Back to the Roots of Internal Credit Risk Models: Why Do Banks' Risk-Weighted Asset Levels Converge over Time?*

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Abstract

Internal credit risk models have been introduced to map banks' distinct risk profiles more adequately than the standardized approach. After the switch to the internal ratings-based (IRB) approach, banks' risk-weighted asset (RWA) densities are thus expected to diverge, especially across countries with different supervisory strictness and risk levels. However, by examining 52 listed banks headquartered in 14 European countries that adopted the IRB approach, we observe a gradual convergence of their RWA densities over time. For banks in high-risk countries with high initial RWA densities, and in countries with lax regulation, the reduction is more notable. In contrast, RWA densities of banks in countries with strict supervision increase. Furthermore, especially for banks in high-risk countries, the RWA densities underestimate banks' actual economic risk position, becoming a less suitable indicator for country risk. We show evidence that the IRB approach provides opportunities for regulatory arbitrage, whereby authorities only enforce strict supervision on capital requirements if they do not jeopardize bank resilience.

JEL classification: G21, G28

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1 Introduction

The Basel Committee on Banking Supervision (BCBS) defined two distinct methodologies for calculating banks' capital requirements for credit risk. Banks using the less risk-sensitive standardized approach use external credit assessments based on a predefined classification system. The regulatory purpose of the risk-sensitive internal ratings-based (IRB) approach is to map differences in bank risks more adequately than with the standardized approach, based on a thorough assessment of the asset composition of banks' balance sheets and their business models. Differences across banks are expected to lead to higher dispersion in risk-weighted asset (RWA) estimations than obtained when employing the standardized approach (e.g., BCBS, 2013).

Calculated as the banks' RWAs over total assets, the RWA density provides a measure of the average riskiness of banks' assets (e.g., Mariathasan and Merrouche, 2014). As credit RWA usually represent by far the largest share of total RWAs, they are commonly used in this context (e.g., Berg and Koziol, 2017). An increase in the RWA density shows that the overall quality of a bank's assets deteriorated from the regulatory perspective. This increase may arise as assets with higher risk substitute lower-risk assets, without any change in the corresponding risk weight factors. Accordingly, a decrease in banks' RWA density would indicate that the average assets' risk profile improved. Alternatively, these changes in RWA density may be due to national regulations influencing RWA calculations. Countries' regulatory authorities impose regulations that set a soft or hard minimum capital requirement which translates in a lower bound on banks' RWA density. Whereas a capital ratio may mask different risk levels or measurement approaches, changes in RWA densities reflect gradual changes in banks' business models, the macroeconomic situation, and the regulatory and supervisory framework (Le Leslé and Avramova, 2012).

Whereas previous studies have focused on the heterogeneity of RWA densities across banks and jurisdictions (e.g., Mariathasan and Merrouche, 2014; Montes et al., 2018), changes in RWA densities over time across countries with different risk profiles and supervisory strictness have not yet been explored. Research on implications of internal credit risk models on banks' RWAs largely focus on two questions. First, they analyze whether the resulting RWA levels are consistent across banks and jurisdictions (e.g., Mariathasan and Merrouche, 2014; Berg and Koziol, 2017). Second, it is investigated whether capital requirements are sufficiently risk-sensitive to ultimately achieve a strong and resilient banking system (e.g., Barakova and Palvia, 2014; Ahnert et al., 2020). Also, prior research acknowledges differences in national banking supervision, domestic credit supply, as well as the economic conditions (Agarwal et al., 2014; Gropp et al., 2021). However, their effects on the dynamic temporal development of banks' RWA density reductions are not discussed.

To study the evolution of RWA densities, we investigate quarterly data of 52 listed banks headquartered in 14 European countries that adopted the IRB approach between Q1/2007 and Q4/2019. First, we group countries based on sovereign risk, and on regulatory and supervisory strictness. To the best of our knowledge, we are the first to introduce a country grouping which accounts for both sovereign credit risk and the national levels of banking regulation and supervision. Second, we employ a cross-sectional setting to analyze the development of RWA densities relative to the quarter of the switch across countries with different sovereign credit risk profiles and distinguished national levels of regulatory strictness. Third, we estimate a panel model to examine the factors impacting the changes in RWA density over time.

Our results reveal that RWA densities of banks using the IRB approach converge downwards over time. The mean RWA density decreases from 49.77 in 2007 to 35.47 in 2019 and the corresponding standard deviation decreases from 18.70 to 13.18. We find that factors like bank profitability, equity capital, and the countries' credit supply are significant in explaining variation in RWA density (e.g., Ferri and Pesic, 2017; Montes et al., 2018). Moreover, countries in the same risk- or regulatory strictness group share some common traits. In countries with high country risk, banks' RWA density only slightly decreases or even increases with the adoption of the IRB approach, still closely reflecting the high country risk. Yet, the initial change is followed by a gradual decrease which occurs at a higher pace than in countries with medium-risk. Apart from risk, we additionally take into account the countries' regulatory and supervisory strictness.

In countries with lax regulations, we document a significant initial reduction of RWA density upon adoption of the IRB approach, followed by further gradual decreases over time. In contrast, countries with strict supervision as well as medium-risk countries reduce their RWA densities to a smaller extent after the switch to the IRB approach. Most notably, in countries with strict supervision, banks' RWA densities subsequently remain on a largely stable level and even increase in response to the tightening of regulations. Furthermore, we shed light on the inconsistencies in banking regulation and supervision across countries (e.g., Agarwal et al., 2014; Gropp et al., 2021) and show how national differences distort the validity of RWA densities, representing the key measure of regulatory risk (Berger, 1995; Vallascas and Hagendorff, 2013).

In line with the original regulatory intention, the IRB approach enables banks to have the required capital available according to their individual risk exposure (BCBS, 2004). Prior studies emphasize the importance of risk sensitivity in capital regulation and indicate potential problems of insensitivity to risk (e.g., Barakova and Palvia, 2014; Colliard, 2019; Ahnert et al., 2020). However, RWAs of banks that use internal models are not reflecting the actual economic risk, suggesting a reduction beyond the amount intended by the regulator (European Banking Authority (EBA), 2015a; Plosser and Santos, 2018; Colliard, 2019).

Generally, banks are motivated to switch to the IRB approach if they can achieve lower RWA densities. Indeed, empirical studies show that after obtaining the approval to use the IRB approach, banks' RWA densities decrease (e.g., Mariathasan and Merrouche, 2014; Montes et al., 2018). On the one hand, the calculation procedure of the IRB approach is tailor-made and maps banks' individual risk profile more adequately than the standardized approach but, on the other hand, it seems to allow certain leeway in RWA calculations. Indeed, prior studies argue that the IRB approach provides opportunities for regulatory arbitrage where banks reduce their regulatory capital without an analogous and adequate decrease in economic risk (e.g., Jones, 2000). This is reflected by the substantial initial reduction in RWA density in all banks directly after the switch.

Previous literature documents inconsistencies in the regulation and supervision of banks. Some studies show systematic differences in the strictness of supervision between banks under surveillance of the national supervisory authorities and banks under supranational supervision (e.g., Haselmann et al., 2019; Colliard, 2020). Several studies document that supervisory authorities are lenient with potential bank failures (e.g., Brown and Dinç, 2011; Morrison and White, 2013; Walther and White, 2020). Reasons include political influence on the regulatory authorities and considerations on the competitiveness of domestic banks (e.g., Schoenmaker, 2012; Reinhardt and Sowerbutts, 2015).

To further explain the discretion of supervisory authorities, Gropp et al. (2021) focus on the introduction of supranational regulation at the national level. Gropp et al. (2019) show how banks increase their capital ratios through RWA reduction. However, Gropp et al. (2021) reveal that this increase neither coincides with a corresponding increase in book equity nor adequate risk reduction. Gropp et al. (2021) also indicate how regulators allow for leeway in defining regulatory capital. Banks' ability to reduce their RWA densities should reflect economic outlooks, country- and bank-specific risks. From the regulatory perspective, authorities aim to limit this ability to redefine risk without a change in actual risk levels.

Further studies analyze the impact of model-based capital regulation on bank profitability (Ferri and Pesic, 2019; Mascia et al., 2019; Böhnke and Woyand, 2021). Beltratti and Paladino (2016) find that banks that are more aggressive in reducing their RWA densities subsequently have a lower return on equity and are more likely to raise new capital during a credit crisis. Banks can adjust to new capital levels by reducing lending, or raising new capital. Further, banks with low profitability are more likely to reduce lending. Thus, regulators refrain from imposing stricter regulations on low profitability banks or when the real economy experiences low growth (Repullo and Suarez, 2013).

Our study relates directly to the literature on the effect of changes in capital requirements on bank credit supply (e.g., Hyun and Rhee, 2011; Brei et al., 2013; Han et al., 2018; De Jonghe et al., 2020; Fraisse et al., 2020) and rests on an understanding of the real effects of increasing capital requirements. With reference to the IRB approach, Behn et al. (2016) show that internal models increase the procyclicality of loan supply. Ferri and Pesic (2020) suggest that high capital requirements reduce national credit supply with potential negative effects on medium-size banks. Moreover, Juelsrud and Wold (2020) show that banks react to higher capital requirements by reducing their average risk weights and document their influence on the real economy.

Our findings become relevant in the wake of the relaxed financial regulations on minimum capital requirements and credit risk management intended to overcome Covid-19 crisis-related challenges to the banking system (EBA, 2020; EBA, 2021). In the absence of regulatory relaxations, higher probabilities of default in economic downturns lead to increasing RWA densities (Behn et al., 2016), which increases the burden on banks, with possible negative spillover effects on the economy. Thereby, authorities only enforce strict supervision on capital requirements if they do not jeopardize bank resilience. Disentangling the influence of country risk, different regulatory and supervisory strictness on banks' RWA densities is, thus, highly important to assess the effects of updated regulatory policies in times of crises.

2 Stylized facts

In the regulatory frame of Basel II, the IRB approach, which is subject to the explicit approval of the bank's supervisor, allows banks to rely on their internal estimates of relevant credit risk parameters (BCBS, 2004). After switching to the IRB approach, no bank has been allowed to return to the standardized approach, so switching is de facto irreversible. During the 2008 financial crisis, the weaknesses in the banking sector were rapidly transmitted to the rest of the financial system and the real economy, resulting in a massive contraction of credit available. Consequently, Basel III comes with an updated frame for credit risk practices and supervision. Thus, after the financial crisis, regulators keep increasing requirements regarding the minimum capital ratio to further ensure the resilience of banks and the stability of the banking sector (e.g., BCBS, 2011; EU, 2013; BCBS, 2017).

Figure 1 illustrates the development of the countries' quarterly mean RWA density for the IRB approach banks. We observe large dispersion between the countries' RWA densities at the beginning of our observation period which, however, converge to a similar level over time.[1] Most banks switch shortly after the adoption of the IRB approach becomes possible in their country.[2] To illustrate the RWA density development relative to the quarter of IRB approval, Table 1 provides an overview of average RWA densities across countries at the quarter of switch as well as five and ten years later. In contrast to the overall downward trend, we observe increasing RWA densities for banks in some countries between five and ten years after the switch.

[Figure 1 and Table 1 about here.]

Table 2 provides summary statistics of banks' RWA densities across years. Both mean and median values confirm the downward trend. In line with the convergence of RWA densities over time, the standard deviation gradually decreases across years. Moreover, the minimum values remain on a similar level, while the maximum values sharply decline, indicating downward convergence.

[Table 2 about here.]

The reduction in RWAs contributes to the banks' effort to fulfil the higher capital ratios while banks do not reduce their economic risk accordingly (e.g., Gropp et al., 2019, 2021). Potential explanations for these stylized facts include bank-level changes in the calculation approach of RWAs, different business models across banks, as well as country-level differences in the economic situation or banking regulation and supervision.

The regulatory authorities allow a gradual implementation of the IRB approach. Moreover, they allow for a permanent partial use, where banks may refrain from applying the IRB approach to all portfolios (BCBS, 2004; BCBS, 2017; EBA, 2019). Banks most likely initially implement the IRB approach for portfolios where they expect the

[1] For comparison purposes, Figure A.1 in the internet appendix illustrates the development of the countries' annual mean RWA density of banks using the standardized approach.

[2] Figures A.2 and A.3 in the internet appendix present the evolution of RWA densities for each bank and illustrate when each bank switches to the IRB approach.

largest reduction in average risk weights per volume unit. As implementation progresses, banks may continue to reduce their risk-weights resulting in decreasing RWA densities over time.

When analyzing changes in banks' RWA density over time and across countries, we additionally expect regulation and supervision to play a major role. Scandinavian countries may serve as an example to explain differences in their RWA density dynamics as being linked to the different levels of regulatory strength. Indeed, we find significant differences in banks' RWA density changes post switch between the Nordic countries, Norway, Finland, Sweden, and Denmark. This is in line with the different extent at which these countries have been affected by a prior banking crisis. We put forward that countries that have experienced high economic and social cost from a collapse in the banking sector have a higher willingness to impose strict minimum capital requirement regulations on banks. However, incentives to regulate further depend on whether the banking sector is robust, and if banks have the ability to build up capital through profitability. In the 1990-banking crisis, Finland, Norway, and Sweden were among the industrialized countries that experienced the most severe losses in the economy due to defaulting banks (Reinhart and Rogoff, 2008). Denmark did not experience such an impact. Thus, Denmark being less affected, has a lower willingness to impose strict regulations on banks' minimum capital requirements, believing more in the markets' ability to self regulate. In addition, Nordic banks have high levels of exposure to mortgages on their balance sheets, and GDP and real estate price growth have a large impact on bank profitability (Martins et al., 2019). Norway has experienced a more steady increase in GDP and real estate prices after the introduction of the IRB approach than Denmark, Sweden, and Finland. The strictest capital requirements imposed in Norway are grounded on the high profitability in the banking sector, which facilitates building up capital. Focusing on the implementation of the Third Basel Accord in Norway that has been introduced earlier than in other European countries, Juelsrud and Wold (2020) describe the implementation of this policy reform to increase capital requirements.

Despite notable differences in economic risk levels between countries, we observe downward convergence in regulatory risk levels over time (see Figure 1 and Table 2). In order to support the competitiveness of domestic banks, banking authorities may decide to relax regulatory requirements, having as result banks' RWA density convergence. According to the literature on regulatory leakage, the market of a strictly regulated banking sector becomes more attractive for branches of foreign banks subject to lower capital requirements (Reinhardt and Sowerbutts, 2015). An increase in foreign banks' market share can both be perceived as a threat to the banking sector, and give rise to political pressure to reduce differences in capital regulation.

3 Empirical Design

3.1 Data

In this section, we describe the data preparation and the sample selection procedure. Table 3 summarizes bank- and country-specific data, as detailed in this section. We focus on the 80 largest listed European banks by total assets. Listed banks are required to publish financial reports quarterly, and generally provide granular information on capital, loans, losses, and profit. We employ quarterly data over a fourteen year time period to explore differences between banks, countries, and regulatory regimes. As banks have been able to obtain the IRB approach approval since 2007,[3] our data covers the period from Q1/2006 to Q4/2019, which enables us to analyze the impact of the switch to the IRB approach on banks' RWA density development.

[Table 3 about here.]

Previous studies show that RWA densities of banks using internal models are lower than those calculated using the standardized approach. Whereas previous literature compares the levels of RWAs between banks using the IRB approach versus the standardized approach, we aim at analyzing the short- and long-term effects of banks' switch to the IRB approach on their RWA densities. We focus solely on banks which seek and obtain approval to use an internal credit risk model during our sample period and analyse the immediate effect of the switch in a cross-sectional analysis. We furthermore

[3] Note that not all national supervisors started to approve banks' internal credit risk models in 2007. In the internet appendix B, we provide information on the year and quarter when the IRB approach adoption becomes possible for each country.

identify factors that explain the development of RWA densities over time, after the switch.

Among the 80 largest listed European banks, 58 switched to the IRB approach by the end of 2019. We gather information on the IRB approach approval date which is published either in banks' annual reports or disclosure reports following the public disclosure requirements (BCBS, 2004). From banks' quarterly reports, we manually collect the share of a bank's loan portfolio, where RWAs are calculated using the IRB approach. All other quarterly bank-specific information is retrieved from the Refinitiv Datastream database. Unfortunately, the Refinitiv Datastream database contains random gaps in the time series for some entities. To improve the data quality, we replace missing values of banks' RWAs using banks' quarterly reports. Moreover, we follow Kofman and Sharpe (2003) and use imputation methods bridging short gaps to deal with missing values in banks' RWAs, net income, net loans, and loan-loss reserves data. As we calculate quarterly changes based on this information, sufficient data availability and quality are necessary to obtain unbiased results. RWA data at the quarter of the switch and for the subsequent four quarters is missing for six banks which switched at the beginning of the sample period. We eliminate these six banks, as the corresponding quarterly reports are no longer available on banks' websites and imputation techniques are not applicable or would bias the cross-sectional analysis. Our final data set includes 52 listed banks headquartered in 14 European countries.[4]

We measure country risk based on 5-year sovereign credit-default swap (CDS) spreads taken from the Refinitiv Datastream database. In addition to cross-country differences in risk, we take into account the economic outlooks as well as the regulatory stringency and the supervisory power for each country. Country-specific macroeconomic data originates from the International Monetary Fund and the World Bank. Information on regulatory stringency and supervisors' disciplinary power across countries is based on the World Bank's Bank Regulation and Supervision Survey.[5] The capital regulatory

[4] Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. Table C.2 in the internet appendix presents an overview of our data set across countries.

[5] Our data is based on the 2007, 2011, and 2019 surveys. We summarize the survey questions used in both indices as suggested by Barth et al. (2013) in the internet appendix D. Following Barth et al. (2004) and Anginer et al. (2014), we assume that regulations are persistent over time and

index evaluates the countries' regulatory capital rules and their capacity to result in a reliable regulatory capital base. The index ranges from 0 to 10 where higher values indicate greater regulatory stringency. The supervisory power index assesses the supervisors' authority to enforce applicable regulations and to conduct effective bank resolution activities. The index ranges from 0 to 14 and higher values indicate greater supervisory power.

3.2 Country grouping

To structure the countries in our cross-sectional data set and check if there are systematic differences in banks' RWA density development after the switch, we group the countries based on sovereign risk as well as regulatory and supervisory strictness. Table 4 summarizes the country grouping based on national levels of banking regulation and supervision, and according to sovereign CDS spreads.

[Table 4 about here.]

First, we take into account differences in the countries' regulation and supervision based on the two indices suggested by Barth et al. (2013). On the one hand, banks in countries with less tight regulation may be able to reduce their RWA densities below the appropriate level. Especially in Europe, where the authorities allow gradual roll-out of the IRB approach, banks have incentives to adjust their asset composition towards more risky assets (Dautović, 2020). According to Barth et al. (2013), regulatory stringency in Denmark and Sweden is the lowest on average between 2007 and 2019. Facing lax regulation, especially banks in those countries are able to exploit moral hazard incentives. The fact that the 2018 regulation change introducing higher capital requirements in Sweden is specifically targeting banks with IRB approach approval, corroborates this assertion (Finansinspektionen Sweden, 2018). On the other hand, strict supervision may prevent moral hazard behavior and force banks to refrain from further reducing their RWA densities. Again, referring to Barth et al. (2013), Austria and Switzerland score the highest supervisory power index values, on average.

rely on a country's index value until new information is available. Index values of all countries in our data set based on the 2007 and 2011 survey are retrieved from Barth et al. (2013). To track the more recent changes, we calculate the index values based on the latest survey published in 2019 for the years 2018 and 2019.

