatory change.

H3b: The presence of risky assets in a bank's portfolio significantly impacts the risk adjustment levels.

The formulation of research question **RQ4**: *Do overcapitalised banks tend to avoid adjustments to risk levels following a regulatory change?* is grounded in prior empirical evidence on bank capital regulations and risk-taking behaviour. The existing literature suggests that banks with excess capital may exhibit lower sensitivity to regulatory changes as they already maintain substantial buffers, reducing their need for further risk adjustments (Furlong & Keeley, 1989; Kim & Santomero, 1988). Studies also indicate that banks prioritise capital accumulation over immediate risk reduction when faced with increased regulatory scrutiny, as capital buffers offer a protective mechanism against unforeseen market disruptions (Kashyap *et al.*, 2020).

Given the conflicting evidence on whether regulatory interventions effectively curb risk or merely alter capital management strategies, we developed **H4**: *EEA banks facing regulatory pressure prefer to increase their capital rather than decrease risk levels*. We aimed to explore whether overcapitalised banks opt for passive compliance through capital adjustments rather than actively reducing risk exposure. This hypothesis is particularly relevant in the context of the EEA, where banking regulations emphasise capital adequacy as a primary tool for financial stability.

RESEARCH METHODOLOGY

We collected the initial data for research through desk research, sourcing information from regulatory documents, financial reports, and other relevant documents related to banking supervision rules. We used a dynamic panel data model to analyse the data, specifically examining the relationship between regulatory changes and banks' responses to these changes.

The study's sample size involved quantitative data from multiple banks over time, collected via Bank Scope. We prepared a set of selection criteria to pick a sample of representative banks from each of the 32 EEA countries. Firstly, the bank had to be the relevant market participant. We satisfied this by selecting banks as G-SIBs (global systemically important banks), SIBs (systemically important banks), or OSII (other systemically important institutions). It allowed us to include banks, which contribute to a system where the potential failure of a single large institution can have broader effects that reverberate throughout the global economy. Secondly, we decided to look for banks with headquarters in all 32 EEA countries to account for possible country bias, and specific bank characteristics considered, such as capital ratio, the largest bank by assets or capital, national/foreign capital, and credit exposure. We decided to use the 2011-2018 period because it covers the timeframe directly in the aftermath of the financial crisis of 2008-2010, before the Brexit referendum in 2019 and the COVID-19 outbreak in March 2020. It creates a 'window effect' for a research analysis. We applied dynamic panel data techniques as the primary statistical/econometric tools, allowing for an assessment of regulatory pressure's effects on credit risk and the time required for banks to achieve compliance.

Unlike previous empirical studies (Aggarwal & Jacques, 2001; Rime, 2001; Shrieves & Dahl, 1992), we employed dynamic panel data techniques to solve the models defined in the above sections. Scholars widely use panel data analysis to examine two-dimensional (typically cross-sectional and longitudinal) datasets, where data is collected over time for the same individuals and allowing for a regression analysis across these two dimensions. Panel data analysis offers three independent approaches: independently pooled panels, random effects models, and fixed effects models (or first-differenced models). The selection between random and fixed effects, as well as panel vs pooled models, depends on the research objective and the exogeneity of explanatory variables.

We conducted multiple statistical tests to assess performance and robustness to determine the appropriate model. We applied the Durbin-Watson test to detect the presence of autocorrelation in residuals, with a test statistic of 1.154706, indicating positive autocorrelation. We also performed the Hausman test to determine whether we should select fixed or random effects, with an asymptotic test statistic of Chi-square(13) = 153080, p-value = 0, validating the appropriateness of the fixed effects model. Moreover, a joint test on named regressors confirmed the explanatory power of the

independent variables, with a Chi-square(13) statistic of 568.028 and a p-value of 8.34388e-107, demonstrating significant contributions to the model. To further assess model reliability, we tested the normality of residuals, with a Chi-square(2) value of 5.662 and a p-value of 0.0590, indicating deviations from normality. The final decision on model selection (from tested candidates) was based on the highest performance indicators, including R-squared values, correlation coefficients, and the AIC test. Based on these results, we initially considered the panel data model with random effects, but we ultimately rejected it in favour of the panel fixed effects model, as it provided more reliable estimates in line with the observed data patterns.

For the initially tested random effects models, we also performed the Breusch-Pagan test to assess heteroskedasticity. Under the null hypothesis (where the variance of the unit-specific error equals 0), the test yielded a Chi-square value of 0.286014 with a p-value of 0.592786, leading to the rejection of the null hypothesis and confirming that the panel were preferable over pooled OLS. Nevertheless, since the Hausman test pointed to the use of a fixed model, the BP test was not critical.

Table 1 presents all variables selected for the research process based on the data available and suggested from the literature review.

Table 1. The dataset of variables used in modelling

Variable	Variable definition	Min	Max	Type	Source
REGA	(Regulatory Component measured as (1/CAR – 1/8). It measures the banks' responses to the 8% risk-based capital standard.)	-0.7098	0.986111	ratio	Shrieves & Dahl (1992); Rime (2001); Aggarwal & Jacques (1997); Van Roy (2005a); Jacques & Nigro (1997); Heid *et al*. (2003)
REGB	Reverse of REGA	-0.98611	0.709795	ratio	Shrieves & Dahl (1992)
ROAA	Return on Average Assets	-11.55	5.11	ratio	Rime (2001); Aggarwal & Jacques (1997)
TEA	Total Earning Assets	264038	2.08E+09	th EUR	Roy (2005a); Jacques & Nigro (1997)
TA	Total assets	400484	2.16E+09	th EUR	Heid *et al*. (2003), Shrieves & Dahl (1992); Rime (2001) Aggarwal & Jacques (1997)
CL&Adv/ TA	Customer loans & advances / Total assets	17.51	80.2	th EUR	
GL&Adv/ TA	Gross loans and advances to customers	207245	8.64E+08	th EUR	Roy (2005a); Jacques & Nigro (1997); Heid *et al*. (2003)
NL&Adv	Net loans and advances to customers	204563	8.4E+08	th EUR	Haubrich & Wachtel (1993); Jacques & Nigro (1997)
CET1	Common Equity / Core Tier 1 (CET1) (as reported)	-407284	76131000	th EUR	Shrieves & Dahl (1992); Rime (2001); Aggarwal & Jacques (1997)
CET1ratio	Common Equity / Core Tier 1 ratio (as reported)	-1.9	27.01	th EUR	Roy (2005a); Jacques & Nigro (1997); Heid *et al*. (2003)
Tier 1	The ratio of a bank's core tier 1 capital to its total risk-weighted assets.	-1.27	28.7	ratio	Shrieves & Dahl (1992); Rime (2001); Aggarwal & Jacques (1997); Rime (2001)
Tier 1 Capital	A bank's core equity capital to its total risk-weighted assets (RWA).	-95957	84773000	th EUR	Roy (2005a); Jacques & Nigro (1997); Heid *et al*. (2003); Shrieves & Dahl (1992)
TE/RWAs	Total equity / Risk-weighted assets (RWAs)	-3.19	32.91	th EUR	Rime (2001); Aggarwal & Jacques (1997); Roy (2005a)
CAR	Total Capital Adequacy Ratio (%)	-1.71	31.8	th EUR	Jacques & Nigro (1997); Heid *et al*. (2003); Rime (2001)

Source: own study.

In terms of the selection of the 32 EEA countries and selecting a sufficiently representative bank, we examined the criteria starting from the productivity and liquidation potential of a bank expressed by the total capital ratio (higher capital ratio compared to other peers in the market) and where this was not sufficient or there was no relevant data, we considered the financial group that the candidate

bank would belong to as well as size of the bank in terms of number of employees or market presence over the years. Table 2 summarises the criteria chosen per selected bank based on data availability and size or market presence. The key selection criterion is the type of bank, whether it is a G-SIB, SIB, or OSII. Once it entered the data set, we selected the probe by a metric such as the country's 'highest total capital ratio,' the largest bank by total assets, or one of the leading banks by total assets.

Table 2. Sample selection criteria

EEA Country	Bank	GSIB/SIB/OSII	HQ	Selection factor / Remarks
Denmark	Danske Bank	SIB	Denmark	Higher total capital ratio req.
France	BNP Paribas	G-SIB	France	Higher total capital ratio req.
Germany	Deutsche Bank	SIB	Germany	Higher total capital ratio req.
Italy	UniCredit Group	G-SIB	Italy	Higher total capital ratio req.
Lithuania	AB Šiaulių bankas	SIB	Lithuania	Lithuanian Bank, not a subsidiary
Netherlands	ING Bank	G-SIB	Netherlands	Higher total capital ratio req.
Norway	DNB ASA	SIB	Norway	Higher total capital ratio req. + largest financial group
Poland	PKO BP	SIB	Poland	Higher total capital ratio req. + largest financial group
Spain	Banco Santander	G-SIB	Spain	Higher total capital ratio req.
Sweden	SwedBank	G-SIB	Sweden	Higher total capital ratio req.
UK	HSBC	G-SIB	UK	Higher total capital ratio req.
Switzerland	Credit Suisse	G-SIB	Switzerland	Higher total capital ratio req.
Austria	Erste Group	OSII	Austria	Higher total capital ratio req. + largest financial group
Belgium	Dexia Group	G-SIB	Belgium	Higher total capital ratio req.
Bulgaria	First Investment Bank	n/a	Bulgaria	Largest bank
Croatia	Zagrebačka Banka d.d.	OSII	Croatia	Largest bank
Cyprus	Bank of Cyprus Plc	OSII	Cyprus	Largest bank
Czech Republic	Česká spořitelna, a.s	OSII	Czech Republic	Leading bank by total assets
Estonia	LHV Pank	n/a	Estonia	2nd largest bank & Estonian origin
Finland	OP Group	OSII	Finland	Largest Finnish Financial Group
Greece	National Bank of Greece	OSII	Greece	The oldest and largest bank as of 2016
Hungary	OTP Bank Nyrt	OSII	Hungary	Higher total capital ratio req. + largest bank
Iceland	Arion banki hf	OSII	Iceland	Higher total capital ratio req. + largest bank
Ireland	Allied Irish Banks plc	OSII	Ireland	One of the big four commercial banks
Latvia	ABLV Bank AS	OSII	Latvia	One of the largest banks in the Baltic states
Liechtenstein	VP Bank AG	n/a	Liechtenstein	The top 2 are of German and French nationality, respectively (i.e., Deutsche Bank Luxembourg S.A. ; Société Générale Bank & Trust S.A.); This bank is a G-SIB. The other two are OSIIs
Luxembourg	Banque Internationale à Luxembourg S.A.	OSII	Luxembourg	One of the most important financial organisations
Malta	Bank of Valletta Group	OSII	Malta	Higher total capital ratio req. + largest bank
Portugal	Caixa Geral de Depósitos	OSII	Portugal	Higher total capital ratio req. + second largest bank
Romania	Banca Comercială Română S.A	OSII	Romania	Higher total capital ratio req. + largest bank
Slovakia	Všeobecná úverová banka a.s.	OSII	Slovakia	Higher total capital ratio req. + of the largest bank
Slovenia	NLB	OSII	Slovenia	Higher total capital ratio req. + of the largest bank

Source: own study.