Second, to distinguish the countries' risk level, we rely on sovereign CDS spreads. CDS spreads are especially suitable for our study, as they provide information on country-specific credit risk on a daily basis (e.g., Fontana and Scheicher, 2016). We classify a country as a high-risk country if average CDS spreads across the sample period are larger than 100 basis points. Hence, Ireland, Italy, and Spain are categorized as high-risk countries.[6] Similarly, Beltratti and Paladino (2016) classify these three countries among the European peripheral ones[7], supporting our classification of high-risk countries.

Again referring to Figure 1 and Table 1, the development of the countries' quarterly mean of banks' RWA density validates this country grouping. Focusing on high-risk countries, banks initially have high RWA densities and start using the IRB approach later than several banks in medium-risk countries or countries with lax regulation or strict supervision. As shown in Table 1, the average RWA density of these banks is substantially lower ten years after the switch. Similarly, banks in the two countries with lax regulation have been able to reduce their RWA densities over time. In contrast, the RWA densities of Norwegian banks, representing a special case among the medium-risk countries as discussed in Section 2, slightly decreased but remained on a very high level (see Figure 1). Among the countries with strict supervision, average RWA densities of Austrian banks have already been on a high level at the time of the switch and remained so. Even though the RWA densities of Austrian banks decrease at times, we observe a notable increase, which is due to a response to the additional capital requirements introduced by the Capital Requirements Directive IV, which was implemented in the EU until the end of 2013 (EU, 2013). In Switzerland, RWA densities were the lowest in Europe until 2012 but capital of Swiss banks almost doubled within ten years, as the

[6] In Table 4, we illustrate the country grouping with reference to the classification of high-risk countries. Figure A.4 in the internet appendix presents the development of sovereign CDS spreads across the countries in our data set over time. Unsurprisingly, a classification based on sovereign credit ratings, which summarizes available macroeconomic and market-based information, results in the same categorization of high-risk countries (e.g., Hilscher and Nosbusch, 2010).

[7] Beltratti and Paladino (2016) analyze the effect of the Second Basel Accord on banks' RWA density during the 2008 financial crisis and the sovereign debt crisis. The authors classify Cyprus, Greece, Ireland, Italy, Portugal, and Spain as the peripheral countries and indicate that they are associated with high country risk.

responsible authorities introduced higher capital requirements for the two largest Swiss banks to be implemented by 2013 (Swiss Bankers Association, 2009).[8]

Thus, the impact of the IRB approach adoption on the evolution of banks' RWA densities shows distinguishing patterns across country groups classified with respect to sovereign risk, as well as regulatory and supervisory strictness. Table 4 additionally includes the country ranking for each of the three categories. Specifically, the concurrence of different levels of regulatory stringency and supervisory power is expected to influence banks' strategies. As an example, banks in countries with strict regulation may be able to exploit leeway due to low supervisory power. Moreover, regulatory authorities may refrain from strict supervision in countries with high country risk. In the panel analysis, we take into account dynamics with respect to countries' regulatory stringency, supervisory power, and sovereign credit risk.

3.3 Variables and descriptive statistics

Our empirical study comprises both cross-sectional and panel analyses, requiring two distinct data sets. To create the cross-sectional data set, we focus on the differences between individual banks and define our variables relative to the switch date or use averages across the sample period with one observation per bank. Adding the time dimension, the panel data set additionally tracks the development of the variables for the time period between Q1/2007 and Q4/2019. Tables 5 and 6 provide an overview of all variables included in both analyses.[9] In the following, we present these variables in detail and explain their choice in the analysis.

[Tables 5 and 6 about here.]

Cross-section

In the cross-sectional analysis, we define both short- and long-term RWA density changes relative to the quarter of the IRB approach approval. First, to analyze the RWA density

[8] We summarize the timeline of relevant events in the European banking sector in the internet appendix B.

[9] Descriptive statistics of all variables are provided in Tables C.3 and C.4 in the internet appendix. Non-binary bank-specific panel variables are winsorized at the 1% and 99% levels. Tables C.5 and C.6 in the internet appendix present the correlation matrices.

reduction[10] right after the switch, let us define $\Delta RWAD^{s}_{i,j}$ for bank i in country j as the percent change in RWA density at the end of the quarter of the switch s compared to the end of the quarter before approval. To additionally model the long-term development after the switch, we calculate the average of the quarterly changes in RWA density across r quarters after the switch ($\varnothing\Delta RWAD^{s+r}_{i,j}$). However, as several banks switch later during our sample period, the number of available banks and therefore the number of observations in the cross-section decreases.[11]

Most importantly, we include indicator variables to control for the country grouping explained in Section 3.2. The indicators $HIGH\_RISK_j$, $LAX\_REGULATION_j$, and $STRICT\_SUPERVISION_j$ track the differences in RWA density changes across country groups. To illustrate the importance of disentangling between short- and long-term RWA density reductions, Figure 2 presents the RWA density development pattern relative to the quarter of approval $s = 0$. Panel A shows that the average RWA density decreases for high-risk countries and countries with lax regulation, while it decreases only slightly for medium-risk countries. Notably, the average RWA density of the two countries with strict supervision slightly increases in the quarters following the IRB approach approval. Given banks' different risk profiles, the introduction of internal credit risk models should have increased the dispersion between banks as their RWAs became more risk sensitive (e.g., BCBS, 2004; Barakova and Palvia, 2014). However, we observe that RWA densities of banks in high-risk countries decrease at a faster pace than banks in medium-risk countries. Rather, banks in high-risk countries reduce their RWA densities at a similar pace as banks in countries with lax regulation. On the contrary, banks in countries with strict supervision even increase their RWA densities in the long-term perspective.

[10] Following previous literature, we expect a reduction in RWA densities for the majority of banks (see Section 1).

[11] The majority of banks chooses to apply for IRB approach approval before the end of 2009. Thus, we can calculate the average RWA density change across 40 quarters for 41 banks. To test if our results are systematically influenced by late switchers, we estimate the cross-sectional model based on the subsample of 41 banks that switch early. The results of this robustness test, presented in Table E.10 in the internet appendix, confirm our conclusions as detailed in Section 5.1 and we find that banks in high-risk countries can already reduce their RWA densities eight years after switching.

Panel B focuses on the time when banks switch to the IRB approach and illustrates the RWA density change four quarters before and after the quarter of the switch to the IRB approach. The change at the quarter of the switch $s = 0$ corresponds to the variable $\Delta RWAD^{s}_{i,j}$ and represents the reduction upon approval. Unsurprisingly, most banks are able to reduce their RWA densities and reduction in countries with lax regulation is especially large at the quarter of the switch. As shown in Figure 1, banks in both countries with lax regulation, Denmark and Sweden, continue to reduce their RWA densities over time. Notably, Swedish banks again increase their RWA densities following the implementation of an average institution-specific risk weight floor for Swedish mortgage exposures at the end of 2018 (Finansinspektionen Sweden, 2018).

[Figure 2 about here.]

For the short-term dynamics, we control for the distance of RWA densities relative to the minimum capital requirement at the quarter before the bank obtains the approval to use the IRB approach ($REL\_MIN^{s-1}_{i,j}$). Larger values indicate an upward pressure on the RWA density change. For the long-term development, we instead include $\varnothing RWAD_{i,j}$ to take into account the impact of a trend in total assets influencing the banks' average RWA density development across the sample period. All other explanatory variables in the cross-sectional analysis are the same for both versions of the dependent variable.

Moreover, we address possible confounding factors which are expected to impact the RWA density development. Particularly, banks gradually implement the IRB approach across portfolios after they obtain approval (BCBS, 2004; BCBS, 2017). The gradual roll-out process may have both a short- as well as a long-term effect on the evolution of RWA densities since banks are expected to start calculating the IRB approach for portfolios with the largest expected RWA density reduction (BCBS, 2004; Moessinger and Woyand, 2021). In the analysis of the effect of IRB approach implementation on banks' RWA densities, we use the share of banks' loan portfolio where RWAs are calculated based on the IRB approach at the quarter of the switch. The variable $IRB\_COVERAGE^{s}_{i,j}$ describes the initial coverage of the IRB approach at the first quarter where a bank uses an internal model. Regarding the long-term development, we compute an indicator variable which is equal to 1 if banks' average IRB approach coverage is larger than the third quartile of the average coverage of all banks across the sample period ($\varnothing HIGH\_IRB\_CVG_{i,j}$). Hence, this variable indicates if a bank implements the IRB approach for the majority of its loan portfolio volume until the end of 2019.

Besides, banks' net income to RWAs $RETURN\_ON\_RWA_{i,j}^{s-1}$ or the share of loan-loss reserves at the quarter before the switch $LLR_{i,j}^{s-1}$ may further affect the RWA density reduction upon approval (EBA, 2015b). We furthermore introduce simple indicator variables to describe bank-specific characteristics in our sample. As the majority of banks obtain approval shortly after switching becomes possible in their country and most banks switch before the crisis, the timing may influence the banks' options to reduce their RWA densities. We thus introduce an indicator variable $PRE\_CRISIS_{i,j}$ which is equal to 1 if a bank switches before the third quarter of 2008. Moreover, the indicator variable $EURO_{i,j}$, which is equal to 1 for banks headquartered in euro countries, controls for effects specific to the euro area.[12] As an example, euro banks are part of the European Banking Union and with the introduction of the so called Single Supervisory Mechanism in 2014, the European Central Bank (ECB) becomes their central supervisor (ECB, 2018).

We furthermore create variables based on the calculation of averages across our sample period, as suggested by Goddard et al. (2004). On the bank-level, we define $\varnothing EQUITY_{i,j}$ equal to 1 if banks' average equity ratio is larger than the mean value of all banks across the sample period, and $\varnothing SIZE_{i,j}$ equal to 1 if banks' average natural logarithm of total assets is larger than the corresponding mean across the sample period. On the country level, $\varnothing DOMESTIC\_CREDIT_j$ is equal to 1 if countries' average credit to the private non-financial sector in percent of GDP is larger than the mean across countries. Hereby, we take into account the relation between capital regulation and bank credit supply, as discussed in Hyun and Rhee (2011). To consider overall macroeconomic dynamics $\varnothing \Delta GDP_j$ describes the country average real GDP growth across the sample period.

[12] Euro countries include Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, and Spain.

Panel analysis

In the panel analysis, we use the quarterly change in RWA densities ($\Delta RWAD_{i,j,t}$) as dependent variable, exploring the development over time and across banks. In contrast to the two versions of banks' RWA density change used in the cross-sectional model, this variable does not relate to the quarter of approval but tracks the RWA density changes on a quarterly basis between Q1/2007 and Q4/2019. Figure 3 illustrates the development over time across country groups (Panel A to D). As described by Lindquist (2004), we observe a seasonal variation of RWA density changes. This seasonality is a result of accumulation of profit before annual distribution of dividends to shareholders. Interestingly, both mean and median of banks' change in RWA density for banks in countries with lax regulation and in high-risk countries are negative and the lowest across groups, suggesting that these banks substantially reduce their RWA densities.[13]

[Figure 3 about here.]

The variation in RWA density changes may be attributed to particular events. Negative changes in Panels A to D, especially during the first three years of our observation period, relate to banks' IRB approach approval. Positive changes at the end of 2013 can be attributed to the implementation of the Capital Requirements Directive IV, introducing higher capital requirements in the euro countries. Similarly, the introduction of higher capital requirements for Swedish banks at the end of 2018 explains the spike in Panel A. The higher positive changes in the countries with strict supervision can be explained by the introduction of higher capital requirements for the two large Swiss banks to be implemented until 2013 (Panel B). We provide an overview of relevant events in the European banking system during our sample period in the internet appendix B.

Similar to the cross-sectional analysis, the key explanatory variables relate to the countries' regulatory and supervisory strictness, as well as economic conditions. The indicator variable $LAX\_REGULATION_{j,t}$ is equal to 1 if the countries' regulatory stringency index is lower than the mean, indicating less stringent regulation. The indicator $STRICT\_SUPERVISION_{j,t}$ is equal to 1 if the countries' supervisory power

[13] Table C.7 in the internet appendix provides summary statistics of the variable $\Delta RWAD_{i,j,t}$ across country groups.

index is larger than the mean, indicating strict supervision.[14] Moreover, we include $CDS\_SOVEREIGN_{j,t}$, calculated as the natural logarithm of countries' sovereign CDS spreads.[15] As described in Section 3.2, sovereign risk mirrors the countries' risk level (e.g., Fontana and Scheicher, 2016). Corresponding to the country grouping in the cross-sectional analysis, we expect differences in RWA density development depending on country risk. National authorities may relax certain aspects of banking regulation and/or supervision as a response to high sovereign risk, leading to the possibility to further reduce their RWA densities. As individual bank risk may differ from country risk, we alternatively calculate the variable $CDS\_BANK_{i,j,t}$ as the natural logarithm of banks' CDS spreads for all banks where this data is available.

Changes in relevant bank fundamentals are expected to influence RWA density development. $\Delta LOANS_{i,j,t}$ represents the quarterly change of banks' net loans. Banks which increase their net loans are expected to increase their RWA densities. Similarly, banks which increase their share of loan-loss reserves ($\Delta LLR_{i,j,t}$) are expected to tie up more capital. Furthermore, $\Delta RETURN\_ON\_RWA_{i,j,t}$ describes the quarterly change of banks' return on RWAs. Even though there is no direct effect on banks' RWA densities, authorities may relax requirements for low profitability banks as they cannot cope with high minimum capital requirements. The variable $\Delta EQUITY_{i,j,t}$ represents the quarterly change of banks' equity to total assets ratio to control for the banks' available equity capital. $IRB_{i,j,t}$ represents an indicator variable equal to 1 if a bank uses the IRB approach, and zero otherwise.[16] Similar to the cross-section analysis, we also compute the share of banks' RWAs that are calculated using the IRB approach ($IRB\_COVERAGE_{i,j,t}$). Quantifying the gradual implementation across portfolios over time, this variable tests whether RWA density reduction depends on the IRB ap-

[14] Alternatively, we use the two categorical variables $REGULATION\_INDEX_{j,t}$ and $SUPERVISION\_INDEX_{j,t}$, representing the two indices as detailed in Table 6, to test the robustness of our findings. The results presented in Table E.14 in the internet appendix confirm results discussed in Section 5.2.

[15] We use the natural logarithm to deal with outliers, as illustrated by Figure A.4. Results are robust to using the absolute value of countries' sovereign CDS spreads instead of the natural logarithm.

[16] Banks may either seek approval to use the advanced IRB approach, which permits the estimation of the probability of default, the exposure at default, and the resulting loss, or to use the foundation IRB approach, which only allows to estimate the probability of default based on internal models. As the risk weight depends on the probability of default for both the advanced and the foundation IRB approach, we do not distinguish between the two (Behn et al., 2016; Dautović, 2020).

proach coverage. $SIZE_{i,j,t}$ is calculated as banks' natural logarithm of total assets. Especially small banks may face comparatively high capital requirements.

Furthermore, we take into account the countries' level of bank credit supply. The variable $DOMESTIC\_CREDIT_{j,t}$ represents the countries' bank credit to the private non-financial sector in percent of GDP. As discussed above, capital regulation influences bank lending in a way that banks reduce credit supply to meet minimum capital requirements (e.g., Hyun and Rhee, 2011; Behn et al., 2016). Accordingly, national authorities may relax requirements at low levels of bank lending. Besides, we incorporate the quarterly growth rate of countries' real GDP ($\Delta GDP_{j,t}$) to consider the overall macroeconomic development. Finally, it is important to account for the seasonality across quarters. Following Lindquist (2004), we include quarter indicators and expect a systematic seasonal effect with an increase in RWA densities within each year.

4 Methodology

We address the question of why the RWA density reduction differs across countries and over time based on two different empirical approaches. Similarly to Beck and Levine (2004), we begin with the cross-section and subsequently estimate a panel data model to analyze the development over time. These two steps are especially suitable for the purpose of our study because they complement each other. First, the cross-sectional analysis sheds light on factors that explain the RWA density change directly at the quarter of the switch as well as the subsequent RWA density development relative to the quarter of the switch. Second, in the frame of the panel model, we identify bank-specific and macroeconomic factors which influence RWA density development over time.

The empirical design of our cross-sectional analysis is comparable to the empirical model developed by Mehran and Thakor (2011). The authors analyze bank capital structure in the context of bank mergers and define most variables used in their cross-sectional analysis relative to the acquisition announcement date. Similarly, our employed variables are observed relative to the approval date of the IRB approach. We aim at analysing the short-term reduction in RWA densities upon IRB approval observed at the quarter of the switch as well as in the subsequent quarters. Equation (1) formalizes the cross-sectional model:

$$\Delta RWAD_{i,j} = \alpha_i + \beta \cdot GROUPING'_j + \delta \cdot CONTROLS'_{i,j} + \varepsilon_i, \quad (1)$$

where, for bank i in country j, $\Delta RWAD_{i,j}$ refers to the dependent variable estimated for the two versions, as defined in Section 3.3, α_i represents bank-specific effects, and ε_i denotes the error term. $GROUPING_j$ describes a vector of indicator variables which are defined according to the country grouping as described in Section 3.2 and detailed in Table 4. The vector $CONTROLS_{i,j}$ contains all other relevant bank-specific and macroeconomic control variables as detailed in Section 3.3.

In the panel analysis, we aim to understand whether the evolution of RWA densities over time accomplishes the purpose of the IRB approach regulations. We expect differences in countries' economic situation to be reflected in differences in RWA densities, as most banks' balance sheets contain primarily home country assets. We take into account both bank-specific information, as well as differences in macroeconomic conditions, financial regulatory frames, and supervision regimes across countries. After testing the relevant variables for stationarity, we use a fixed-effects estimation procedure based on a heteroscedasticity robust covariance matrix. Equation (2) illustrates the formal design of our regression model:

$$\Delta RWAD_{i,j,t} = \eta_i + \vartheta \cdot GROUPING'_{j,t-1} + \omega \cdot CONTROLS'_{i,j,t-4} + \zeta \cdot q'_t + \tau_t + \xi_{i,j,t}. \quad (2)$$

For bank i in country j and quarter t, $\Delta RWAD_{i,j,t}$ represents the dependent variable. $GROUPING_{j,t-1}$ refers to a vector containing the main explanatory variables, and the vector $CONTROLS_{i,j,t-4}$ includes the remaining control variables, as detailed in Section 3.3.[17] Moreover, we include a vector of quarter indicators (q_t) to adjust for the RWA density seasonality and quarter-fixed effects (τ_t) to capture effects specific

[17] As $\Delta RWAD_{i,j,t}$ is calculated as the change in quarter t compared to the previous quarter, we use lagged explanatory variables. As the effect of the bank-specific and macroeconomic variables is not expected to directly influence banks' RWA densities, we use the four-quarter lagged variables. Note that we re-estimate our model with one-quarter lagged bank-specific variables as a robustness test. The results reported in Table E.15 in the internet appendix confirm the conclusions discussed in Section 5.2.

to a quarter during the observation period.[18] η_i represents unobserved time-invariant individual bank-specific effects and $\xi_{i,j,t}$ denotes the error term.