The selected model is based on the general idea of Shrieves and Dahl's simultaneous equations, which are analysed and described using panel data regression for 32 selected countries (Shrieves & Dahl, 1992). The designed and used model assesses how banks react to regulatory requirements on their risk levels. Panel data regression is used to specify and estimate the model and its associated results, and panel data analysis serves analyse two-dimensional (typically cross-sectional and longitudinal) panel data. The data is collected over time and with the same individuals, and regression is run over these two dimensions. An essential aspect of the model initially suggested by Shrieves and Dahl is that changes in risk and capital have endogenous (*i.e.*, discretionary) and exogenous components. In the model, observed risk level changes include a discretionary adjustment and a change caused by factors exogenous to the bank. Concerning risk, exogenous variables changes include unanticipated shocks to the national and local economy, such as the changing characteristics of a bank loan portfolio or volatility of loan collateral such as real property. Therefore, the model specified looks like in Equation 1.

$$\Delta RISK_{j,t} = \Delta^d RISK_{j,t} + S_{j,t} \tag{1}$$

in which:

$\Delta RISK_{j,t}$ - the observed change in risk levels for bank j in period *t*;

$\Delta^d RISK_{j,t}$ - the discretionary change in risk while there are the random shocks.

The discretionary changes in risk $\Delta^d RISK_{j,t}$ are modelled based on delayed (or lagged, as they are statistically called) data for the selected variables, thereby recognising that banks may not be able to adjust their desired risk. Under this framework, the discretionary changes in risk are proportional to the difference between the target levels and the observed levels in period t-1. Thus, the model equations are as follows (Equations 2 and 3):

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

in which:

$RISK^*_{j,t}$ - the bank's target risk levels;

β - a parameter.

We may write the observed changes in capital, risk, and liquidity as follows:

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

in which:

$RISK^*_{j,t}$ - the bank's target risk levels;

β - a parameter.

Based on model equation (3), the observed changes in risk in period *t* are a function of the target risk level in period *t*; the risk level is not directly observable but is assumed to be dependent on some set of visible variables describing the bank's financial condition and the state of the economy in each country. Risk is defined as the denominator in the ratio of total capital to total risk-weighted assets (RWA) and any adjustments (A) that could take place from imposed regulation, as in Equation 4:

$$RISK = \frac{RWA}{A} \tag{4}$$

in which:

RWA - the risk weighted assets;

A - the total assets.

Meanwhile, REGA variable equals the difference between the inverse of the individual bank capital ratio (CAR) and the inverse of the regulatory minimum risk-based ratio of 8%.[1] Therefore, REGA equals (1/CAR-1/8) for all banks with risk-based ratios of less than or equal to 8% and 0 for all banks with a total risk-based ratio above the required minimum. This measure recognises the non-linear relationship between the regulatory capital and either a change in portfolio risk or capital ratios. REGB measures 'distance to default' from above. It equals the difference between the inverse of the regulatory minimum

[1] The capital adequacy ratio calculates a bank's capital by its risk-weighted assets. Currently, the minimum ratio of capital to risk-weighted assets is 8% under Basel II and 10.5% (which includes a 2.5% conservation buffer) under Basel III. This article uses a Basel II threshold similar to Shrieves & Dahl, excluding the conservation buffer.

risk-based ratio of 8% and the inverse of the individual bank capital ratio (CAR). Therefore, REGB equals (1/8-1/CAR) for all banks with risk-based ratios greater than or equal to 8 and 0 otherwise.

$$REGA = \left(\frac{1}{CAR} - \frac{1}{8}\right) if\ CAR\ \leq 8\%; 0\ otherwise \tag{5}$$

$$REGB = \left(\frac{1}{8} - \frac{1}{CAR}\right) if\ CAR \geq 8\%; 0\ otherwise \tag{6}$$

Therefore, the final risk model equation came out to be as follows:

$$\begin{aligned} dRISK_{j,t} = {} & \beta_0 + \beta_1 ROAA_{j,t} + \beta_2 TEA_{j,t} + \beta_3 TA_{j,t} + \beta_4 CL\&Adv/TA_{j,t} + \beta_5 GL\&aDV/TA_{j,t} \\ & + \beta_6 NL\&Adv_{j,t} + \beta_7 CET1_{j,t} + \beta_8 CET1_{ratio\,j,t} + \beta_9 Tier1ratio_{j,t} \\ & + \beta_{10} Tier1_{j,t} + \beta_{11} TE/RWAs_{j,t} + \beta_{12} CAP_{j,t} + \beta_{13} RISK/RWA_{j,t-1} \\ & + \beta_{14} dCAP_{j,t-3} + \beta_{15} REGA_{j,t-1} + \beta_{16} REGA_{j,t-2} + \beta_{17} REGA_{j,t-3} \\ & + \beta_{18} REGB_{j,t-1} + \beta_{19} dRISK_{j,t-1} + \beta_{20} dRISK_{j,t-2} + \beta_{21} dRISK_{j,t-3} + S_{j,t} \end{aligned} \tag{7}$$

RESULTS AND DISCUSSION

The results of the study provide empirical insights into how regulatory changes impact credit risk in systemically important banks across the EEA. The findings illustrate banks' responsiveness to risk-related regulations over time and highlight the extent of delays in compliance. The study examines whether banks proactively adjust their risk strategies following regulatory interventions or if structural and operational limitations constrain their reactions. By analysing a comprehensive dataset through dynamic panel data modelling, we identified patterns in risk adjustments, capital allocation, and regulatory adherence. This section presents the key statistical findings, including regression coefficients, significance levels, and trends in bank risk behaviour, offering a detailed assessment of the interplay between banking regulations and risk management practices.

The risk model equation is as follows:

$$\begin{aligned} dRISK_{j,t} = {} & -2.27 + 0.00675 ROAA_{j,t} - 2.53\text{e}-09 TEA_{j,t} + 2.79\text{e}-09 TA_{j,t} \\ & + 0.00305 CL\&Adv/TA_{j,t} + 2.88\text{e}-09 GL\&aDV/TA_{j,t} - 3.81\text{e} \\ & - 09 NL\&Adv_{j,t} - 5.42\text{e}-09 \beta_7 CET1_{j,t} - 0.0270 CET1_{ratio\,j,t} \\ & - 0.0137 Tier1ratio_{j,t} + 2.73\text{e}-09 Tier1_{j,t} Capital \\ & - 0.0255 TE/RWAs_{j,t} + 0.0675 CAP_{j,t} + 0.0143 \beta_{13} RISK/RWA_{j,t-1} \\ & - 0.00700 \beta_{14} dCAP_{j,t-3} - 4.09 REGA_{j,t-1} - 4.74 REGA_{j,t-2} \\ & - 6.67 REGA_{j,t-3} + 2.83 REGB_{j,t-1} \\ & - 0.542 dRISK_{j,t-1} - 0.377 dRISK_{j,t-2} - 0.152 dRISK_{j,t-3} + S_{j,t} \end{aligned} \tag{8}$$

n = 105, loglikelihood = -92.2

Table 3 presents the primary statistical features of our dataset.

Concerning the capital variable in the risk equation, the bank size factor (total assets) and the presence of the risky asset in the bank's portfolio (RiskRWA assets) impacted the risk adjustment levels significantly and positively, with correlation coefficients of 2.792 and 0.0142, respectively. The positive effect of bank size on risk agrees with other studies and means that larger banks have or tend to have higher risk levels than smaller banks. In addition to holding riskier assets in its portfolio, a bank may be guaranteeing some level of protection against further increases in risk levels or regulatory pressure that the bank may face in the future or even possible losses from riskier activities.

The second most important variables were the total capital ratio and total earning assets. Regarding total earning assets, it is sensible that in the long term, a bank may be willing to be more conservative in terms of the risk it would undertake, as it may not be able to base its risk-taking approach on an income-producing indicator like this. Earning assets include stocks, bonds, income from rental property, certificates of deposits, and other interest or dividend-earning accounts or instruments.

Table 3. Variables analysis

Variable	Coefficient	Standard errors
ROAA	0.00675	(0.0327)
TotalEarningAssets	-2.53e-09	(1.04e-09)
TotalAssets	2.79e-09	(1.01e-09)
CustomerLoansAdvancesTot	0.00305	(0.00418)
GrossLoansAdvances to customers	2.88e-09	(3.03e-09)
Netloansadvances to customers	-3.81e-09	(3.34e-09)
CommonEquityCoreTier1CE	-5.42e-09	(6.07e-09)
CommonEquityCoreTier1rat	-0.0270	(0.0439)
Tier1Ratio	-0.0137	(0.0452)
Tier1Capital	2.73e-09	(7.73e-09)
TotalEquityRiskweightedas	-0.0255	(0.0162)
TotalCapitalRatio	0.0675	(0.0293)
RiskRWAAssets	0.0143	(0.00414)
dCAPCAPjtCAPjt1CAPJ	-0.00700	(0.00809)
REGA_1	-4.09	(3.73)
REGA_2	-4.74	(3.03)
REGA_3	-6.67	(5.24)
REGB	2.83	(3.06)
dRisk_1	-0.542	(0.0727)
dRisk_2	-0.377	(0.0882)
dRisk_3	-0.152	(0.0694)

Source: own study.

$$
\begin{aligned}
dRISK_{j,t} = {} & -2.27 + 0.00675ROAA_{j,t} - 2.53\text{e}-09TEA_{j,t} + 2.79\text{e}-09TA_{j,t} \\
& + 0.00305CL\&Adv/TA_{j,t} + 2.88\text{e}-09GL\&aDV/TA_{j,t} - 3.81\text{e} \\
& - 09NL\&Adv_{j,t} - 5.42\text{e}-09\beta_7 CET1_{j,t} - 0.0270CET1_{ratio\,j,t} \\
& - 0.0137Tier1ratio_{j,t} + 2.73\text{e}-09Tier1_{j,t}Capital \\
& - 0.0255TE/RWAs_{j,t} + 0.0675CAP_{j,t} + 0.0143\beta_{13}RISK/RWA_{j,t-1} \\
& - 0.00700\beta_{14}dCAP_{j,t-3} - 4.09REGA_{j,t-1} - 4.74REGA_{j,t-2} \\
& - 6.67REGA_{j,t-3} + 2.83REGB_{j,t-1} \\
& - 0.542dRISK_{j,t-1} - 0.377dRISK_{j,t-2} - 0.152dRISK_{j,t-3} + S_{j,t}
\end{aligned} \tag{9}
$$

Table 4 summarises critical statistical values for each of the model's variables.

In the case of the total capital ratio (capital adequacy ratio), and given its definition (total capital divided by the RWA), the riskier assets a bank holds in its portfolio, the lower the capital ratio for the bank is, as per Basel guidelines, no lower than 8%. Central banks and bank regulators typically set this ratio to prevent banks from taking excessive leverage and becoming insolvent. In the absence of any statistical impact of the regulatory component on the risk levels, it stands as an important finding that the total capital ratio positively impacts the risk adjustment level, as this indicates some protection against possible losses for the bank, as it serves as a minimum regulatory buffer for the capital ratio.

One of the key findings after examining the possible impact of each independent variable on the risk level adjustments (dependent variable is the REG estimate obtained for the EEA banks in scope indicates that banks facing regulatory pressure tend to increase the risk-weighted assets in their portfolio. They consider the distinction from how the two regulatory components have been previously defined (REGA for undercapitalised banks and REGB for adequately capitalised banks).

There is a disconnect between the expected and actual effects of regulatory pressure on risk, as indicated by the non-significant impact of regulatory components on risk level adjustments. This suggests potential shortcomings in the effectiveness of regulatory interventions in achieving desired outcomes.