5 Empirical results and interpretation

5.1 Cross-sectional analysis

In Tables 7 and 8, we show estimation results of Equation (1) for changes in RWA density at the time of the switch and in the subsequent quarters, respectively, for the list of variables defined in Table 5.

As shown in Table 7, the coefficients of $LAX\_REGULATION_j$ are negative and statistically significant, confirming that banks in countries with lax regulation are able to reduce their RWA densities right after the switch. In contrast, the coefficients of the variable $STRICT\_SUPERVISION_j$ are positive and statistically significant, indicating that some banks in countries with strict supervision show a short-term increase in RWA densities. On average, as illustrated in Figure 2, RWA densities of banks in all country groups decrease, implying that RWA densities of banks in countries with strict supervision decrease relatively less than other banks in the sample. Similarly, the coefficients of the variable $HIGH\_RISK_j$ are positive and in columns (1) to (3) statistically significant, suggesting that RWA densities of banks in high-risk countries increase or decrease less than other banks upon IRB approach approval. This seems plausible, as regulators originally intended internal credit risk models to be more risk-sensitive than the standardized approach, requiring regulatory capital according to banks' actual credit risk.

The positive and significant coefficients of the variable $REL\_MIN_{i,j}^{s-1}$ suggest that banks with high RWA densities relative to the countries' minimum capital requirements before the switch are associated with lower RWA density reductions overall. Thus, a significant difference between the RWA densities and minimum capital requirements signalising high risk is fairly mapped after the switch to the more risk-sensitive IRB approach. Furthermore, the result is intuitive for banks in strict regulatory regimes

[18] For an overview of events in the European banking system during our sample period which are relevant in specific quarters, see internet appendix B.

where there is a high minimum capital requirement that would further bound the RWA density reductions, by contrast to banks' situation in countries with lax regulation.

Moreover, the $EURO_{i,j}$ coefficient is statistically significant and of negative sign, indicating that banks headquartered in euro countries have been able to reduce their RWA densities more than other banks when switching to the IRB approach. This effect is mainly influenced by the Dutch, German and Finish banks in our sample. Our results imply that supervisors in euro countries allowed more flexibility in RWA density calculations.

Concerning the role of the countries' average bank lending, the negative and significant coefficient of the variable $\varnothing DOMESTIC\_CREDIT_j$ suggests that banks in countries with a high level of domestic credit are associated with a more notable reduction in RWA densities post switch. On the one hand, low RWA densities are linked to a more expansive bank growth strategy which would allow for risk diversification, hence growth in lending would typically lead to lower RWA densities. On the other hand, procyclicality may explain this finding as low losses in the boom phase promote higher credit growth, but low losses also imply lower RWA densities on loans as internal models take into account the default rate (Behn et al., 2016).

We additionally introduce the variable $IRB\_COVERAGE^s_{i,j}$ to test if the gradual roll-out process of the IRB approach influences our findings and present the results in column (2). Typically, banks start implementing the IRB approach for portfolios where they expect the largest RWA density reductions (Dautović, 2020). If the reduction was mainly influenced by the gradual implementation process, banks with a high initial IRB approach coverage at the quarter of the switch would have larger RWA density reductions. Yet, the coefficient of the variable $IRB\_COVERAGE^s_{i,j}$ is not statistically significant.[19]

[19] Similarly, we take into account the influence of the IRB approach implementation process when analyzing the long-term development after the switch (see Table 8). In Table E.11 in the internet appendix, we replicate results when including the additional variable $\varnothing HIGH\_IRB\_CVG_{i,j}$, which indicates if a bank's average IRB approach coverage is larger than the third quartile, corresponding to 81.7%. Results show that the implementation process only influences the average RWA density reductions up until about two years after the switch. In the long run, the gradual implementation process does not explain why banks further reduce their RWA densities.

Bank's profitability before the switch may further influence capital adjustments upon IRB approach approval. Thus, in column (3), we test for the impact of the return to RWAs at the quarter before the switch ($RETURN\_ON\_RWA_{i,j}^{s-1}$). We find that the RWA density changes at the quarter of the switch do not depend on bank profitability. Hence, in line with the regulatory intention, return considerations do not influence the RWA density change (BCBS, 2001).

Similarly, we employ the variable $LLR_{i,j}^{s-1}$ to account for the banks' credit risk exposure at the quarter before the switch. The results presented in column (4) corroborate the grouping of high-risk countries. The positive and significant coefficient of the variable $LLR_{i,j}^{s-1}$ validates our expectation that banks with a high share of loan-loss reserves before the switch reduce their RWA densities less than other banks. As larger reserves for loan-losses indicate higher credit risk and lower bank stability, this finding confirms the higher risk-sensitivity of the IRB approach. Results are presented in Table 7 and provide initial evidence that IRB approach adoption increases the spread between banks' RWA densities at the time of the switch, especially as banks in high-risk countries with high initial values further increase their RWA densities.

[Table 7 about here.]

We further analyze the long-term development after the switch by employing the variable $\varnothing\Delta RWAD_{i,j}^{s+r}$ as the dependent variable. Table 8 reports results for $r = \{8, 16, 24, 32, 40\}$ quarters, corresponding to the average of the quarterly changes across 2, 4, 6, 8, and 10 years after the switch.[20] The explanatory power, which ranges from 0.281 to 0.478, is fairly high, confirming previous findings of Mehran and Thakor (2011).

The coefficients of the grouping variables suggest two interesting conclusions. First, the levels of regulatory and supervisory strictness play a significant role. The coefficients of the variable $LAX\_REGULATION_j$ ($STRICT\_SUPERVISION_j$) in columns (2) to (5) are all negative (positive). Even though the magnitudes are lower than in Table 7, they confirm the direction of the effect at the quarter of the switch across the sample period. Second, the coefficient of the variable $HIGH\_RISK_j$ is negative and statisti-

[20] We replicate the analysis for alternative dependent variables corresponding to 1, 3, 5, 7, and 9 years after the switch and report the results in Table E.12 in the internet appendix.

cally significant, as shown in column (5). Thus, if high sovereign risk implies that RWA densities remain on a high level in the short term, the effect is reverted in the long term. Even though the introduction of internal credit risk models has initially resulted in high RWA densities mapping high risk, this effect diminishes over time. Instead, banks in high-risk countries have been able to substantially reduce their RWA densities, which fosters convergence across countries.[21]

Moreover, coefficients of the variable $PRE\_CRISIS_{i,j}$ in columns (1), (2), and (4) are positive and significant. This finding suggests that early switchers did not necessarily benefit in terms of RWA density reductions in the long term. Potentially, after the 2008 financial crisis, banks only seek IRB approach approval if they expect large RWA density reductions.

[Table 8 about here.]

To test the robustness of the country grouping, we include individual country indicators instead of country grouping indicators. To estimate the model, we have to exclude the country-specific variables. Table 9 provides the results of the cross-sectional model with country indicators, again corresponding to the average changes across r quarters after the switch. The findings allow a valuable insight into country differences and corroborate the grouping discussed in Section 3.2. Most coefficients of the country indicators in column (5) are negative and significant, including the three high-risk countries Ireland, Italy, and Spain. The fact that their coefficients are among the largest coefficients by absolute value in column (5) confirms our conclusion that banks in these countries have been able to further reduce their RWA densities ten years after the switch. Documenting an even more pronounced reduction, the coefficients which describe Denmark and Sweden, representing the two countries with lax regulation, equal the largest absolute values. Overall, most coefficients representing these countries are negative and statistically significant. Most other countries only have one or two significant coefficients, so banks in those countries do not seem to be able to reduce their

[21] To test the robustness of the country grouping, we modify the classification of countries based on the ranking detailed in Table 4. As an example, we report results when additionally defining Finland as country with lax regulation and Belgium as country with strict supervision in Table E.13 in the internet appendix. The robustness checks based on the broader country grouping confirm our conclusions.

RWA densities to the same extent. In contrast, the positive and significant coefficients of the country indicators of Austria and Switzerland demonstrate the effect of strict supervision. Especially, the tightening of regulations for the large banks in Switzerland (see internet appendix B) in combination with overall strict supervision forced banks to substantially increase their RWA densities. Unsurprisingly, the remaining results are very similar to the findings presented in Table 8.

[Table 9 about here.]

5.2 Panel analysis

We estimate Equation (2) for different subsamples to shed light on factors influencing the development of RWA density changes over time. Table 10 reports regression results based on the complete panel data set in column (1), and the results for different subsamples in columns (2) to (4). Macroeconomic shocks and regulation changes to further stabilize the financial sector, as presented in the internet appendix B, motivate the choice of the subsamples. As the 2008 world financial crisis has substantially affected banks across countries, the subsample reported in column (2) starts after the end of the crisis in the third quarter of 2009 and includes the time period until the end of the sample period. Besides, we create a subsample including both the financial crisis and the sovereign debt crisis. Column (3) reports the results for this subsample starting in 2007 until the end of 2012 and isolates the time period where banks switched to the IRB approach from subsequent periods. On the contrary, the macroeconomic situation in Europe in the years between 2013 and 2019 has been stable. Column (4) reports the results based on the subsample that isolates this recent development.[22]

[Table 10 about here.]

The results reported in Table 10 extend our findings from the cross-sectional analysis of long-term RWA density adjustments. The negative and significant coefficient of the

[22] We additionally test the robustness of the panel model based on three additional subsamples. Table E.16 in the internet appendix reports results for the period after the financial crisis (Q3/2009) to the end of 2017 before the introduction of IFRS 9 (column (2)), for the period from the introduction of Basel III in the forth quarter of 2010 until the end of the sample period (column (3)), and for the period from the introduction of the Capital Requirements Directive IV in the euro area effective in the first quarter of 2014 to the end of the sample period (column (4)). Note that we compare the results to the findings based on the complete sample period (see column (1) of Table 10). The results confirm the findings detailed in this section.

variable $LAX\_REGULATION_{j,t-1}$ shown in column (1) confirms the overall downward trend of RWA densities in countries with lax regulation over time. With respect to the variable $STRICT\_SUPERVISION_{j,t-1}$, the coefficient is significant and positive, as shown in column (4), suggesting that RWA densities in countries with strict supervision increase in recent years. The negative and significant coefficients of the variable $CDS\_SOVEREIGN_{j,t-1}$ in columns (1) to (3) show that banks in countries with higher CDS spreads, corresponding to high country risk, are associated with decreasing RWA densities after the switch to the IRB approach.[23] These results show that especially for banks in high-risk countries, the RWA density does not reflect anymore realistically the country risk, thereby underestimating banks' actual economic risk position. Moreover, the RWA densities of banks in countries with strict supervision increase, in response to higher capital requirements. Overall, our results show a downward convergence over time, as illustrated in Figure 1.

Before switching to the IRB approach, banks' RWA densities across countries could be clearly grouped accordingly to sovereign risk, as shown in Table 1. Since the purpose of IRB approach regulations is to increase risk sensitivity compared to the standardized approach, one would expect the dispersion of RWA densities across countries to further increase after the switch. Yet, as shown in Table 2, the standard deviation of banks' RWA density decreases across years and the downward trend is mainly influenced by a decrease in maximum values. Hence, our results show that on long term, banks adopting the IRB approach converge to similar RWA density levels.

Interestingly, the coefficients of the variable $IRB_{i,j,t-1}$ are positive and significant in all four columns. As most banks switch at the beginning of the sample period, the variable may be partially influenced by the overall increasing minimum capital requirements and the introduction of a risk weight floor for banks with the approval to use the IRB approach in some countries.[24]

[23] To test for potential differences between sovereign credit risk and bank-specific risk, we use banks' CDS spreads instead of sovereign CDS spreads. The results reported in Table E.17 in the internet appendix are largely in line with our main results and confirm the robustness of our conclusions.

[24] As a robustness test, we use the variable $IRB\_COVERAGE_{i,j,t-1}$ instead of $IRB_{i,j,t-1}$ and report the results in Table E.18 in the internet appendix. Whereas the results are very similar, the coefficients of the variable $IRB\_COVERAGE_{i,j,t-1}$ are insignificant in all four columns, suggesting that more progress in implementing the IRB approach does not influence ongoing RWA density reductions.

The coefficient of $\Delta RETURN\_ON\_RWA_{i,j,t-4}$ is positive and statistically significant in column (2). This result suggests that an increase in profitability creates further incentives for banks to increase their RWA densities. Banks may aim to further increase their profitability based on more risky business activities requiring higher risk weights, hence more equity capital. This is in line with earlier studies that provide evidence that retained earnings are the main source of increasing RWA densities (e.g., Cohen, 2013). Moreover, the coefficients of the variable $\Delta EQUITY_{i,j,t-4}$ are positive and significant in all four columns. By increasing the share of equity, banks marginally increase their RWA densities.

Alternatively, as a response to increasing bank profitability, regulators may boost capital requirements, which ultimately leads to positive RWA density adjustments. The introduction of higher capital requirements in Norway in 2013 may serve as an example (Juelsrud and Wold, 2020). A regulator would prefer this to drastic changes in lending policy that may have a negative impact on credit supply. This is even more plausible as these changes would typically occur in regimes of low economic growth, when regulators must avoid radical measures that may reduce households' and businesses' ability to borrow.

With regard to the seasonal variation of RWA densities, the coefficients of the quarter indicators for columns (1) to (3) are mostly positive, confirming the seasonality across quarters, as capital from profit builds up during the year, but is typically disbursed only annually through dividends. Yet, the negative coefficients in column (4) indicate that banks adjusted their RWA densities downward between 2013 and 2019.

In the euro area, the introduction of the Single Supervisory Mechanism in 2014 assigned the ECB to be directly responsible for the most significant institutions, whereas supervision of less significant ones remains with the national supervisors (ECB, 2018). Due to the large share of euro banks in our data set, we subdivide the full sample into banks headquartered in euro countries, which belong to the European Banking Union, and non-euro countries.[25] Table 11 presents the subsample analysis results which reveal interesting differences between the two samples and help to explain the overall effects.

[25] Countries outside of the euro area include Denmark, Norway, Sweden, Switzerland, and the UK.

The negative and significant coefficient of $LAX\_REGULATION_{j,t-1}$ and the positive and significant coefficient of $STRICT\_SUPERVISION_{j,t-1}$ in column (2) show that regulatory and supervisory strictness are important factors influencing the RWA density change outside of the euro area. In contrast, especially due to the Single Supervisory Mechanism, the regulatory framework in the euro area is very similar and does not give rise to large differences across banks and countries. In column (1), the coefficient of the variable $CDS\_SOVEREIGN_{j,t-1}$ is negative and statistically significant, suggesting that banks in euro countries associated with high country risk show decreasing RWA densities. These results confirm that RWA densities cease to map banks' full country risk, hereby underestimating their actual economic risk. Compared to the RWA densities of banks in countries with lower CDS spreads and respectively lower risk, RWA densities of banks in countries with high CDS spreads gradually decrease despite consistently higher levels of risk.

The positive and significant coefficients of the two variables $\Delta EQUITY_{i,j,t-4}$ and $SIZE_{i,j,t-4}$ in column (1) further suggest that in the euro area especially large banks with an increasing share of equity are associated with increasing RWA densities over time. With respect to the non-euro subsample reported in column (2), the positive and significant coefficients of $RETURN\_ON\_RWA_{i,j,t-4}$ and $DOMESTIC\_CREDIT_{j,t}$ indicate that especially regulators outside of the European Banking Union take into account bank resilience to ensure sufficient credit supply to the economy.

[Table 11 about here.]

To examine if there is a relationship between strict supervision and high country risk, we additionally introduce $CDS\_SOVEREIGN_{j,t-1} \times STRICT\_SUPERVISION_{j,t-1}$ as an interaction term in Equation (2) and report the results in Table 12. We again estimate this model based on the four subsamples discussed at the beginning of this subsection. Overall, the results confirm our findings as reported in Table 10. The coefficients of the variables $STRICT\_SUPERVISION_{j,t-1}$ and $CDS\_SOVEREIGN_{j,t-1}$ again indicate the two contrary effects on banks' RWA density development. The positive and significant coefficients of $STRICT\_SUPERVISION_{j,t-1}$ in columns (2) and (4) show that banks in countries with strict supervision are associated with increasing RWA densities. Yet, the coefficient of the interaction term is negative and significant in both columns, indicating that banks in countries with strict supervision and high country risk reduce their RWA densities over time. Compared to the main results reported in Table 10, the influence of high country risk seems to dominate the impact on banks' RWA density development, in particular since 2013 (column (4)). Again, referring to the country grouping as detailed in Table 4, examples of countries with high country risk and high supervisory power include Belgium, Italy, and Spain. Even though the supervisory power index for these countries indicates comparatively higher supervisory power, regulatory authorities seem to allow certain leeway for gradual RWA density reduction over time.

[Table 12 about here.]

In summary, our analysis provides evidence on why banks' RWA densities converge to a lower level over time, compared to 2007, before the switch to the IRB approach. Whereas banks' RWA densities before the switch have been largely corresponding to sovereign risk, introducing the more risk-sensitive IRB approach is expected to further increase the dispersion of RWA densities across banks and countries. Yet, we solely observe high RWA densities of banks in high-risk countries shortly after the switch, which are decreasing over time. On the contrary, banks in countries with strict supervision increase their RWA densities in the long term and in particular in recent years, corresponding to higher capital requirements implemented by the national authorities. Hence, jurisdiction-specific differences in banking regulation and supervision partially explain banks' RWA density changes. All in all, despite notable differences in sovereign risk, we observe downward convergence of the RWA densities of European banks over time. Banks in countries with high country risk reduce their RWA densities despite high supervisory power, as authorities may refrain from imposing restrictive supervision. Introducing regulatory requirements above the level the average bank in a country can comply with, would lead to the counterproductive effect of destabilizing the banking sector. Hence, regulatory authorities have an incentive to relax regulations to a level that leads to a build up of RWA densities, reflecting both the national banking sectors' ability and the perceived level of risk. Even though the gradual implementation of the

IRB approach provides incentives for moral hazard, our results show that the roll-out process does not explain our findings.

6 Conclusion and policy implications

As per regulatory intention, internal credit risk models are supposed to render banks' RWAs more risk sensitive. The IRB approach should align capital and risk levels and increase the banks' focus on risk management and transparency. Thus, after the adoption of the IRB approach, one would expect the dispersion of RWA densities across banks to increase. Yet, we observe a downward convergence of RWA densities across banks and countries over time. To the best of our knowledge, this is the first study in the literature that sheds light on the dispersion of RWA densities across countries and on their development over time.

Our analysis is based on quarterly data of 52 listed banks headquartered in 14 European countries from Q1/2007 to Q4/2019. We study the differences in RWA density changes across countries and groups after the switch to the IRB approach, and identify the factors impacting their development over time. We investigate both country- and bank-specific factors.