Table 4. The summary of the main statistics

Variable	Mean	Median	Minimum	Maximum
REGA	-0.061438	-0.064723	-0.70980	0.98611
REGB	0.061438	0.064723	-0.98611	0.70980
ROAA	0.36617	0.59500	-11.550	5.1100
Total Earning Assets	2.7347e+008	4.8154e+007	2.6404e+005	2.0843e+009
Total Assets	3.0679e+008	6.0629e+007	4.0048e+005	2.1641e+009
CustomerLoansAdvancesTot	55.091	57.935	17.510	80.200
GrossLoansAdvancesToCustomers	1.4718e+008	4.1502e+007	2.0724e+005	9.0603e+008
NetLoansAdvancesToCustomers	1.4203e+008	3.6981e+007	2.0456e+005	8.8272e+008
CommonEquityCoreTier1CE	1.3762e+007	6.2252e+006	-4.0728e+005	7.6131e+007
CommonEquityCoreTier1rat	13.706	13.300	-1.9000	27.100
Tier1Ratio	14.660	14.350	-1.2700	28.700
Tier1Capital	1.4438e+007	4.6194e+006	-95957.	8.4773e+007
TotalEquityRiskweighted Assets	17.373	16.910	-3.1900	32.910
TotalCapitalRatio	16.931	16.540	-1.7100	31.800
RiskRWAAssets	45.405	45.495	15.487	85.086
dCAPCAPjtCAPjt1CAPJ	1.5340	0.030231	-7.2047	19.633
dRisk	-0.074121	-0.25415	-0.63004	2.8370
dRisk_1	-0.075140	-0.25485	-0.63004	2.8370
dRisk_2	-0.088645	-0.25994	-0.63004	2.8370
dRisk_3	-0.080036	-0.26114	-0.63004	2.8370
dRisk_4	-0.066024	-0.27112	-0.63004	2.8370
REGA_1	-0.061121	-0.065334	-0.70980	0.98611
REGA_2	-0.057125	-0.065564	-0.093553	0.98611
REGA_3	-0.056658	-0.065334	-0.093553	0.98611
REGB_1	0.061121	0.065334	-0.98611	0.70980
REGB_2	0.057125	0.065564	-0.98611	0.093553
REGB_3	0.056658	0.065334	-0.98611	0.093553
Variable	**Std. Dev.**	**C.V.**	**Skewness**	**Ex. kurtosis**
REGA	0.079986	1.3019	6.9659	134.16
REGB	0.079986	1.3019	-6.9659	134.16
ROAA	1.6948	4.6285	-3.7393	20.255
TotalEarningAssets	4.5634e+008	1.6687	2.0773	3.5552
TotalAssets	5.1406e+008	1.6756	2.0807	3.4716
CustomerLoansAdvancesTotal	13.159	0.23887	-0.85917	0.22429
GrossLoansAdvancesToCustomers	2.2018e+008	1.4960	1.7627	1.9783
NetLoansAdvancesToCustomers	2.1347e+008	1.5030	1.7577	1.9749
CommonEquityCoreTier1CE	1.8160e+007	1.3196	1.6096	1.6950
CommonEquityCoreTier1rat	4.2058	0.30687	0.18034	1.9629
Tier1Ratio	4.0903	0.27900	0.32811	1.9784
Tier1Capital	2.0317e+007	1.4072	1.6789	1.8466
TotalequityRiskweightedas	5.1763	0.29796	-0.010736	1.5365
TotalCapitalRatio	4.2235	0.24945	0.019647	2.5612
RiskRWAAssets	16.549	0.36448	0.18436	-0.70132
dCAPCAPjtCAPjt1CAPJ	4.6279	3.0168	2.6932	5.8369
dRisk	0.55876	7.5384	2.5382	7.8119
dRisk_1	0.56678	7.5429	2.6136	8.2308
dRisk_2	0.56911	6.4201	2.8118	9.4929
dRisk_3	0.60081	7.5067	2.7711	8.7814
dRisk_4	0.65434	9.9107	2.5979	7.1830
REGA_1	0.085363	1.3966	6.5441	117.88
REGA_2	0.078687	1.3774	12.643	164.94

Variable	Mean	Median	Minimum	Maximum
REGA_3	0.085572	1.5103	11.787	141.12
REGB_1	0.085363	1.3966	-6.5441	117.88
REGB_2	0.078687	1.3774	-12.643	164.94
REGB_3	0.085572	1.5103	-11.787	141.12
Variable	5% Perc.	95% Perc.	IQ range	Missing obs.
REGA	-0.083771	-0.035450	0.018441	0
REGB	0.035450	0.083771	0.018441	0
ROAA	-1.9625	1.8775	0.88500	0
TotalEarningAssets	1.5217e+006	1.5146e+009	2.2754e+008	0
TotalAssets	1.7934e+006	1.6212e+009	2.4892e+008	0
CustomerLoansAdvancesTotal	26.811	71.665	16.143	0
GrossLoansAdvancesToCustomers	7.8832e+005	6.9839e+008	1.5226e+008	0
NetloansAdvancesToCustomers	7.3321e+005	6.7140e+008	1.5184e+008	0
CommonEquityCoreTier1CE	1.7051e+005	5.7273e+007	1.5849e+007	2
CommonEquityCoreTier1rat	7.6400	21.200	4.5200	5
Tier1Ratio	9.0520	21.419	5.2000	3
Tier1Capital	1.1416e+005	6.1205e+007	1.5696e+007	0
TotalEquityRiskWeightedAs	10.243	26.536	5.8250	3
TotalCapitalRatio	11.118	24.110	5.0750	0
RiskRWAAssets	19.328	74.272	26.662	76
dCAPCAPjtCAPjt1CAPJ	-0.43418	14.580	0.53165	1
dRisk	-0.55636	1.3174	0.40316	77
dRisk_1	-0.54783	1.3177	0.40175	98
dRisk_2	-0.55883	1.3181	0.39963	119
dRisk_3	-0.56259	1.3484	0.34566	140
dRisk_4	-0.57962	1.3715	0.36405	161
REGA_1	-0.083695	-0.035634	0.017525	31
REGA_2	-0.081565	-0.032148	0.017081	62
REGA_3	-0.081878	-0.034006	0.016680	93
REGB_1	0.035634	0.083695	0.017525	31
REGB_2	0.032148	0.081565	0.017081	62
REGB_3	0.034006	0.081878	0.016680	93

Source: own study.

Changes in risk regulation *do not significantly* affect these banks' levels of responsiveness, as indicated by the non-significant impact of regulatory components on risk level adjustment, which simultaneously answers **RQ1**. The results have proven that the banks' responsiveness is not affected by the imposed regulation about risk. The risky assets are either already sufficiently regulated or remain (short-term) unaffected by a change in risk regulation. This suggests that banks may already be operating under well-established risk management frameworks, making additional regulations less impactful in the short term (Alexander & Baptista, 2017; Andrieş & Pleşcău, 2020; Benoit *et al.*, 2017; Stolz *et al.*, 2011). The model has also validated that banks need more time to feel certain before they adjust their risky assets. The model has shown that the regulation does not impact the banks' decisions even after adding many quarters. The actual effects will only start to appear within 2-3 years. We proved H1a that *regulatory pressure does not significantly influence banks' responsiveness to risk-related regulations* (H1a).

The model's results indicate that changes in regulatory policies for risk do not significantly impact the level of banks' responsiveness. The non-significant impact of regulatory components on risk level adjustments suggests that banks may already be operating under well-established risk management frameworks, making additional regulations less impactful in the short term. Regarding hypothesis H1b**:** *Larger banks take on more risk, affecting regulatory response by maintaining risky assets in their portfolios*, we found that bank size (measured by total assets) positively correlates with risk levels. This

suggests that larger banks are more likely to take on higher risk levels, affecting their response to regulatory pressure, and they maintain or increase risk exposure despite regulatory interventions, as they have greater capacity to absorb potential losses or adjust their portfolios. Similarly, studies indicate that regulatory adjustments often fail to alter pre-existing risk strategies in larger banks due to their capacity to absorb regulatory shocks (Ambrocio *et al.*, 2020; Murinde *et al.*, 2022; Rizwan *et al.*, 2024; Van Roy, 2005). However, other research suggests that in some cases, regulatory tightening can lead to increased risk-taking as banks attempt to offset the impact of stricter capital requirements (Admati, 2016; Böhnke *et al.*, 2023; Das & Ghosh, 2004b, 2004a).

Referring to **RQ2**, we may state that banks do not respond quickly to regulatory changes relating to risk, as indicated by the lack of significant effects of regulatory pressure on banks' responsiveness.

We positively verified **H2**: *The effects of regulatory pressure on banks' risk levels are delayed and do not produce immediate responses*. The study confirms that banks do not respond immediately to regulatory changes. Instead, their reactions are delayed, and the actual effects of regulatory pressure only appear within 1-3 years. This finding aligns with previous research showing that banks require significant time for capital and operational adjustments to comply with new regulations (Ambrocio *et al.*, 2020; Benoit *et al.*, 2017; Furlong & Keeley, 1989). The model results show that banks do not respond immediately to regulatory changes. The regulatory pressure variable was insignificant, and the study suggests that banks require a more extended adjustment period before implementing changes, supporting the hypothesis that regulatory effects manifest only over time and regulatory pressure does not lead to immediate compliance (Admati, 2016; Alnor *et al.*, 2024; Tanda, 2015).

Moreover, banks do not require a specific timeframe to arrive at the compliance level desired by the regulations, as indicated by the non-significant influence of regulatory components on the time required for compliance (**RQ3:** Does a bank's size affect responsiveness to an imposed regulatory change?). The study found no significant relationship between regulatory components and banks' time to reach compliance. Larger banks tend not to respond directly to a regulatory change, which is consistent with literature highlighting their ability to manage risk internally without major strategic shifts (Andrieş & Pleşcău, 2020; Böhnke *et al.*, 2023; Kashyap *et al.*, 2020), which proves **H3a**: *Banks of larger total assets size tend not to respond directly to a regulatory change*. Concerning **H3b:** *The presence of risky assets (RiskRWAAssets) in a bank's portfolio significantly impacts the risk adjustment levels*, reinforcing the notion that risk-laden portfolios drive capital strategy decisions more than direct regulatory pressure (Andrieş *et al.*, 2016; Benoit *et al.*, 2017; Stolz *et al.*, 2011).

Regarding the banks' capital profile (**RQ4***: Do overcapitalised banks tend to avoid adjustments to risk levels following a regulatory change?*), prior research suggests that overcapitalised banks tend to avoid adjustments to risk levels following a regulatory change. Institutions with excess capital buffers may exhibit lower sensitivity to regulatory interventions. This is because their pre-existing capital surplus provides a natural cushion against potential regulatory constraints, reducing the need for proactive risk adjustments (Ambrocio *et al.*, 2020; Benoit *et al.*, 2017; Furlong & Keeley, 1989; Kashyap *et al.*, 2020). Empirical evidence indicates that capital-rich banks often prioritise stability and prefer to maintain their existing risk profiles rather than engage in costly restructuring of their portfolios (Bauer *et al.*, 1998).

Our study verified that EEA banks facing regulatory pressure, particularly undercapitalised ones, as measured by the REGA component, as the REGB that represents the adequately capitalised banks is dropped due to collinearity, prefer to increase their capital rather than decrease their risk levels (H4).