First, we introduce a country grouping not only based on sovereign risk, as commonly done in prior studies, but also based on national banking regulation and supervision.

Second, we observe an immediate decrease in RWA densities right after the switch, determining different reactions of national supervisory authorities across country groups. Especially authorities in countries with strict regulation or supervision reacted to the initial drop in RWA densities by imposing regulations that increased RWA densities. In contrast, authorities in high-risk countries allowed certain leeway in IRB capital requirement calculations, which explains the gradual decrease in RWA densities over time for this country group.

Third, with respect to the development of RWA densities over time, we show that they converge to a lower level compared to the values prior to the switch to the IRB approach. Especially for banks in countries with high country risk and high initial levels of RWA densities, we observe a more significant reduction over time. Moreover, results suggest that authorities do not impose strict supervision in countries with high risk and for low profitability banks, as these cannot cope with high minimum capital requirements. In contrast, banks in countries with strict supervision increase their RWA densities, especially in recent years.

Regulatory authorities' key objective is to foster financial stability and provide a strong and resilient banking system to support sustainable economic growth. Our results suggest that prior negative effects of banking crises on society impact the regulators' policy to impose higher minimum capital requirements. We discuss factors that facilitate the enforcement of strict regulations without negatively affecting the supply of credit in a downturn. For example, competition among banks in a country may foster strict regulations.

Overall, our results show that the adoption of the IRB approach reduces differences in RWA densities between countries, which makes internal models less suitable to reflect the country-specific risk factors. Internal credit risk models are supposed to map the risk in each institution more adequately than the standardized approach, yet, a downward convergence in risk across countries is counter intuitive.

As a response to growing criticism against internal model-based regulations, especially regarding the lack of transparency, the Basel Committee suggests to restrict their use. Thus, the committee proposes to introduce an output floor for IRB capital requirements of 72.5% of the capital requirements calculated based on the standardized approach (BCBS, 2017). However, output floors on minimum capital levels in the IRB frame should be defined with caution, as too high pre-imposed levels might have the counter-effect of leaving banks less maneuver possibilities, which will ultimately lead to the RWA density convergence across banks, failing to reflect actual economic risk.

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7 Tables

Table 1: Average risk-weighted asset density per country.

	Average RWA density			RWA density change (%)	
Country	**Quarter of switch**	**5 years after switch**	**10 years after switch**	**5 years after switch**	**5-10 years after switch**
Austria	55.71	52.23	54.79	-6.25	4.91
Belgium	28.69	26.88	24.97	-6.33	-7.11
Denmark	47.58	39.43	35.13	-17.13	-10.92
Finland	33.53	33.00	36.70	-1.56	11.19
France	29.53	27.14	28.43	-8.09	4.75
Germany	44.38	42.93	35.14	-3.27	-18.14
Ireland	63.48	50.24	48.75	-20.87	-2.96
Italy	56.10	50.11	34.18	-10.68	-31.79
Netherlands	44.43	33.36	37.92	-24.92	13.67
Norway	62.94	58.17	54.00	-7.58	-7.17
Spain	60.54	45.77	43.76	-24.40	-4.41
Sweden	41.50	25.15	17.66	-39.39	-29.79
Switzerland	17.45	22.70	30.45	30.13	34.11
UK	40.21	36.14	31.37	-10.11	-13.20
Number of banks	**52**	**48**	**41**		
Average across banks	**46.13**	**40.20**	**36.86**	**-12.84**	**-8.31**

This table provides an overview of the development of average risk-weighted asset (RWA) densities per country after banks started to use the internal ratings-based approach. Comparable to the cross-sectional analysis, we calculate the average RWA density of each bank relative to the quarter of approval $s = 0$. As several banks switch later during our sample period, the number of available banks to calculate the average RWA density decreases.

Table 2: Risk-weighted asset density per year.

Year	**N**	**Mean**	**SD**	**Median**	**Min**	**Max**
2007	133	49.77	18.70	49.64	14.90	94.04
2008	183	47.41	18.61	48.43	13.16	105.54
2009	193	47.47	17.61	48.10	14.36	94.91
2010	196	45.98	17.44	46.84	14.13	89.60
2011	192	44.91	17.39	44.91	14.41	97.22
2012	192	42.15	17.00	42.44	15.29	87.51
2013	198	41.10	15.30	41.64	15.98	88.27
2014	200	41.78	15.11	42.63	17.06	78.56
2015	192	40.69	14.89	40.46	16.10	75.78
2016	188	39.10	14.43	37.46	15.67	70.39
2017	188	38.01	13.68	35.93	15.64	69.86
2018	184	37.29	13.41	35.62	16.42	70.01
2019	156	35.47	13.18	31.98	14.69	67.81
Total	**2,395**	**42.33**	**16.46**	**40.86**	**13.16**	**105.54**

This table provides descriptive statistics for the risk-weighted asset (RWA) density across years. N refers to the number of observations. “Mean” (“SD”) describes the mean (standard deviation) of the variable across observations, respectively.

Table 3: Data overview.

Key data	Definition
Risk-weighted assets	Bank i's assets and off-balance sheet exposures calculated based on regulatory risk assessment which are used to determine the bank's minimum capital requirements
IRB approach approval date	Date where bank i obtains the supervisor's approval and is allowed to officially use the internal ratings-based (IRB) approach
IRB approach coverage	The share of a bank i's risk-weighted assets that are calculated using the internal ratings-based (IRB) approach
Bank CDS spreads	Bank i's 5-year sovereign credit default swap (CDS) spreads
Other bank-specific data	Information on bank i's total assets, equity, net income, net loans, and loan-loss reserves
Sovereign CDS spreads	Country j's 5-year sovereign credit default swap (CDS) spreads
Other country-specific data	Information on country j's real GDP growth and credit to private non-financial sector from banks in percent of GDP
Regulatory stringency	Index describing country j's regulatory stringency ranging from 0 to 10 where higher values indicate greater regulatory stringency
Supervisory power	Index describing country j's supervisory power ranging from 0 to 14 where higher values indicate greater supervisory power

This table provides an overview of the basic data as detailed in Section 3.1 that are used to calculate the variables described in Tables 5 and 6.

Table 4: Overview of the country grouping.

		Regulatory Stringency		Supervisory Power		Sovereign Credit Risk	
Country	**Classification**	**Average**	**Rank**	**Average**	**Rank**	**Average**	**Rank**
Austria	strict supervision	5.14	5	11.21	2	32.06	9
Belgium	medium-risk	6.04	8	10.93	3	51.26	4
Denmark	lax regulation	4.50	2	10.07	6	28.25	10
Finland	medium-risk	4.93	3	7.50	14	26.29	11
France	medium-risk	7.64	13	9.43	9	35.11	6
Germany	medium-risk	7.21	11	9.57	8	18.09	13
Ireland	high-risk	5.97	7	8.86	10	157.15	1
Italy	high-risk	5.07	4	10.43	5	131.41	2
Netherlands	medium-risk	6.79	9	10.02	7	34.45	7
Norway	medium-risk	7.50	12	8.50	13	17.86	14
Spain	high-risk	8.14	14	10.68	4	108.49	3
Sweden	lax regulation	3.93	1	8.86	10	22.56	12
Switzerland	strict supervision	7.00	10	12.71	1	33.75	8
UK	medium-risk	5.14	5	8.64	12	38.72	5

This table shows mean values of the indices describing regulatory stringency and supervisory power, and the sovereign credit default swap (CDS) spreads per country as well as the country ranking for the three categories. The country grouping as used in the cross-sectional analysis is summarized in the second column. In the panel analysis, we use the variables described in Table 6 to track the development of regulatory and supervisory strictness and country risk over time. CDS spreads are retrieved from Refinitiv Datastream and the two indices are calculated based on data provided by the World Bank's Bank Regulation and Supervision Surveys as suggested by Barth et al. (2013). Internet appendix D provides an overview of both indices.

Table 5: Descriptions of the cross-sectional variables.

Variable	Description	Source
Cross-section: dependent variables		
$\Delta RWAD_{i,j}^{s}$	Change in bank i's risk-weighted assets to total assets from the quarter before the switch to the quarter of the switch s in percent	Refinitiv Datastream
$\varnothing\Delta RWAD_{i,j}^{s+r}$	Average change in bank i's risk-weighted assets to total assets across r quarters after the quarter of switch s in percent	Refinitiv Datastream
Cross-section: independent variables		
$LAX\_REGULATION_j$	Indicator equal to 1 if country j is classified as country with lax regulation and 0 otherwise (i.e., Denmark and Sweden)	World Bank
$STRICT\_SUPERVISION_j$	Indicator equal to 1 if country j is classified as country with strict supervision and 0 otherwise (i.e., Austria and Switzerland)	World Bank
$HIGH\_RISK_j$	Indicator equal to 1 if country j is classified as high risk according to the sovereign credit-default swap spreads and 0 otherwise (i.e., Ireland, Italy, and Spain)	Refinitiv Datastream
$REL\_MIN_{i,j}^{s-1}$	Bank i's risk-weighted assets to total assets relative to the minimum capital requirements at the quarter before the switch s	Refinitiv Datastream
$\varnothing RWAD_{i,j}$	Bank i's average risk-weighted assets to total assets across the sample period	Refinitiv Datastream
$IRB\_COVERAGE_{i,j}^{s}$	Share of bank i's risk-weighted assets that are calculated using the internal ratings-based approach at the quarter of the switch s	Quarterly reports
$\varnothing HIGH\_IRB\_CVG_{i,j}$	Indicator equal to 1 if bank i's average coverage of the internal ratings-based approach is larger than the third quartile of the average coverage of all banks across the sample period and 0 otherwise	Quarterly reports
$RETURN\_ON\_RWA_{i,j}^{s-1}$	Bank i's net income to risk-weighted assets at the quarter before the switch s	Refinitiv Datastream
$LLR_{i,j}^{s-1}$	Bank i's loan-loss reserves to total assets at the quarter before the switch s	Refinitiv Datastream
$PRE\_CRISIS_{i,j}$	Indicator equal to 1 if bank i switches before the crisis (2008 Q3) and 0 otherwise	Annual & disclosure reports
$EURO_{i,j}$	Indicator equal to 1 if bank i is headquartered in a euro country and 0 otherwise	Refinitiv Datastream
$\varnothing EQUITY_{i,j}$	Indicator equal to 1 if bank i's average equity to total assets ratio is larger than the mean value of the average equity ratio of all banks across the sample period and 0 otherwise	Refinitiv Datastream
$\varnothing SIZE_{i,j}$	Indicator equal to 1 if bank i's average natural logarithm of total assets is larger than the mean value of the average bank size of all banks across the sample period and 0 otherwise	Refinitiv Datastream
$\varnothing DOMESTIC\_CREDIT_j$	Indicator equal to 1 if country j's average credit to private non-financial sector from banks in percent of GDP is larger than the mean across the sample period and 0 otherwise	World Bank
$\varnothing\Delta GDP_j$	Country j's average real GDP growth across the sample period	IMF

This table describes the variables used in the cross-sectional regression models.

Table 6: Descriptions of the panel variables.

Variable	**Description**	**Source**
Panel: dependent variable		
$\Delta RWAD_{i,j,t}$	Quarterly change in bank i's risk-weighted assets to total assets in percent	Refinitiv Datastream
Panel: independent variables		
$LAX\_REGULATION_{j,t}$	Indicator equal to 1 if country j's regulatory stringency index calculated as suggested by Barth et al. (2013) is lower than the mean and 0 otherwise	World Bank
$REGULATION\_INDEX_{j,t}$	One over country j's regulatory stringency index initially calculated as suggested by Barth et al. (2013) where higher values indicate less stringent regulation	World Bank
$STRICT\_SUPERVISION_{j,t}$	Indicator equal to 1 if country j's supervisory power index calculated as suggested by Barth et al. (2013) is larger than the mean and 0 otherwise	World Bank
$SUPERVISION\_INDEX_{j,t}$	Country j's supervisory power index calculated as suggested by Barth et al. (2013) where higher values indicate stricter supervision	World Bank
$CDS\_SOVEREIGN_{j,t}$	Natural logarithm of country j's sovereign credit-default swap spreads	Refinitiv Datastream
$CDS\_BANK_{i,j,t}$	Natural logarithm of bank i's credit-default swap spreads	Refinitiv Datastream
$IRB_{i,j,t}$	Indicator equal to 1 if bank i uses the internal-ratings based approach in a quarter and 0 otherwise	Annual & disclosure reports
$IRB\_COVERAGE_{i,j,t}$	Share of bank i's risk-weighted assets that are calculated using the internal ratings-based approach	Quarterly reports
$\Delta LOANS_{i,j,t}$	Quarterly change of bank i's net loans in percent	Refinitiv Datastream
$\Delta RETURN\_ON\_RWA_{i,j,t}$	Quarterly change of bank i's net income to risk-weighted assets in percent	Refinitiv Datastream
$\Delta LLR_{i,j,t}$	Quarterly change of bank i's loan-loss reserves to total assets in percent	Refinitiv Datastream
$\Delta EQUITY_{i,j,t}$	Quarterly change of bank i's equity to total assets in percent	Refinitiv Datastream
$SIZE_{i,j,t}$	Bank i's natural logarithm of total assets	Refinitiv Datastream
$DOMESTIC\_CREDIT_{j,t}$	Country j's credit to private non-financial sector from banks in percent of GDP	World Bank
$\Delta GDP_{j,t}$	Quarterly growth rate of a country j's real GDP in percent	IMF
q2 / q3 / q4	Indicators equal to 1 in quarter 2, 3 or 4 and 0 otherwise	-

This table describes the variables used in the panel regression models.

Table 7: Cross-sectional analysis: effect at the quarter of the switch.

	Dependent variable: $\Delta RWAD^{s}_{i,j}$			
	(1)	**(2)**	**(3)**	**(4)**
$IRBA\_COVERAGE^{s}_{i,j}$		-4.722		
		(6.022)		
$RETURN\_ON\_RWA^{s-1}_{i,j}$			0.004	
			(4.193)	
$LLR^{s-1}_{i,j}$				1.624**
				(0.775)
$LAX\_REGULATION_{j}$	-15.976***	-15.230***	-15.975***	-16.224***
	(5.034)	(5.001)	(5.146)	(5.557)
$STRICT\_SUPERVISION_{j}$	9.231**	8.916**	9.231**	7.862**
	(3.736)	(3.959)	(3.774)	(3.929)
$HIGH\_RISK_{j}$	10.677**	10.098**	10.677**	9.830
	(5.038)	(4.859)	(5.069)	(6.592)
$REL\_MIN^{s-1}_{i,j}$	0.263**	0.244**	0.263**	0.206
	(0.121)	(0.120)	(0.121)	(0.141)
$PRE\_CRISIS_{i,j}$	5.038	5.918*	5.038	4.688
	(3.284)	(3.404)	(3.330)	(3.433)
$EURO_{i,j}$	-7.367**	-7.002**	-7.366**	-7.746**
	(3.035)	(2.994)	(3.137)	(3.324)
$\varnothing EQUITY_{i,j}$	-1.248	-0.716	-1.248	-2.050
	(2.901)	(2.908)	(2.946)	(3.061)
$\varnothing SIZE_{i,j}$	1.686	1.306	1.686	0.176
	(2.732)	(2.791)	(2.928)	(2.911)
$\varnothing DOMESTIC\_CREDIT_{j}$	-6.794*	-7.088*	-6.793*	-8.254*
	(4.038)	(3.907)	(4.071)	(4.813)
$\varnothing \Delta GDP_{j}$	1.532	1.375	1.531	3.066
	(4.342)	(4.318)	(4.412)	(5.277)
Constant	-13.656***	-11.014*	-13.657***	-11.618*
	(5.178)	(6.341)	(5.207)	(6.447)
Observations	52	52	52	48
R^2	0.363	0.373	0.363	0.373
Adjusted R^2	0.207	0.201	0.187	0.181
Residual Std. Error	9.723	9.762	9.844	9.632
	(df = 41)	(df = 40)	(df = 40)	(df = 36)
F Statistic	2.333**	2.167**	2.070**	1.943*
	(df = 10; 41)	(df = 11; 40)	(df = 11; 40)	(df = 11; 36)

This table reports regression results of the cross-sectional analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 5.

Table 8: Cross-sectional analysis: long-term development after the switch.

	Dependent variable: $\varnothing\Delta RWAD_{i,j}^{s+r}$				
	$r = 8$	$r = 16$	$r = 24$	$r = 32$	$r = 40$
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
$LAX\_REGULATION_j$	−1.556	−1.588***	−1.794***	−1.783***	−1.544***
	(1.092)	(0.455)	(0.395)	(0.377)	(0.267)
$STRICT\_SUPERVISION_j$	2.413***	1.009*	1.248***	1.063***	0.679***
	(0.866)	(0.518)	(0.303)	(0.298)	(0.245)
$HIGH\_RISK_j$	0.316	0.0004	−0.073	−0.464	−0.878**
	(1.403)	(0.575)	(0.507)	(0.532)	(0.375)
$\varnothing RWAD_{i,j}$	0.036	0.004	−0.019	−0.011	−0.008
	(0.040)	(0.018)	(0.019)	(0.017)	(0.013)
$PRE\_CRISIS_{i,j}$	2.100***	1.366***	0.524	0.883*	0.252
	(0.748)	(0.373)	(0.431)	(0.467)	(0.451)
$EURO_{i,j}$	−0.141	−0.091	−0.577	−0.181	0.033
	(0.621)	(0.286)	(0.403)	(0.359)	(0.266)
$\varnothing EQUITY_{i,j}$	−0.022	−0.057	0.355	0.066	−0.204
	(0.642)	(0.320)	(0.404)	(0.382)	(0.318)
$\varnothing SIZE_{i,j}$	0.887	−0.079	0.017	0.072	−0.111
	(0.860)	(0.427)	(0.441)	(0.389)	(0.350)
$\varnothing DOMESTIC\_CREDIT_j$	−1.271	−0.594	0.109	0.351	0.672**
	(1.052)	(0.373)	(0.312)	(0.388)	(0.275)
$\varnothing\Delta GDP_j$	0.616	−0.493	−0.654	−0.142	0.026
	(1.077)	(0.476)	(0.408)	(0.457)	(0.290)
Constant	−4.604**	−1.510	0.148	−0.560	−0.087
	(2.136)	(0.970)	(0.967)	(0.727)	(0.555)
Observations	50	49	48	46	41
R^2	0.433	0.555	0.434	0.514	0.608
Adjusted R^2	0.287	0.437	0.281	0.376	0.478
Residual Std. Error	1.907 (df = 39)	0.869 (df = 38)	0.969 (df = 37)	0.875 (df = 35)	0.636 (df = 30)
F Statistic	2.975*** (df = 10; 39)	4.733*** (df = 10; 38)	2.834** (df = 10; 37)	3.709*** (df = 10; 35)	4.659*** (df = 10; 30)

This table reports regression results of the cross-sectional analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 5.

Table 9: Cross-sectional analysis: including country indicators.