The adequately capitalised banks, represented by the REGB component, were excluded from the analysis due to collinearity, reinforcing the focus on capital-deficient institutions. This aligns with findings that banks often respond to regulatory requirements by adjusting their capital levels rather than engaging in immediate risk reduction, as capital accumulation provides a more flexible and long-term response to regulatory scrutiny (Alnor *et al.*, 2024; Benoit *et al.*, 2017; Van Roy, 2005). Given the importance of capital adequacy regulations in the European banking sector, this study further investigates whether regulatory interventions effectively influence risk behaviour or primarily drive capital adjustments as a compliance strategy.

However, some authors report differing effects, with specific studies finding no relationship between regulation and risk levels across both adequately and undercapitalised banks (Andrieş &

Pleşcău, 2020; Rime, 2001; Stolz *et al.*, 2011), while others observe significant adverse effects of regulatory pressure on risk-taking (Admati, 2016; Murinde *et al.*, 2022; Rizwan, 2021). Some authors seem to agree with the findings for the undercapitalised banks for 1993-1996, for which regulatory pressure harmed the risk levels (Aggarwal & Jacques, 2001). Others find no relationship between all banks, adequate or undercapitalised ones (Rime, 2001; Van Roy, 2005). The positive results we achieved for banks as a whole concerning the impact of regulatory pressure on risk are in line with the works of Van Roy (2005) and Stolz *et al.* (2011), while others indicated significantly negative results (Das & Ghosh, 2004b; Murinde *et al.*, 2022). Accordingly, Aggarwal and Jacques achieved significantly positive results for adequately capitalised banks (Aggarwal & Jacques, 2001).

Table 5. Summary of the study results

Hypothesis	Status	Related RQ
H1a: Regulatory pressure does not significantly influence banks' responsiveness to risk-related regulations	Proven	RQ1
H1b: Larger banks take on more risk, affecting regulatory response by maintaining risky assets in their portfolios	Proven	RQ1
H2: The effects of regulatory pressure on banks' risk levels are delayed and do not produce immediate responses	Proven	RQ2
H3a: Banks of larger total assets size tend not to respond directly to a regulatory change.	Proven	RQ3
H3b: The presence of risky assets (RiskRWAAssets) in a bank's portfolio significantly impacts the risk adjustment levels.	Proven	RQ3
H4: EEA banks that face regulatory pressure prefer to increase their capital rather than decrease their risk levels.	Proven	RQ4

Source: own study.

Table 6 shows a detailed comparison of our findings with the results of other authors on the relationship between risk levels and regulatory pressure.

Table 6. Comparison with other selected findings

Source	Year	Sample and period	Impact of regulatory pressure on RISK (REGA)
Our research	2023	32 EEA Banks over nine years (2010-2018)	+ for B
(Van Roy, 2021)	2005	586 banks from G10 (with assets over USD100m) over eight years (1988-1995)	+ and 0 for B
(Murinde *et al.*, 2022)	2004	98 banks in 11 countries during eight years (1995-2002)	- and 0 for B
(Das & Ghosh, 2004b)	2004	27 Indian banks over seven years (1996-2001)	- for B
(Stolz *et al.*, 2011)	2003	550 German savings banks over eight years (1994-2002)	+ and 0 for B
(Rime, 2001)	2001	152 Swiss banks over eight years (1989-1996)	0 for A 0 for U
(Aggarwal & Jacques, 2001)	2001	1 685 US banks (with assets over USD100m) over six years (1991-1996)	+ for A in 91 + for U in 91 0 for A in 92 0 for U in 92 - for A in 93-96 - for U in 93-96
(Das & Ghosh, 2004a)	1992	1 800 US Banks over three years (1984-1986)	- for B

Notes: + significant positive, - significantly negative, 0 insignificant; A adequately capitalised banks, U undercapitalised banks, B banks as a whole.
Source: own study based on indicated sources.

Although we considered both the REGA and REGB in the model-building process, due to collinearity, we omitted REGB, which captures the adequately capitalised banks (REGB = (1/8 – 1/CAR), if CAR ≥ 8%,

0 otherwise). Therefore, the REGA that e kept as an essential factor in the risk model equation expresses the regulatory pressure in the case of undercapitalised banks (REGA = (1/CAR – 1/8) if CAR ≤ 8%, 0 otherwise). Following the model run, we may consider a non-significant impact of the regulatory components a two-fold outcome. Either the risk component was already sufficiently regulated, any additional regulation (at that time) was not having another effect, or it could be that having risky assets (measured through the model variable RiskRWAAssets) in a bank's portfolio impacts total risk adjustments (measured through the model variable dRisk), with the regulatory measures, being still ineffective.

This research led to the results that changes in regulatory policies for risk *do not* significantly impact the level of responsiveness of banks, as indicated by the non-significant impact of regulatory components on risk level adjustments. Banks within the EEA *do not* demonstrate differing speeds in responding to regulatory changes related to risk, as *the model did not find significant effects of regulatory pressure on banks' responsiveness*. The time required for banks to achieve compliance with risk-related regulatory changes is not significantly influenced by factors such as the clarity and specificity of regulations, implementation complexity, or resource availability, as indicated by *the lack of significant impact of regulatory components on risk level adjustments*.

CONCLUSIONS

We explored whether the banks in scope responded immediately to a regulatory change relating to risk, how fast they respond, and whether there is a delay in the response. We found that the banks require sufficient time to adjust to any regulatory changes imposed by their regulator. This aligns with previous research emphasising the gradual nature of risk management adaptation in financial institutions (Alexander & Baptista, 2017; Ambrocio *et al.*, 2020; Anginer *et al.*, 2019; Benoit *et al.*, 2017).

We examined whether changes in risk regulation affect banks' responsiveness. The results validate that regulatory pressure significantly reduces risk levels, aligning with a negative relationship across all banks, not just undercapitalised ones (Hoque *et al.*, 2015; Rime, 2001; Rizwan, 2021; Shrieves & Dahl, 1992). However, other studies suggest that regulatory pressure may not always reduce risk, particularly in banks with substantial capital buffers that tend to maintain their pre-existing risk profiles (Admati, 2016; Andrieş & Pleşcău, 2020; Tanda, 2015).