	Dependent variable: $\varnothing\Delta RWAD^{s+r}_{i,j}$				
	$r = 8$	$r = 16$	$r = 24$	$r = 32$	$r = 40$
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
AUSTRIA	1.507	1.079	1.345**	0.964	−0.256
	(1.323)	(0.872)	(0.573)	(0.797)	(0.620)
BELGIUM	0.531	0.281	0.068	−0.446	−0.954***
	(0.757)	(0.571)	(0.516)	(0.750)	(0.365)
DENMARK	−4.808***	−1.610***	−0.682	−1.164	−1.643***
	(1.343)	(0.505)	(0.537)	(0.773)	(0.414)
FINLAND	−1.977**	0.475	0.160	−0.089	−0.836**
	(0.870)	(0.522)	(0.728)	(0.799)	(0.423)
FRANCE	0.395	0.925**	0.542	−0.216	−0.801***
	(0.744)	(0.447)	(0.457)	(0.765)	(0.207)
GERMANY	−2.436**	0.446	0.002	−0.168	−0.510
	(1.034)	(0.381)	(0.921)	(1.062)	(0.556)
IRELAND	−1.448	−0.495	−0.117	−0.082	−0.943*
	(1.487)	(0.602)	(0.625)	(0.845)	(0.548)
ITALY	−0.939	1.132	0.617	0.045	−1.232**
	(1.888)	(0.899)	(0.619)	(0.719)	(0.495)
NORWAY	−0.842	0.214	0.674	0.093	−0.848
	(1.280)	(0.679)	(1.002)	(1.161)	(0.751)
SPAIN	−1.727*	−0.777	−0.107	−0.670	−1.243**
	(0.992)	(0.522)	(0.701)	(0.860)	(0.557)
SWEDEN	−0.344	−1.185	−1.547***	−2.404***	−2.382***
	(1.488)	(0.747)	(0.465)	(0.821)	(0.374)
SWITZERLAND	0.852	1.477***	2.075***	1.216	0.831***
	(1.085)	(0.374)	(0.613)	(0.783)	(0.186)
UK	−0.079	0.360	0.646	−0.245	−0.979***
	(0.969)	(0.342)	(0.477)	(0.756)	(0.292)
$\varnothing RWAD_{i,j}$	0.029	0.018	−0.016	−0.014	−0.002
	(0.066)	(0.029)	(0.037)	(0.030)	(0.026)
$PRE\_CRISIS_{i,j}$	2.221***	1.605***	0.643*	1.097**	0.380
	(0.761)	(0.534)	(0.390)	(0.523)	(0.323)
$\varnothing EQUITY_{i,j}$	0.217	−0.136	0.299	0.001	−0.217
	(0.727)	(0.397)	(0.506)	(0.493)	(0.393)
$\varnothing SIZE_{i,j}$	−0.252	−0.065	0.026	0.156	−0.008
	(0.998)	(0.570)	(0.504)	(0.379)	(0.355)
Observations	50	49	48	46	41
R^2	0.598	0.616	0.472	0.561	0.648
Adjusted R^2	0.384	0.405	0.173	0.295	0.388
Residual Std.	1.773	0.894	1.039	0.930	0.689
Error	(df = 32)	(df = 31)	(df = 30)	(df = 28)	(df = 23)
F Statistic	2.797***	2.925***	1.577	2.107**	2.490**
	(df = 17; 32)	(df = 17; 31)	(df = 17; 30)	(df = 17; 28)	(df = 17; 23)

This table reports regression results of the cross-sectional analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 5.

Table 10: Baseline results of the panel analysis.

	Dependent variable: $\Delta RWAD_{i,j,t}$			
	(1)	**(2)**	**(3)**	**(4)**
	2007 Q1 – 2019 Q4	2009 Q3 – 2019 Q4	2007 Q1 – 2012 Q4	2013 Q1 – 2019 Q4
$LAX\_REGULATION_{j,t-1}$	-0.478^{*}	-0.351	1.776	-0.399
	(0.249)	(0.246)	(1.208)	(0.300)
$STRICT\_SUPERVISION_{j,t-1}$	0.170	0.395	-0.417	0.941^{***}
	(0.195)	(0.246)	(0.450)	(0.338)
$CDS\_SOVEREIGN_{j,t-1}$	-0.819^{***}	-0.977^{***}	-0.941^{***}	0.230
	(0.243)	(0.360)	(0.340)	(0.699)
$IRB_{i,j,t-1}$	1.059^{**}	0.849^{*}	1.636^{**}	1.365^{**}
	(0.520)	(0.458)	(0.816)	(0.593)
$\Delta LOANS_{i,j,t-4}$	-0.028	-0.045	-0.033	-0.024
	(0.026)	(0.032)	(0.032)	(0.030)
$\Delta RETURN\_ON\_RWA_{i,j,t-4}$	0.379	0.577^{*}	0.343	0.348
	(0.297)	(0.350)	(0.384)	(0.461)
$\Delta LLR_{i,j,t-4}$	-0.234	-0.464	0.535	-0.531
	(0.462)	(0.445)	(0.557)	(0.582)
$\Delta EQUITY_{i,j,t-4}$	1.385^{***}	1.205^{**}	1.371^{***}	1.628^{**}
	(0.508)	(0.571)	(0.458)	(0.794)
$SIZE_{i,j,t-4}$	0.338	-0.062	0.800	1.353
	(0.412)	(0.487)	(1.657)	(0.888)
$DOMESTIC\_CREDIT_{j,t-4}$	0.005	0.008	0.023	0.007
	(0.005)	(0.007)	(0.025)	(0.009)
$\Delta GDP_{j,t-4}$	0.103	0.031	0.100	0.089
	(0.067)	(0.064)	(0.207)	(0.067)
q2	1.159	0.727	0.271	-1.546
	(1.024)	(0.716)	(1.998)	(1.199)
q3	0.105	2.682^{***}	-0.571	-2.011^{*}
	(0.636)	(0.949)	(1.072)	(1.184)
q4	0.652	0.630	1.812^{*}	-1.446
	(1.309)	(1.329)	(1.097)	(1.532)
Observations	2,395	1,984	1,089	1,306
R^2	0.112	0.125	0.108	0.129
Adjusted R^2	0.069	0.077	0.035	0.067
F Statistic	4.723^{***} (df = 61; 2282)	5.144^{***} (df = 52; 1881)	3.678^{***} (df = 33; 1006)	4.742^{***} (df = 38; 1218)

This table reports regression results of the panel analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 6.

Table 11: Panel analysis: euro and non-euro subsample.

	Dependent variable: $\Delta RWAD_{i,j,t}$	
	(1)	**(2)**
	euro	non-euro
$LAX\_REGULATION_{j,t-1}$	-0.052	-1.278^{***}
	(0.324)	(0.383)
$STRICT\_SUPERVISION_{j,t-1}$	-0.082	1.103^{**}
	(0.220)	(0.475)
$CDS\_SOVEREIGN_{j,t-1}$	-0.706^{**}	-1.065
	(0.307)	(0.808)
$IRB_{i,j,t-1}$	1.069	1.955
	(0.652)	(1.290)
$\Delta LOANS_{i,j,t-4}$	-0.037	-0.017
	(0.032)	(0.036)
$\Delta RETURN\_ON\_RWA_{i,j,t-4}$	0.092	1.127^{*}
	(0.359)	(0.656)
$\Delta LLR_{i,j,t-4}$	-0.428	0.418
	(0.519)	(0.887)
$\Delta EQUITY_{i,j,t-4}$	1.419^{***}	1.397
	(0.532)	(1.105)
$SIZE_{i,j,t-4}$	0.771^{*}	0.150
	(0.401)	(1.036)
$DOMESTIC\_CREDIT_{j,t-4}$	-0.005	0.044^{***}
	(0.006)	(0.012)
$\Delta GDP_{j,t-4}$	0.082	0.227
	(0.050)	(0.209)
q2	1.670	1.457
	(1.647)	(2.303)
q3	0.401	0.084
	(1.001)	(0.900)
q4	1.788	-0.274
	(1.872)	(1.699)
Observations	1,434	961
R^2	0.133	0.154
Adjusted R^2	0.073	0.078
F Statistic	3.384^{***}	2.631^{***}
	(df = 61; 1340)	(df = 61; 881)

This table reports regression results of the panel analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 6.

Table 12: Panel analysis: interaction between strict supervision and high country risk.

	Dependent variable: $\Delta RWAD_{i,j,t}$			
	(1)	**(2)**	**(3)**	**(4)**
	2007 Q1 – 2019 Q4	2009 Q3 – 2019 Q4	2007 Q1 – 2012 Q4	2013 Q1 – 2019 Q4
$LAX\_REGULATION_{j,t-1}$	−0.392	−0.154	1.742	−0.123
	(0.262)	(0.270)	(1.244)	(0.360)
$STRICT\_SUPERVISION_{j,t-1}$	1.035	2.367***	−0.857	3.891**
	(0.641)	(0.876)	(1.359)	(1.687)
$CDS\_SOVEREIGN_{j,t-1}$	−0.644**	−0.580	−1.014**	1.016
	(0.257)	(0.379)	(0.394)	(0.809)
$CDS\_SOVEREIGN_{j,t-1} \times$	−0.254	−0.547**	0.103	−1.048*
$STRICT\_SUPERVISION_{j,t-1}$	(0.181)	(0.227)	(0.304)	(0.555)
$IRB_{i,j,t-1}$	1.119**	0.997**	1.619**	1.640***
	(0.521)	(0.451)	(0.817)	(0.559)
$\Delta LOANS_{i,j,t-4}$	−0.028	−0.046	−0.033	−0.025
	(0.026)	(0.032)	(0.032)	(0.030)
$\Delta RETURN\_ON\_RWA_{i,j,t-4}$	0.375	0.572	0.347	0.370
	(0.298)	(0.351)	(0.389)	(0.463)
$\Delta LLR_{i,j,t-4}$	−0.232	−0.473	0.522	−0.499
	(0.468)	(0.453)	(0.556)	(0.596)
$\Delta EQUITY_{i,j,t-4}$	1.378***	1.177**	1.371***	1.610**
	(0.506)	(0.567)	(0.458)	(0.785)
$SIZE_{i,j,t-4}$	0.345	0.057	0.853	1.626*
	(0.414)	(0.474)	(1.724)	(0.847)
$DOMESTIC\_CREDIT_{j,t-4}$	0.005	0.007	0.022	−0.016
	(0.005)	(0.008)	(0.025)	(0.014)
$\Delta GDP_{j,t-4}$	0.103	0.032	0.106	0.091
	(0.067)	(0.064)	(0.208)	(0.063)
q2	1.381	0.705	0.167	−1.540
	(0.992)	(0.718)	(1.949)	(1.208)
q3	0.088	2.712***	−0.570	−2.011*
	(0.641)	(0.937)	(1.074)	(1.194)
q4	0.632	0.606	1.809*	−1.456
	(1.304)	(1.324)	(1.095)	(1.532)
Observations	2,395	1,984	1,089	1,306
R^2	0.113	0.126	0.108	0.131
Adjusted R^2	0.069	0.079	0.034	0.068
F Statistic	4.669***	5.136***	3.569***	4.694***
	(df = 62; 2281)	(df = 53; 1880)	(df = 34; 1005)	(df = 39; 1217)

This table reports regression results of the panel analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 6.

8 Figures

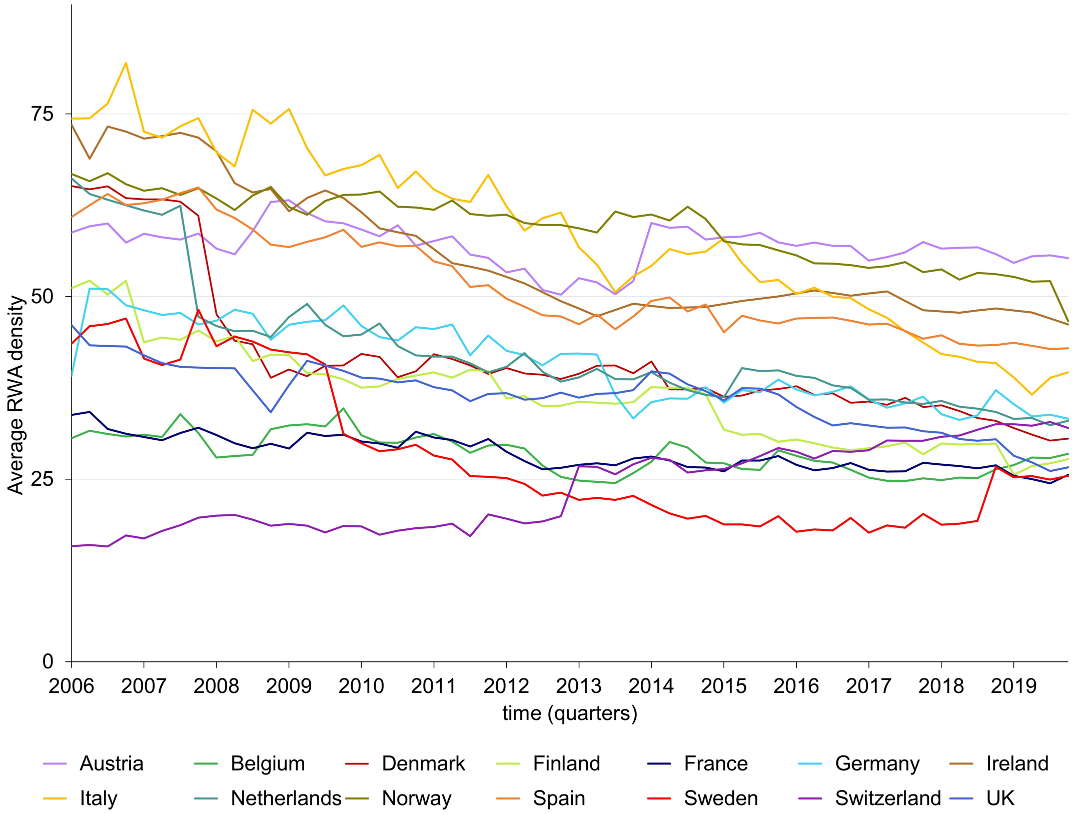
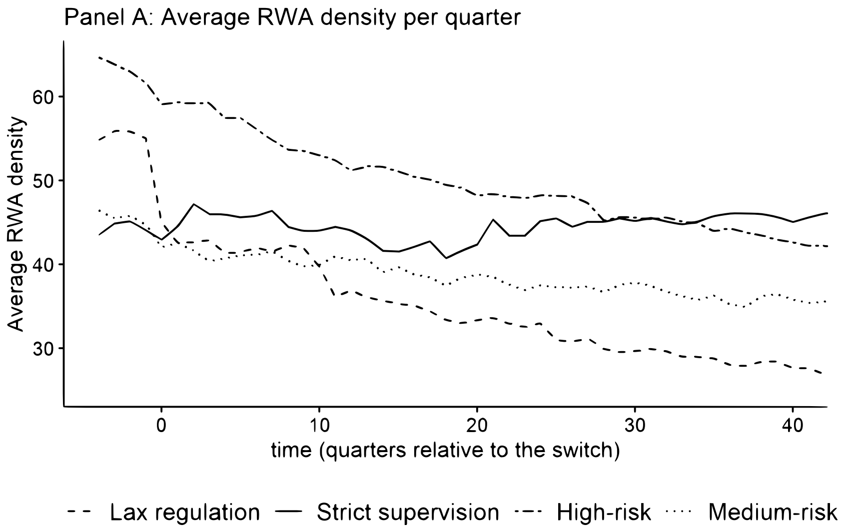


Figure 1: Country average risk-weighted asset density of banks using the internal ratings-based approach over time.

Notes: This figure illustrates the development of the country quarterly mean of internal ratings-based (IRB) approach banks' risk-weighted asset (RWA) densities. Figures A.2 and A.3 in the internet appendix present the RWA density development for each bank separately.



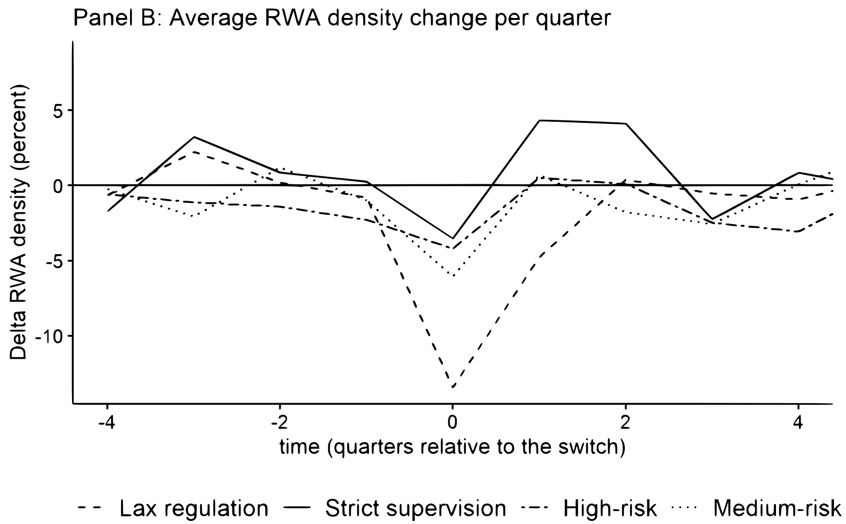


Figure 2: Banks' risk-weighted asset density across country groups.

Notes: This figure illustrates the development pattern of banks' risk-weighted asset (RWA) density relative to the quarter of approval $s = 0$. Panel A shows the development of the quarterly average RWA density over time. Panel B focuses on the four quarters before and after the quarter of approval illustrating the quarterly RWA density change (in percent). "Lax regulation" and "Strict supervision" summarize countries with lax regulation and strict supervision, respectively. "High-risk" refers to high-risk countries, and the remaining countries are classified as "Medium-risk".

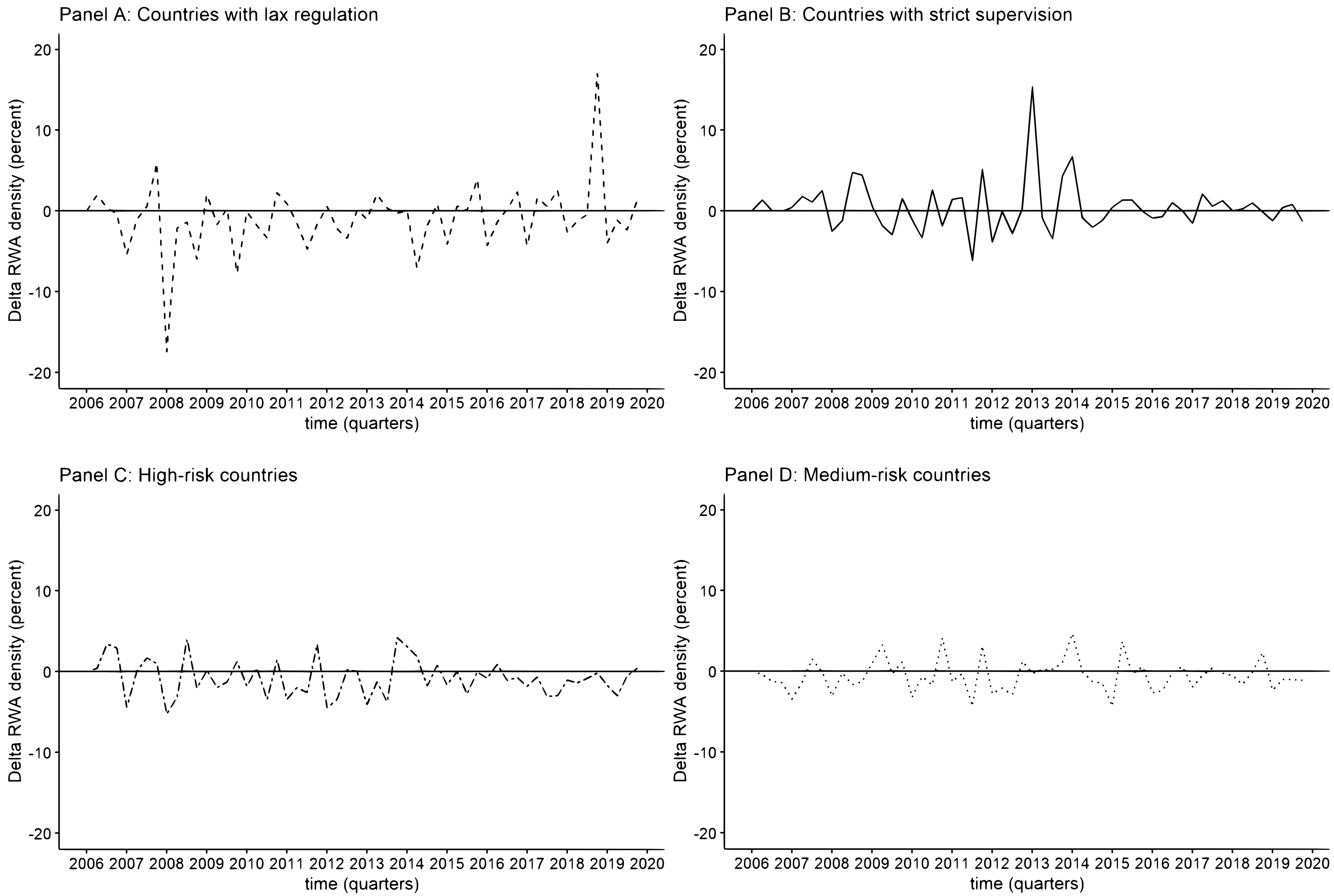


Figure 3: Development of banks' change in risk-weighted asset densities over time.

Notes: This figure illustrates the change in risk-weighted asset (RWA) densities across quarters. Panel A to D show the development for subgroups of countries classified as countries with lax regulation, countries with strict supervision as well as high-risk, and medium-risk countries.

INTERNET APPENDIX

Back to the Roots of Internal Credit Risk Models: Why Do Banks' Risk-Weighted Asset Levels Converge over Time?

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Guide to the internet appendix

This internet appendix includes additional information, complementing the research paper "Back to the Roots of Internal Credit Risk Models: Why Do Banks' Risk-Weighted Asset Levels Converge over Time?" regarding the following five sections:

A Supplementary figures

Figure A.1 illustrates the annual mean risk-weighted asset (RWA) density for banks using the standardized approach. For banks using the internal ratings-based (IRB) approach, Figures A.2 and A.3 provide the evolution of RWA densities for the 52 banks in our sample. Figure A.4 presents the development of the sovereign credit-default swap spreads across countries and over time.

B Details on events in the European banking sector

Table B.1 provides an overview on the timeline of relevant events in the European banking sector.

C Sample description

Table C.2 presents the distribution by country. Tables C.3 and C.4 report summary statistics for the cross-sectional and the panel data set, respectively. Pearson's correlation coefficients are shown in Tables C.5 and C.6, respectively. Table C.7 presents summary statistics for the RWA densities over time for each country group.

D Details on the indices suggested by Barth et al. (2013)

Tables D.8 and D.9 summarize the questions of the World Bank's Bank Regulation and Supervision Survey used to calculate the capital regulatory index and the supervisory power index as suggested by Barth et al. (2013).

E Robustness tests

Tables E.10 to E.13 present the results of the robustness checks with respect to the cross-sectional analysis. Tables E.14 to E.18 report the robustness tests of the panel analysis.

A Supplementary figures

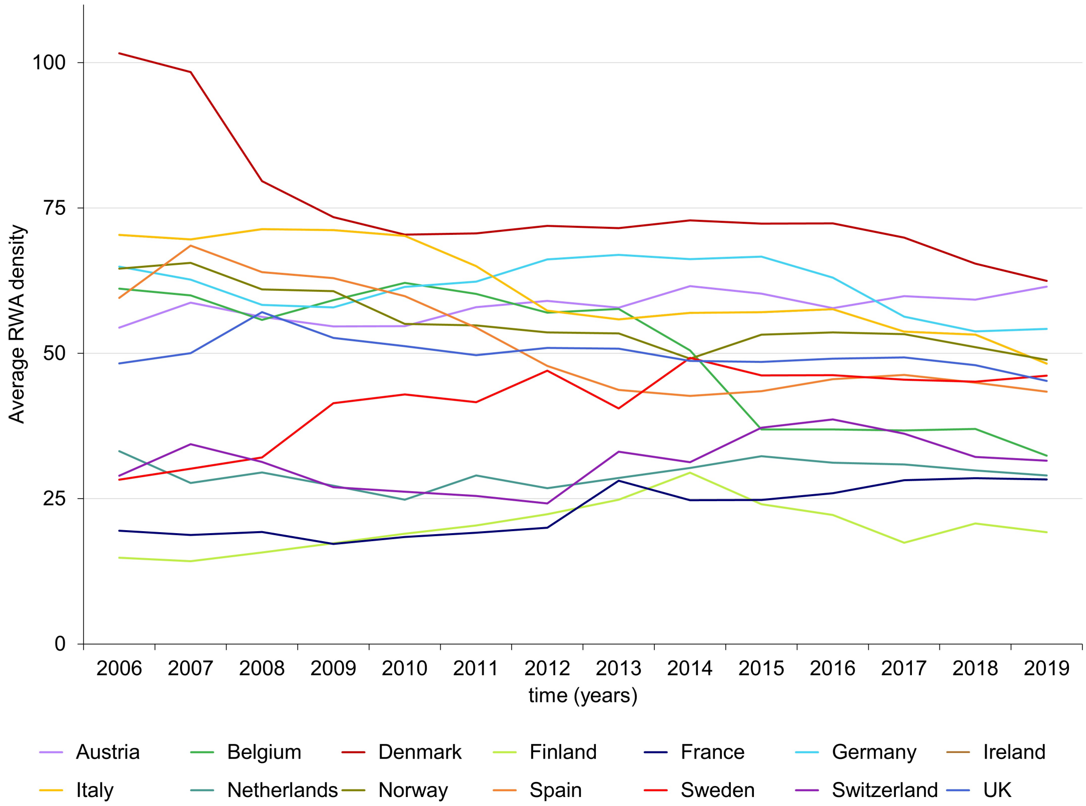

Figure A.1: Country average risk-weighted asset density of banks using the standardized approach over time.

Notes: This figure illustrates the development of the country annual mean of risk-weighted asset (RWA) densities for banks using the standardized approach. In contrast to banks that use the internal ratings-based (IRB) approach, average RWA densities of banks using the standardized approach remain on a similar level over time in all countries. Solely the average RWA density of Danish banks was on a higher level at the beginning of our sample period, since Denmark had a unique way to introduce the Second Basel Accord (Imbierowicz et al., 2018). A detailed analysis of the RWA density of banks that use the standardized approach is beyond the scope of this study.

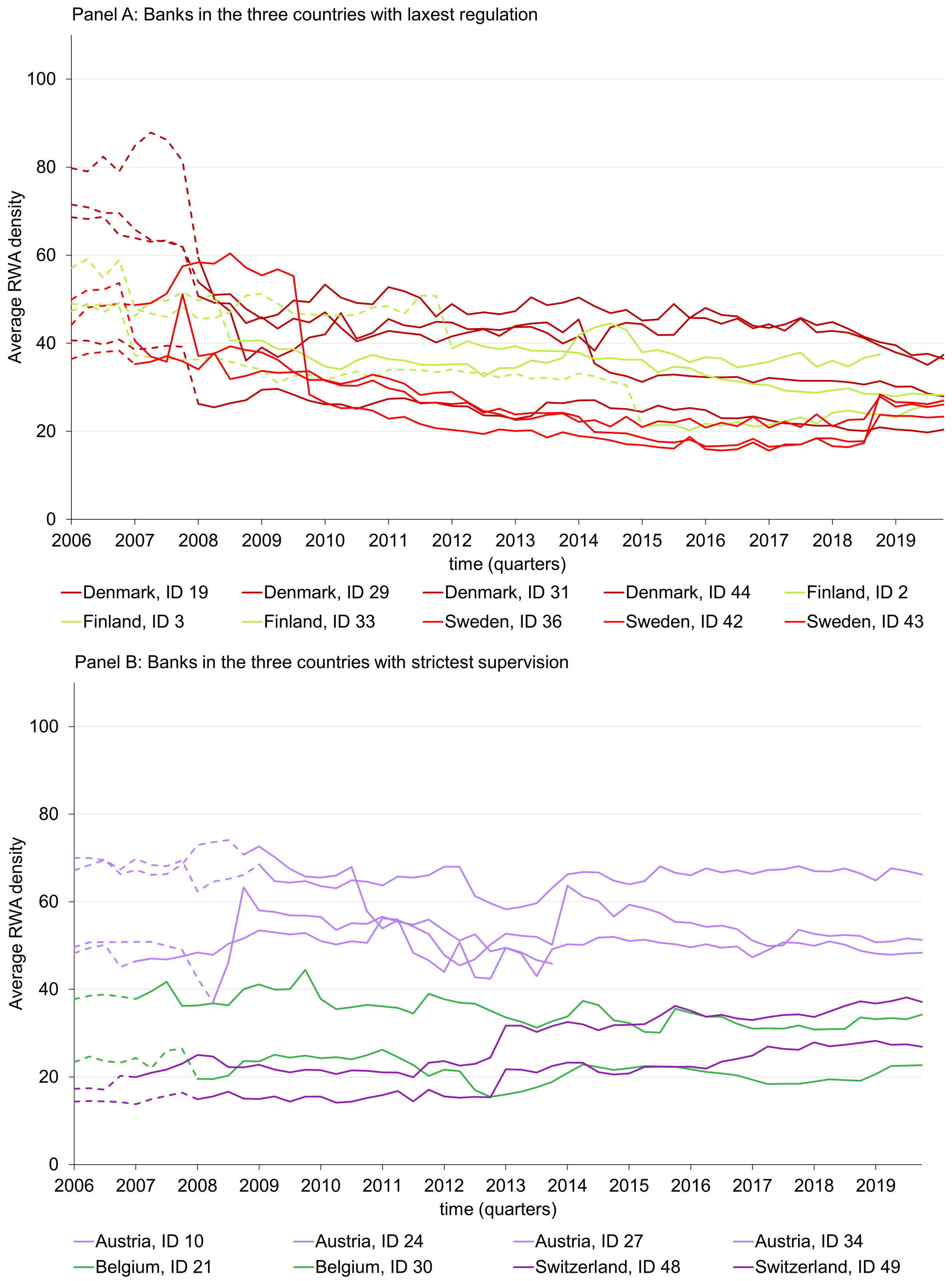

Figure A.2: Development of banks' risk-weighted asset densities over time (Part 1).
Notes: Complementing Figure A.3, this figure illustrates the risk-weighted asset (RWA) density development per bank. For each bank, the dashed line indicates that the bank still uses the standardized approach, the full line starts at the quarter the bank switches to the internal ratings-based (IRB) approach. Country average RWA densities are provided in Figure 1 in the main body of the paper.

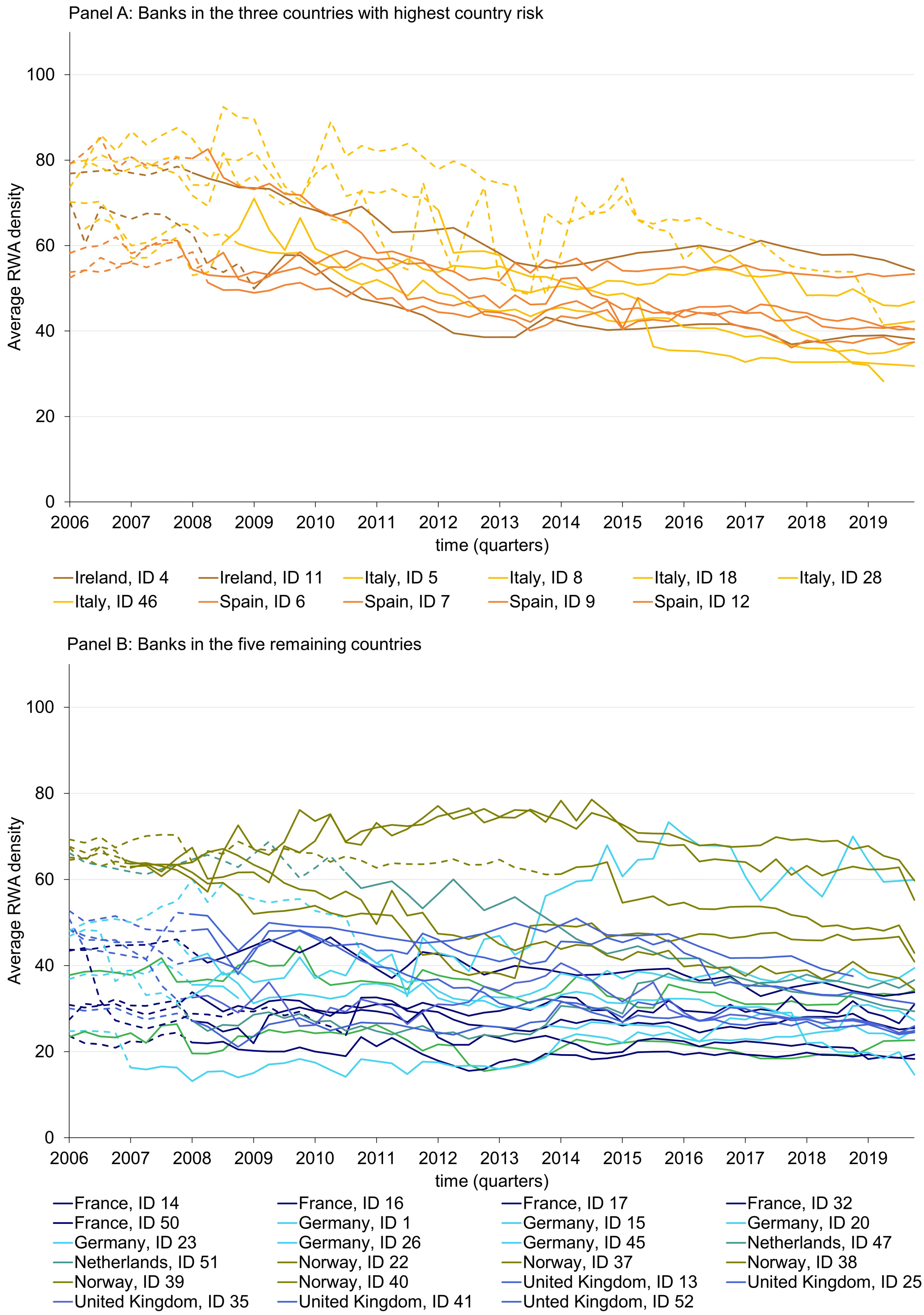

Figure A.3: Development of banks' risk-weighted asset densities over time (Part 2).

Notes: Complementing Figure A.2, this figure illustrates the risk-weighted asset (RWA) density development per bank. For each bank, the dashed line indicates that the bank still uses the standardized approach, the full line starts at the quarter the bank switches to the internal ratings-based (IRB) approach. Country average RWA densities are provided in Figure 1 in the main body of the paper.

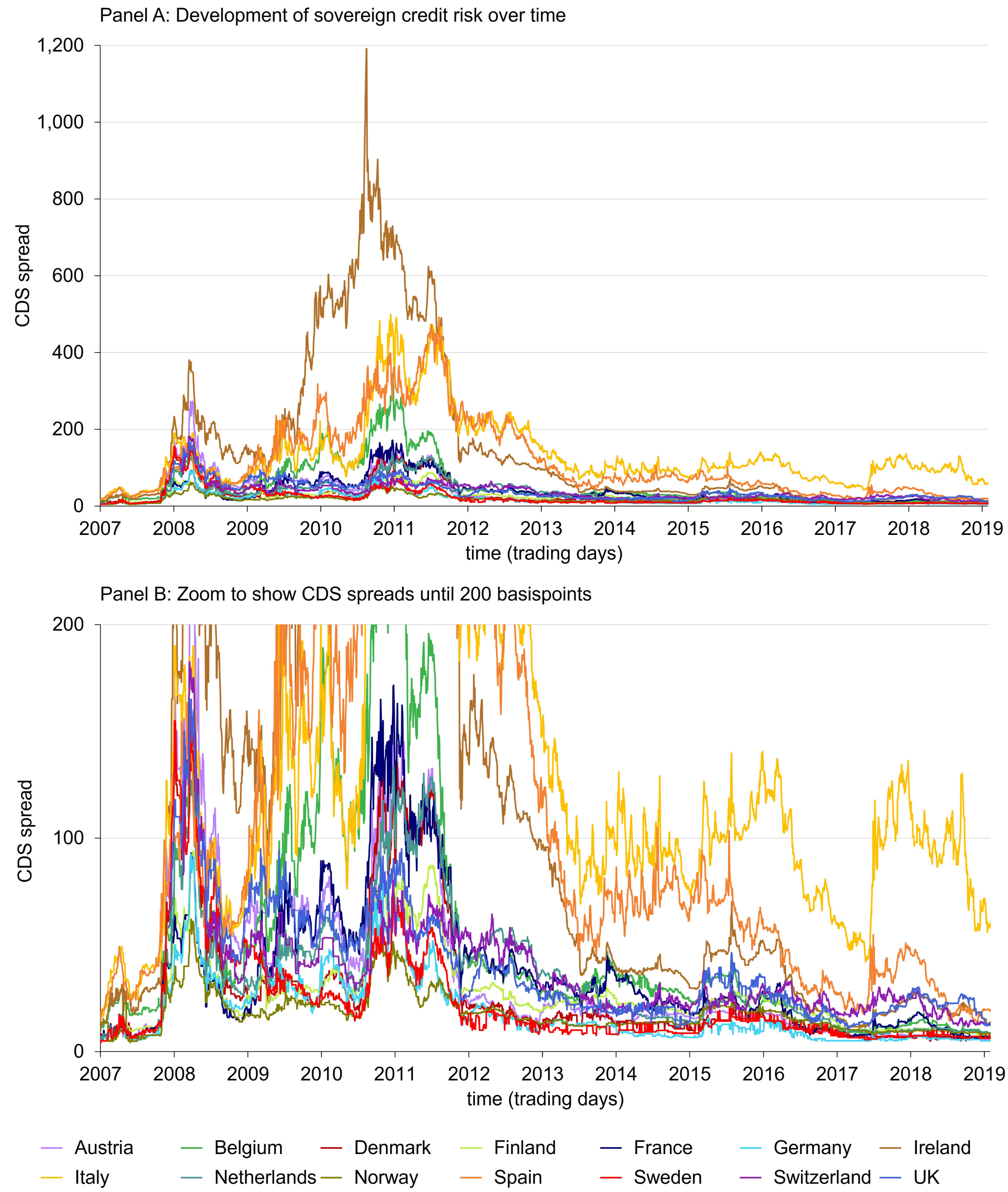

Figure A.4: Sovereign credit risk by country.