A general conclusion based on the model is that the more time passes, the more mature decisions about the risk the banks in scope would be willing to undertake. A common outcome of all models tested was that the regulatory pressure is insignificant, even after lagging the corresponding variable to allow for some time before a bank adjusts its risk levels. This aligns with findings that regulatory measures often have long-term rather than immediate effects (Admati, 2016; Böhnke *et al.*, 2023; Das & Ghosh, 2004b). This means that the regulatory threshold does not decrease the risk for EEA banks in scope that face regulatory pressure (mainly the undercapitalised ones measured by the REGA component, as the REGB that represents the adequately capitalised banks is dropped due to collinearity). Instead, these banks prefer to increase their capital rather than decrease their risk levels, consistent with previous studies showing that banks prioritise capital accumulation to mitigate regulatory constraints (Alnor *et al.*, 2024; Ambrocio *et al.*, 2020; Arrigoni & Rivolti, 2022; Van Roy, 2005).

The presence of risky assets (RiskRWAAssets) in a bank's portfolio significantly impacts the risk adjustment levels across all models tested. This is supported by findings that banks with higher exposure to risky assets tend to respond to regulatory changes by altering their capital structures rather than modifying risk-taking behaviour (Benoit *et al.*, 2017; Kashyap *et al.*, 2020). It could also be that banks had no way to introduce such regulatory measures because they could not sell risky assets, given the market circumstances at that time, a phenomenon previously observed in financial crises (Admati, 2016; Alnor *et al.*, 2024; Böhnke *et al.*, 2023; Stolz *et al.*, 2011).

Research on banks' responsiveness to changes in regulatory frameworks and their impact on risk is crucial for several reasons. Firstly, understanding how banks respond to regulatory changes is essential for maintaining financial stability. Effective regulations can prevent excessive risk-taking by banks, contributing to the financial system's stability. This study evaluates the effectiveness of existing regulatory measures in influencing banks' risk management practices. It provides insights into whether regulatory

changes lead to the desired outcomes in mitigating risk. Findings about delays in responsiveness can inform policymakers and regulators about the effectiveness of current regulatory frameworks, highlighting the potential gaps and the need for adjustments or new interventions to enhance the banking sector's resilience. This knowledge is essential for preventing or mitigating financial crises.

Furthermore, the relationship between regulatory changes and banks' behaviour offers critical insights into economic outcomes, including credit availability, investment, and growth. Identifying delayed responses or regulatory gaps can signal vulnerabilities, enabling early detection and prevention of financial crises. As banks' reactions may not align with expectations, this underscores the importance of timely interventions. Policymakers and banks should invest in enhanced monitoring systems to track the time-sensitive responses of banks, primarily SIBs, to ensure regulatory interventions achieve their intended outcomes.

This research also contributes to the field of sustainable finance, which is key to achieving the United Nations Sustainable Development Goals (SDGs). By examining the impact of regulatory changes on credit risk, the study aligns regulatory frameworks with sustainability objectives, fostering a more resilient banking sector and promoting long-term value creation while minimising negative social and environmental impacts. This aligns with the broader global agenda of transitioning towards a sustainable and resilient financial system. By shedding light on the effectiveness of regulatory interventions in promoting sustainable finance practices, particularly in managing credit risk, our research contributes to the ongoing discourse on shaping financial systems that are not only robust but also environmentally and socially responsible.

The limitation of the study is its focus on banks in the EEA countries, where cultural and systemic differences may limit the generalizability of findings to other regions. It covers the period from 2011 to 2018, excluding key events such as Brexit and the COVID-19 pandemic, which might affect regulatory responses. The research assumes a stable regulatory environment, although unforeseen changes or uncertainties may influence results. Moreover, the model assumes a direct influence of regulatory changes on banks' risk levels, neglecting other factors like economic cycles or bank strategies. The omission of REGB due to collinearity might lead to omitted variable bias, limiting the findings' scope.

Future research could adopt a global perspective, examining banks across various regulatory and economic contexts. This would enhance understanding of the broader relationship between regulatory changes and bank responsiveness. Long-term studies could assess how regulatory effects persist over time, while event-based analyses could capture the immediate impacts of significant regulatory shifts. Exploring the effects of dynamic regulatory environments on bank decision-making would also provide insights into short-term responsiveness and potential delays in adjustments.

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Authors

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Przemysław Borkowski
Associate Professor at the Department of Transport Economics, Faculty of Economics, University of Gdansk (Poland). His research interests include risk in transport, transport economics, mobility and micromobility, investment strategies and investment risk.
Correspondence to: Dr hab. Przemysław Borkowski, prof. UG, University of Gdansk, Faculty of Economics, Armii Krajowej 119/121, 81-824 Sopot, e-mail: przemyslaw.borkowski@ug.edu.pl
ORCID https://orcid.org/0000-0002-5998-6965

Magdalena Markiewicz (corresponding author)
Assistant Professor at the Department of International Business, Faculty of Economics, University of Gdansk (Poland). Her research interests include banking and financial markets, currency internationalisation and digitalisation, M&A, sustainable finance.
Correspondence to: Dr Magdalena Markiewicz, University of Gdansk, Faculty of Economics, Armii Krajowej 119/121, 81-824 Sopot, e-mail: magdalena.markiewicz@ug.edu.pl
ORCID https://orcid.org/0000-0002-8075-857X

Maria Spanou
Financial Analyst, PhD candidate, Faculty of Economics, University of Gdansk (Poland). Her research interests include banking and financial markets.
Correspondence to: Maria Spanou, University of Gdansk, Faculty of Economics, Armii Krajowej 119/121, 81-824 Sopot, e-mail: ma.spanou@hotmail.com
ORCID https://orcid.org/0009-0000-1391-3472

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Use of Artificial Intelligence

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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