Notes: This figure illustrates the development of the 5-year sovereign credit-default swap (CDS) spreads across countries and over time (Source: Refinitiv Datastream).

B Details on events in the European banking sector

Table B.1: Timeline of relevant events in the European banking sector.

Time Period	Event	Affected Countries	Description	Reference
2007 Q1	Adoption of the IRB approach becomes possible	Austria, Belgium, Germany, Norway, Sweden, Switzerland	First bank(s) switch to IRB approach	Annual & disclosure reports
2007 Q4 – 2009 Q2	Macroeconomic shock: Financial crisis	All countries	Worldwide financial crisis causing a severe economic downturn	-
2008 Q1	Adoption of the IRB approach becomespossible	Denmark, France, Ireland, Netherlands, Spain, UK	First bank(s) switch to IRB approach	Annual & disclosure reports
2008 Q3	Adoption of the IRB approach becomes possible	Finland, Italy	First bank(s) switch to IRB approach	Annual & disclosure reports
2009 Q1 – 2012 Q4	Regulation change: Implementation of new requirements	Switzerland	Higher capital requirements for the two large Swiss banks (to be implemented until 2013)	Swiss Bankers Association (2009)
2009 Q3 – 2013 Q1	Macroeconomic shock: Sovereign debt crisis	Ireland, Italy, Spain (high-risk countries)	Crisis related to high government debt and collapsing financial institutions	-
2010 Q4 – 2011 Q4	Regulation change: Introduction of the Third Basel Accord	All countries	Higher capital requirements, banks anticipate introduction in their country	Basel Committee on Banking Supervision (BCBS) (2011)
until 2014 Q1	Regulation change: Implementation of CRD IV	Euro countries	Higher capital requirements, implementation of the Third Basel Accord in the EU (to be implemented until Dec 31, 2013)	European Union (EU) (2013)
since 2016 Q3	Macroeconomic shock: "Brexit"	UK	Process of leavings the EU after referendum in June 2016	-
2018 Q1	Regulation change: Introduction of IFRS 9	All countries	Change of the International Financial Reporting Standard (IFRS) regarding financial instruments	International Accounting Standards Board
2018 Q4	Regulation change: Introduction of risk weight floor	Sweden	Implementation of an average institution-specific risk weight floor for Swedish mortgage exposures for credit institution with approval to use an internal credit risk model	Finansinspektionen Sweden (2018)
2019 Q4	Regulation change: Implementation of CRD IV	Norway	Removal of Basel I floor, introduction of a floor on mortgages for two years, and announcement to increase systemic risk buffer by 1.5 ppt from end 2020	Ministry of Finance Norway (2019)

This table provides an overview of macroeconomic shocks and regulation changes, representing relevant events in the European banking sector during our sample period. "IRB" refers to the internal ratings-based (IRB) approach. "CRD" abbreviates Capital Requirements Directive.

C Sample description

Table C.2: Sample across countries.

Country	Number of banks	Number of observations	% of total assets in the sample
Austria	4	180	1.58
Belgium	2	66	2.17
Denmark	4	200	2.35
Finland	3	121	0.23
France	5	255	25.04
Germany	6	246	11.10
Ireland	2	102	1.23
Italy	5	190	3.49
Netherlands	2	70	2.07
Norway	5	255	1.37
Spain	4	204	9.03
Sweden	3	153	3.30
Switzerland	2	102	7.86
UK	5	251	29.17
Total	**52**	**2,395**	**100.00**

This table presents the sample distribution by country. With a maximum of 52 quarters, a balanced panel would comprise 2,704 observations. Due to limited data availability and banks' merger activity, our final data set contains 2,395 bank-quarter observations.

Table C.3: Summary statistics cross-section.

Variable	N	Mean	SD	Min	p25	Median	p75	Max
Dependent variables								
$\Delta RWAD_{i,j}^{s}$	52	−7.768	10.921	−33.149	−12.982	−5.987	−0.488	12.721
$\varnothing\Delta RWAD_{i,j}^{s+4}$	51	−2.199	4.454	−18.017	−4.341	−1.791	−0.053	10.134
$\varnothing\Delta RWAD_{i,j}^{s+8}$	50	−1.162	2.259	−7.203	−2.163	−1.119	0.361	4.741
$\varnothing\Delta RWAD_{i,j}^{s+12}$	50	−0.981	1.577	−4.527	−2.098	−0.847	0.016	3.184
$\varnothing\Delta RWAD_{i,j}^{s+16}$	49	−0.889	1.159	−3.053	−1.889	−0.828	−0.061	2.046
$\varnothing\Delta RWAD_{i,j}^{s+20}$	49	−0.888	1.085	−3.293	−1.785	−1.005	−0.165	1.272
$\varnothing\Delta RWAD_{i,j}^{s+24}$	48	−0.760	1.142	−3.671	−1.391	−0.697	−0.149	1.854
$\varnothing\Delta RWAD_{i,j}^{s+28}$	47	−0.592	1.090	−3.078	−1.234	−0.679	0.070	2.185
$\varnothing\Delta RWAD_{i,j}^{s+32}$	46	−0.527	1.107	−2.791	−1.241	−0.436	0.129	2.201
$\varnothing\Delta RWAD_{i,j}^{s+36}$	45	−0.506	0.986	−2.473	−1.094	−0.573	0.191	1.828
$\varnothing\Delta RWAD_{i,j}^{s+40}$	41	−0.479	0.881	−2.182	−1.044	−0.597	0.071	1.533
Explanatory variables								
$LAX\_REGULATION_j$	52	0.135	0.345	0	0	0	0	1
$STRICT\_SUPERVISION_j$	52	0.115	0.323	0	0	0	0	1
$HIGH\_RISK_j$	52	0.212	0.412	0	0	0	0	1
$REL\_MIN_{i,j}^{s-1}$	52	25.922	14.379	2.622	16.034	26.200	32.658	76.911
$\varnothing RWAD_{i,j}$	52	43.936	14.259	19.422	30.337	45.192	52.134	69.403
$IRB\_COVERAGE_{i,j}^{s}$	52	0.604	0.259	0.000	0.498	0.625	0.817	1.000
$\varnothing HIGH\_IRB\_CVG_{i,j}$	52	0.250	0.437	0	0	0	1	1
$RETURN\_ON\_RWA_{i,j}^{s-1}$	52	0.326	0.440	−1.214	0.179	0.340	0.505	1.842
$LLR_{i,j}^{s-1}$	48	0.943	1.236	0.044	0.299	0.670	1.205	8.032
$PRE\_CRISIS_{i,j}$	52	0.712	0.457	0	0	1	1	1
$EURO_{i,j}$	52	0.635	0.486	0	0	1	1	1
$\varnothing EQUITY_{i,j}$	52	0.481	0.505	0	0	0	1	1
$\varnothing SIZE_{i,j}$	52	0.538	0.503	0	0	1	1	1
$\varnothing DOMESTIC\_CREDIT_j$	52	0.269	0.448	0	0	0	1	1
$\varnothing\Delta GDP_j$	52	0.325	0.211	−0.031	0.270	0.315	0.362	1.174

This table provides descriptive statistics for the variables in the cross-sectional data set. N refers to the number of observations. "Mean" ("SD") describes the mean (standard deviation) of each variable across all observations, respectively. "p25" ("p75") refers to the 25th (75th) percentile of the distribution of each variable. Comprehensive variable descriptions are provided in Table 5 in the main body of the paper. As several banks switch later during our sample period, the number of available banks to calculate the average risk-weighted asset densities ($\varnothing\Delta RWAD_{i,j}^{s+r}$) decreases. Due to limited data availability, information on banks' loan loss reserves to total assets at the quarter before the switch ($LLR_{i,j}^{s-1}$) is only available for 48 banks.

Table C.4: Summary statistics panel.

Variable	N	Mean	SD	Min	p25	Median	p75	Max
Dependent variable								
$\Delta RWAD_{i,j,t}$	2,395	−0.486	5.333	−18.172	−3.167	−0.613	1.877	18.437
Explanatory variables								
$LAX\_REGULATION_{j,t}$	2,395	0.494	0.500	0	0	0	1	1
$REGULATION\_INDEX_{j,t}$	2,395	0.181	0.067	0.111	0.125	0.143	0.250	0.333
$STRICT\_SUPERVISION_{j,t}$	2,395	0.504	0.500	0	0	1	1	1
$SUPERVISION\_INDEX_{j,t}$	2,395	9.689	1.994	5	8	10	11	14
$CDS\_SOVEREIGN_{j,t}$	2,395	3.309	1.071	0.182	2.570	3.178	4.035	6.595
$CDS\_BANK_{i,j,t}$	1,442	4.554	0.881	1.411	4.094	4.565	5.052	7.269
$\Delta LOANS_{i,j,t}$	2,395	0.798	7.861	−22.378	−3.335	0.048	4.430	28.799
$\Delta LLR_{i,j,t}$	2,395	0.003	0.277	−3.336	−0.026	−0.002	0.022	5.752
$\Delta RETURN\_ON\_RWA_{i,j,t}$	2,395	−0.004	0.363	−3.647	−0.096	0.0001	0.087	3.647
$\Delta EQUITY_{i,j,t}$	2,395	0.042	0.424	−4.485	−0.115	0.027	0.192	3.633
$IRB_{i,j,t}$	2,395	0.868	0.338	0	1	1	1	1
$IRB\_COVERAGE_{i,j,t}$	2,282	0.588	0.286	0.000	0.493	0.661	0.812	1.000
$SIZE_{i,j,t}$	2,395	12.089	1.904	7.217	10.446	12.490	13.682	14.861
$DOMESTIC\_CREDIT_{j,t}$	2,395	105.519	33.875	40.900	84.000	92.000	123.500	199.500
$\Delta GDP_{j,t}$	2,395	0.314	1.172	−6.842	−0.016	0.365	0.748	22.657

This table provides descriptive statistics for the variables in the panel data set. N refers to the number of observations. “Mean” (“SD”) describes the mean (standard deviation) of each variable across all observations, respectively. “p25” (“p75”) refers to the 25th (75th) percentile of the distribution of each variable. Comprehensive variable descriptions are provided in Table 6 in the main body of the paper. Due to limited data availability, information on banks’ credit-default swap spreads ($CDS\_BANK_{i,j,t}$) and on the share of banks’ coverage of the internal ratings-based approach ($IRB\_COVERAGE_{i,j,t}$) are not available for all bank-quarter observations.

Table C.5: Correlation matrix cross-section.

Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
(1) $\Delta RWAD_{i,j}^{s}$	1	0.736	0.446	0.141	0.050	0.081	0.028	0.390	-0.222	0.038	0.077	-0.058
(2) $\varnothing\Delta RWAD_{i,j}^{s+8}$	0.736	1	0.553	0.243	0.173	0.188	-0.243	0.080	-0.325	0.150	-0.047	-0.023
(3) $\varnothing\Delta RWAD_{i,j}^{s+16}$	0.446	0.553	1	0.689	0.700	0.711	-0.389	0.006	-0.118	-0.007	-0.159	-0.135
(4) $\varnothing\Delta RWAD_{i,j}^{t+24}$	0.141	0.243	0.689	1	0.901	0.869	-0.625	-0.086	-0.108	-0.027	-0.058	-0.121
(5) $\varnothing\Delta RWAD_{i,j}^{s+32}$	0.050	0.173	0.700	0.901	1	0.969	-0.619	-0.115	-0.046	-0.004	-0.096	-0.005
(6) $\varnothing\Delta RWAD_{i,j}^{s+40}$	0.081	0.188	0.711	0.869	0.969	1	-0.604	-0.155	-0.049	-0.073	-0.115	0.043
(7) $REL\_MIN_{i,j}^{s-1}$	0.028	-0.243	-0.389	-0.625	-0.619	-0.604	1	0.602	0.142	0.029	0.177	0.019
(8) $\varnothing RWAD_{i,j}$	0.390	0.080	0.006	-0.086	-0.115	-0.155	0.602	1	-0.048	0.135	0.302	0.100
(9) $IRB\_COVERAGE_{i,j}^{s}$	-0.222	-0.325	-0.118	-0.108	-0.046	-0.049	0.142	-0.048	1	-0.299	0.030	-0.017
(10) $RETURN\_ON\_RWA_{i,j}^{s-1}$	0.038	0.150	-0.007	-0.027	-0.004	-0.073	0.029	0.135	-0.299	1	0.079	0.147
(11) $LLR_{i,j}^{s-1}$	0.077	-0.047	-0.159	-0.058	-0.096	-0.115	0.177	0.302	0.030	0.079	1	0.004
(12) $\varnothing\Delta GDP_{j}$	-0.058	-0.023	-0.135	-0.121	-0.005	0.043	0.019	0.100	-0.017	0.147	0.004	1

This table reports correlation coefficients between all non-binary variables of the cross-sectional data set. Comprehensive variable descriptions are provided in Table 5 in the main body of the paper.

Table C.6: Correlation matrix panel.

Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**
(1) $\Delta RWAD_{i,j,t}$	1	-0.030	0.049	-0.055	-0.050	-0.086	-0.013	0.012	0.117	0.010	0.066	0.004	0.015
(2) $REGULATION\_INDEX_{j,t}$	-0.030	1	-0.152	-0.044	-0.022	-0.016	0.051	-0.010	-0.030	0.121	0.012	0.028	-0.005
(3) $SUPERVISION\_INDEX_{j,t}$	0.049	-0.152	1	0.013	0.001	-0.006	0.066	-0.026	-0.060	-0.026	-0.028	0.334	-0.081
(4) $CDS\_SOVEREIGN_{j,t}$	-0.055	-0.044	0.013	1	0.784	-0.060	0.142	-0.003	0.005	-0.069	-0.008	0.169	-0.175
(5) $CDS\_BANK_{i,j,t}$	-0.050	-0.022	0.001	0.784	1	-0.139	0.127	-0.034	-0.001	0.105	-0.098	0.047	-0.112
(6) $\Delta LOANS_{i,j,t}$	-0.086	-0.016	-0.006	-0.060	-0.139	1	-0.036	0.069	-0.062	-0.147	0.001	0.038	0.024
(7) $\Delta LLR_{i,j,t}$	-0.013	0.051	0.066	0.142	0.127	-0.036	1	-0.035	0.060	-0.014	-0.012	0.096	-0.188
(8) $\Delta RENURN\_ON\_RWA_{i,j,t}$	0.012	-0.010	-0.026	-0.003	-0.034	0.069	-0.035	1	0.156	-0.005	-0.009	-0.005	0.049
(9) $\Delta EQUITY_{i,j,t}$	0.117	-0.030	-0.060	0.005	-0.001	-0.062	0.060	0.156	1	-0.021	-0.023	-0.006	0.064
(10) $IRB\_COVERAGE_{i,j,t}$	0.010	0.121	-0.026	-0.069	0.105	-0.147	-0.014	-0.005	-0.021	1	0.121	-0.040	-0.016
(11) $SIZE_{i,j,t}$	0.066	0.012	-0.028	-0.008	-0.098	0.001	-0.012	-0.009	-0.023	0.121	1	-0.029	-0.060
(12) $DOMESTIC\_CREDIT_{j,t}$	0.004	0.028	0.334	0.169	0.047	0.038	0.096	-0.005	-0.006	-0.040	-0.029	1	-0.091
(13) $\Delta GDP_{j,t}$	0.015	-0.005	-0.081	-0.175	-0.112	0.024	-0.188	0.049	0.064	-0.016	-0.060	-0.091	1

This table reports correlation coefficients between the variables of the panel data set. Comprehensive variable descriptions are provided in Table 6 in the main body of the paper.

Table C.7: Summary statistics for the risk-weighted asset densities over time across banks for each country group.

Variable	**N**	**Mean**	**SD**	**Median**
Countries with lax regulation	353	-0.90	5.86	-0.96
Countries with strict supervision	282	0.27	5.29	-0.16
High-risk countries	496	-0.77	4.39	-0.82
Medium-risk countries	1,264	-0.43	5.51	-0.66
Total	**2,395**	**-0.49**	**5.33**	**-0.61**

This table provides descriptive statistics for the change in risk-weighted asset density ($\Delta RWAD_{i,j,t}$) across country groups as defined in Section 3.2. N refers to the number of observations. "Mean" ("SD") describes the mean (standard deviation) of the variable across observations, respectively. Comprehensive variable descriptions are provided in Table 6 in the main body of the paper.

D Details on the indices suggested by Barth et al. (2013)

Table D.8: Overview of the Capital Regulatory Index.

	Description	True	False
	Overall Capital Stringency		
1	Capital adequacy regulations are in line with Basel I guidelines	1	0
2	Credit risk is covered by regulatory minimum capital requirements	1	0
3	Market risk is covered by regulatory minimum capital requirements	1	0
4	Unrealized losses are deducted from regulatory capital	3	0
5	Less than 75% revaluation gains are allowed as part of capital	1	0
	Initial Capital Stringency		
6	Sources of funds to be used as capital are verified by the regulatory/ supervisory authorities	1	0
7	Initial disbursement or subsequent injections of capital can be done with assets other than cash or government securities	0	1
8	Initial capital contributions by prospective shareholders can be done in the form of borrowed funds	0	1
	Capital Regulatory Index		
Σ	Higher values indicate greater stringency	max. 10	

The Capital Regulatory Index has been suggested by Barth et al. (2013) and is created based on the World Bank's Bank Regulation and Supervision Survey. This table summarizes the categories from the 2007, 2011, and 2019 surveys. The columns "True" and "False" indicate the respective score added to the index if the corresponding description is "True" or "False", respectively. The index is computed as the simple sum of the scores for each country.

Table D.9: Overview of the Supervisory Power Index.

	Description	True	False
	Supervisors' Enforcement Powers		
1	The banking supervisor has the right to meet with external auditors to discuss their report without the approval of the bank	1	0
2	Auditors are required by law to communicate directly to the supervisory agency any presumed involvement of bank directors or senior managers in illicit activities, fraud, or insider abuse	1	0
3	In cases where the supervisor identifies that the bank has received an inadequate audit, the supervisor has the power to take actions against the external auditor	1	0
4	The supervisory authority can force a bank to change its internal organizational structure	1	0
5	Banks disclose off-balance sheet items to the supervisors	1	0
6	The supervisory agency cam require banks to constitute provisions to cover actual or potential losses	1	0
7	The supervisory agency can require banks to reduce or suspend dividends to shareholders	1	0
8	The supervisory agency can require banks to reduce or suspend bonuses and other remuneration to bank directors and managers	2	0
	Bank Resolution Activities		
9	The following authority has the powers to declare insolvency	max. 1	
	Bank supervisor	1	0
	Deposit insurance agency	0.5	0
	Bank restructuring or Asset Management Agency	0.5	0
10	The following authority has the powers so supersede	max. 2	
	Bank supervisor	2	0
	Deposit insurance agency	1	0
	Bank restructuring or Asset Management Agency	1	0
11	The following authority has the powers to remove and replace senior management and directors	max. 2	
	Bank supervisor	2	0
	Deposit insurance agency	1	0
	Bank restructuring or Asset Management Agency	1	0
	Official Supervisory Power Index		
Σ	Higher values indicate greater power	max. 14	

The Supervisory Power Index has been suggested by Barth et al. (2013) and is created based on the World Bank's Bank Regulation and Supervision Survey. This table summarizes the categories from the 2007, 2011, and 2019 surveys. The columns "True" and "False" indicate the respective score added to the index if the corresponding description is "True" or "False", respectively. The index is computed as the simple sum of the scores for each country.

E Robustness tests

Table E.10: Robustness test cross-section: identical sample size.

	Dependent variable: $\varnothing\Delta RWAD_{i,j}^{s+r}$				
	$r = 8$	$r = 16$	$r = 24$	$r = 32$	$r = 40$
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
$LAX\_REGULATION_j$	-1.219	-1.606^{***}	-2.017^{***}	-2.037^{***}	-1.544^{***}
	(1.102)	(0.500)	(0.409)	(0.348)	(0.267)
$STRICT\_SUPERVISION_j$	2.244^{***}	0.711	0.699^{*}	0.535^{*}	0.679^{***}
	(0.833)	(0.528)	(0.384)	(0.298)	(0.245)
$HIGH\_RISK_j$	1.841	-0.024	-0.615	-1.129^{***}	-0.878^{**}
	(1.449)	(0.783)	(0.567)	(0.427)	(0.375)
$\varnothing RWAD_{i,j}$	0.033	0.008	-0.012	-0.005	-0.008
	(0.041)	(0.021)	(0.021)	(0.016)	(0.013)
$PRE\_CRISIS_{i,j}$	2.015^{**}	1.279^{**}	-0.177	0.161	0.252
	(0.937)	(0.528)	(0.657)	(0.609)	(0.451)
$EURO_{i,j}$	-0.509	-0.130	-0.564	-0.109	0.033
	(0.699)	(0.342)	(0.486)	(0.389)	(0.266)
$\varnothing EQUITY_{i,j}$	-0.508	-0.196	0.018	-0.204	-0.204
	(0.696)	(0.394)	(0.569)	(0.444)	(0.318)
$\varnothing SIZE_{i,j}$	0.624	-0.037	-0.040	-0.024	-0.111
	(0.877)	(0.531)	(0.558)	(0.462)	(0.350)
$\varnothing DOMESTIC\_CREDIT_j$	-2.077^{*}	-0.480	0.541	0.853^{**}	0.672^{**}
	(1.162)	(0.485)	(0.416)	(0.361)	(0.275)
$\varnothing\Delta GDP_j$	0.139	-0.505	-0.746^{*}	-0.211	0.026
	(1.191)	(0.550)	(0.426)	(0.357)	(0.290)
Constant	-3.753	-1.580	0.758	0.097	-0.087
	(2.322)	(1.356)	(1.025)	(0.754)	(0.555)
Observations	41	41	41	41	41
R^2	0.411	0.527	0.419	0.539	0.608
Adjusted R^2	0.215	0.370	0.226	0.385	0.478
Residual Std. Error	1.807 (df = 30)	0.885 (df = 30)	1.016 (df = 30)	0.854 (df = 30)	0.636 (df = 30)
F Statistic	2.093^{*} (df = 10; 30)	3.348^{***} (df = 10; 30)	2.168^{**} (df = 10; 30)	3.502^{***} (df = 10; 30)	4.659^{***} (df = 10; 30)

This table reports regression results of the cross-sectional analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 5 in the main body of the paper.

Table E.11: Robustness cross-section: IRB approach coverage.

	Dependent variable: $\varnothing\Delta RWAD_{i,j}^{s+r}$				
	$r = 8$	$r = 16$	$r = 24$	$r = 32$	$r = 40$
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
$LAX\_REGULATION_j$	−0.773	−1.529***	−1.504***	−1.711***	−1.498***
	(1.139)	(0.529)	(0.475)	(0.417)	(0.277)
$STRICT\_SUPERVISION_j$	2.602**	1.022*	1.308***	1.076***	0.647**
	(1.027)	(0.549)	(0.360)	(0.316)	(0.260)
$HIGH\_RISK_j$	0.097	−0.031	−0.230	−0.503	−0.952**
	(1.316)	(0.598)	(0.513)	(0.553)	(0.433)
$\varnothing HIGH\_IRBA\_CVG_{i,j}$	−1.534*	−0.125	−0.629	−0.158	−0.132
	(0.819)	(0.368)	(0.432)	(0.431)	(0.335)
$\varnothing RWAD_{i,j}$	0.031	0.004	−0.023	−0.012	−0.008
	(0.038)	(0.017)	(0.020)	(0.018)	(0.013)
$PRE\_CRISIS_{i,j}$	2.218***	1.380***	0.574	0.891*	0.209
	(0.719)	(0.369)	(0.416)	(0.472)	(0.462)
$EURO_{i,j}$	0.165	−0.065	−0.445	−0.150	0.058
	(0.609)	(0.317)	(0.379)	(0.359)	(0.270)
$\varnothing EQUITY_{i,j}$	0.081	−0.047	0.399	0.073	−0.217
	(0.639)	(0.326)	(0.390)	(0.385)	(0.308)
$\varnothing SIZE_{i,j}$	0.410	−0.118	−0.210	0.015	−0.142
	(0.891)	(0.426)	(0.459)	(0.463)	(0.377)
$\varnothing DOMESTIC\_CREDIT_j$	−1.527	−0.610	0.029	0.330	0.693**
	(1.101)	(0.389)	(0.372)	(0.427)	(0.292)
$\varnothing\Delta GDP_j$	0.747	−0.466	−0.523	−0.111	0.034
	(1.142)	(0.491)	(0.447)	(0.487)	(0.299)
Constant	−4.123**	−1.475	0.416	−0.491	−0.011
	(2.058)	(0.964)	(1.014)	(0.811)	(0.634)
Observations	50	49	48	46	41
R^2	0.501	0.556	0.474	0.517	0.611
Adjusted R^2	0.356	0.424	0.314	0.361	0.464
Residual Std. Error	1.812	0.879	0.946	0.885	0.645
	(df = 38)	(df = 37)	(df = 36)	(df = 34)	(df = 29)
F Statistic	3.467***	4.216***	2.953***	3.313***	4.143***
	(df = 11; 38)	(df = 11; 37)	(df = 11; 36)	(df = 11; 34)	(df = 11; 29)

This table reports regression results of the cross-sectional analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 5 in the main body of the paper.

Table E.12: Robustness test cross-section: alternative dependent variables.

	Dependent variable: $\varnothing\Delta RWAD_{i,j}^{s+r}$				
	$r = 4$	$r = 12$	$r = 20$	$r = 28$	$r = 36$
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
$LAX\_REGULATION_j$	0.056	−2.168***	−1.690***	−1.731***	−1.584***
	(2.157)	(0.494)	(0.463)	(0.342)	(0.324)
$STRICT\_SUPERVISION_j$	5.279**	1.307**	0.876**	1.227***	1.065***
	(2.461)	(0.633)	(0.387)	(0.296)	(0.295)
$HIGH\_RISK_j$	3.740	−0.190	−0.242	−0.109	−0.387
	(2.553)	(0.882)	(0.514)	(0.493)	(0.475)
$\varnothing RWAD_{i,j}$	0.084	0.006	0.002	−0.011	−0.015
	(0.079)	(0.024)	(0.017)	(0.017)	(0.015)
$PRE\_CRISIS_{i,j}$	0.426	1.871***	0.702*	0.675	0.818**
	(1.989)	(0.517)	(0.378)	(0.466)	(0.397)
$EURO_{i,j}$	0.240	0.033	−0.329	−0.441	−0.078
	(1.297)	(0.388)	(0.317)	(0.372)	(0.300)
$\varnothing EQUITY_{i,j}$	−1.974	0.148	0.302	0.094	−0.045
	(1.285)	(0.474)	(0.331)	(0.399)	(0.323)
$\varnothing SIZE_{i,j}$	1.890	0.117	−0.027	0.046	−0.120
	(1.880)	(0.586)	(0.437)	(0.402)	(0.319)
$\varnothing DOMESTIC\_CREDIT_j$	−4.013*	−0.647	−0.338	0.067	0.310
	(2.092)	(0.548)	(0.337)	(0.341)	(0.356)
$\varnothing\Delta GDP_j$	4.142**	0.202	−0.189	−0.345	−0.079
	(2.008)	(0.677)	(0.506)	(0.403)	(0.348)
Constant	−8.042*	−2.426*	−1.079	−0.215	−0.265
	(4.385)	(1.324)	(0.974)	(0.784)	(0.594)
Observations	51	50	49	47	45
R^2	0.355	0.552	0.443	0.490	0.569
Adjusted R^2	0.194	0.438	0.297	0.349	0.442
Residual Std. Error	3.999	1.183	0.910	0.879	0.737
	(df = 40)	(df = 39)	(df = 38)	(df = 36)	(df = 34)
F Statistic	2.201**	4.812***	3.026***	3.463***	4.483***
	(df = 10; 40)	(df = 10; 39)	(df = 10; 38)	(df = 10; 36)	(df = 10; 34)

This table reports regression results of the cross-sectional analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 5 in the main body of the paper.

Table E.13: Robustness test cross-section: alternative country grouping.

	Dependent variable: $\varnothing\Delta RWAD_{i,j}^{s+r}$				
	$r = 8$	$r = 16$	$r = 24$	$r = 32$	$r = 40$
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
$LAX\_$ $REGULATION_j$	−1.415	−1.285***	−1.423***	−1.408***	−1.553***
	(0.962)	(0.426)	(0.438)	(0.453)	(0.314)
$STRICT\_$ $SUPERVISION_j$	2.029***	0.592	0.856**	0.715*	0.191
	(0.752)	(0.503)	(0.417)	(0.397)	(0.306)
$HIGH\_RISK_j$	0.148	−0.191	−0.267	−0.609	−1.258***
	(1.283)	(0.530)	(0.562)	(0.597)	(0.399)
$\varnothing RWAD_{i,j}$	0.039	0.004	−0.015	−0.006	−0.008
	(0.042)	(0.020)	(0.021)	(0.018)	(0.014)
$PRE\_CRISIS_{i,j}$	1.639**	1.037***	0.201	0.506	−0.289
	(0.722)	(0.384)	(0.460)	(0.512)	(0.420)
$EURO_{i,j}$	−0.180	0.062	−0.431	−0.071	0.093
	(0.602)	(0.305)	(0.418)	(0.381)	(0.284)
$\varnothing EQUITY_{i,j}$	−0.271	−0.164	0.234	−0.098	−0.268
	(0.610)	(0.310)	(0.440)	(0.429)	(0.306)
$\varnothing SIZE_{i,j}$	0.659	−0.243	−0.063	−0.008	−0.183
	(0.950)	(0.498)	(0.490)	(0.434)	(0.372)
$\varnothing DOMESTIC\_$ $CREDIT_j$	−1.103	−0.567	0.157	0.367	0.871***
	(0.919)	(0.357)	(0.375)	(0.442)	(0.255)
$\varnothing\Delta GDP_j$	0.542	−0.538	−0.716*	−0.247	−0.037
	(1.061)	(0.464)	(0.420)	(0.442)	(0.318)
Constant	−4.102	−1.094	0.295	−0.361	0.548
	(2.557)	(1.245)	(1.111)	(0.924)	(0.763)
Observations	50	49	48	46	41
R^2	0.436	0.498	0.352	0.432	0.565
Adjusted R^2	0.291	0.365	0.177	0.270	0.420
Residual Std. Error	1.902	0.923	1.036	0.946	0.670
	(df = 39)	(df = 38)	(df = 37)	(df = 35)	(df = 30)
F Statistic	3.012***	3.763***	2.012*	2.661**	3.898***
	(df = 10; 39)	(df = 10; 38)	(df = 10; 37)	(df = 10; 35)	(df = 10; 30)

This table reports regression results of the cross-sectional analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 5 in the main body of the paper.

Table E.14: Robustness test panel: categorical variables of regulatory strictness.

	Dependent variable: $\Delta RWAD_{i,j,t}$			
	(1)	**(2)**	**(3)**	**(4)**
	2007 Q1 – 2019 Q4	2009 Q3 – 2019 Q4	2007 Q1 – 2012 Q4	2013 Q1 – 2019 Q4
$REGULATION\_INDEX_{j,t-1}$	−2.079	0.005	7.419	2.137
	(1.570)	(1.528)	(5.829)	(2.275)
$SUPERVISION\_INDEX_{j,t-1}$	0.036	0.097	−0.042	0.324***
	(0.053)	(0.061)	(0.091)	(0.088)
$CDS\_SOVEREIGN_{j,t-1}$	−0.839***	−1.015***	−0.941***	0.315
	(0.243)	(0.358)	(0.342)	(0.710)
$IRB_{i,j,t-1}$	1.068**	0.945**	1.637**	1.393**
	(0.520)	(0.479)	(0.818)	(0.584)
$\Delta LOANS_{i,j,t-4}$	−0.028	−0.045	−0.032	−0.024
	(0.026)	(0.032)	(0.032)	(0.030)
$\Delta RETURN\_ON\_RWA_{i,j,t-4}$	0.375	0.575	0.356	0.361
	(0.297)	(0.350)	(0.380)	(0.463)
$\Delta LLR_{i,j,t-4}$	−0.242	−0.486	0.538	−0.546
	(0.463)	(0.442)	(0.555)	(0.584)
$\Delta EQUITY_{i,j,t-4}$	1.394***	1.218**	1.366***	1.630**
	(0.510)	(0.572)	(0.465)	(0.790)
$SIZE_{i,j,t-4}$	0.312	−0.190	0.892	1.314
	(0.434)	(0.526)	(1.677)	(0.958)
$DOMESTIC\_CREDIT_{j,t-4}$	0.006	0.008	0.024	0.007
	(0.005)	(0.007)	(0.024)	(0.009)
$\Delta GDP_{j,t-4}$	0.103	0.030	0.102	0.086
	(0.067)	(0.064)	(0.207)	(0.066)
q2	1.276	0.723	0.316	−1.798
	(1.018)	(0.715)	(2.020)	(1.154)
q3	0.096	2.888***	−0.573	−2.244**
	(0.634)	(0.945)	(1.059)	(1.128)
q4	0.642	0.610	1.817*	−1.679
	(1.309)	(1.330)	(1.096)	(1.512)
Observations	2,395	1,984	1,089	1,306
R^2	0.112	0.124	0.107	0.131
Adjusted R^2	0.068	0.077	0.034	0.069
F Statistic	4.710*** (df = 61; 2282)	5.135*** (df = 52; 1881)	3.657*** (df = 33; 1006)	4.827*** (df = 38; 1218)

This table reports regression results of the panel analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 6 in the main body of the paper.

Table E.15: Robustness test panel: alternative lag-length of banks-specific variables.

	Dependent variable: $\Delta RWAD_{i,j,t}$			
	(1)	**(2)**	**(3)**	**(4)**
	2007 Q1 – 2019 Q4	2009 Q3 – 2019 Q4	2007 Q1 – 2012 Q4	2013 Q1 – 2019 Q4
$LAX\_REGULATION_{j,t-1}$	-0.642^{**}	-0.448	0.019	-0.267
	(0.289)	(0.300)	(0.784)	(0.383)
$STRICT\_SUPERVISION_{j,t-1}$	0.218	0.522^{**}	-0.553	1.140^{***}
	(0.224)	(0.264)	(0.483)	(0.403)
$CDS\_SOVEREIGN_{j,t-1}$	-0.854^{***}	-1.182^{***}	-0.761^{*}	-0.037
	(0.262)	(0.367)	(0.390)	(0.785)
$IRB_{i,j,t-1}$	0.855	0.999^{*}	1.633^{**}	1.266^{*}
	(0.537)	(0.525)	(0.774)	(0.661)
$\Delta LOANS_{i,j,t-1}$	0.027	0.029	0.023	0.023
	(0.019)	(0.021)	(0.025)	(0.026)
$\Delta RETURN\_ON\_RWA_{i,j,t-1}$	-0.598^{**}	-0.160	-0.929^{**}	-0.236
	(0.272)	(0.293)	(0.463)	(0.339)
$\Delta LLR_{i,j,t-1}$	-0.523	-0.216	-0.030	-1.019
	(0.371)	(0.484)	(0.342)	(0.724)
$\Delta EQUITY_{i,j,t-1}$	-0.771^{**}	-0.967^{**}	-0.560	-0.892^{*}
	(0.361)	(0.432)	(0.476)	(0.495)
$SIZE_{i,j,t-1}$	1.498^{***}	1.524^{**}	4.674^{**}	4.434^{***}
	(0.438)	(0.747)	(1.849)	(1.072)
$DOMESTIC\_CREDIT_{j,t-4}$	0.006	0.010	0.013	0.011
	(0.006)	(0.007)	(0.028)	(0.012)
$\Delta GDP_{j,t-4}$	0.107	0.047	0.137	0.103
	(0.066)	(0.065)	(0.203)	(0.063)
$q2$	0.978	0.143	-0.027	-1.611
	(1.244)	(0.828)	(1.587)	(1.351)
$q3$	0.698	3.081^{***}	-0.910	-1.677
	(1.170)	(1.045)	(1.817)	(1.459)
$q4$	1.478	0.664	2.061	-0.810
	(1.720)	(1.362)	(1.613)	(1.700)
Observations	2,426	1,954	1,151	1,275
R^2	0.110	0.118	0.114	0.131
Adjusted R^2	0.066	0.070	0.043	0.067
F Statistic	4.601^{***} (df = 62; 2312)	4.782^{***} (df = 52; 1851)	4.033^{***} (df = 34; 1065)	4.702^{***} (df = 38; 1187)

This table reports regression results of the panel analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 6 in the main body of the paper.

Table E.16: Robustness test panel: different time periods.

	Dependent variable: $\Delta RWAD_{i,j,t}$			
	(1)	**(2)**	**(3)**	**(4)**
	2007 Q1 – 2019 Q4	2009 Q3 – 2017 Q4	2010 Q4 – 2019 Q4	2014 Q1 – 2019 Q4
$LAX\_REGULATION_{j,t-1}$	−0.478*	0.049	−0.428	−0.476
	(0.249)	(0.294)	(0.295)	(0.328)
$STRICT\_SUPERVISION_{j,t-1}$	0.170	−0.293	0.378	0.883**
	(0.195)	(0.322)	(0.284)	(0.361)
$CDS\_SOVEREIGN_{j,t-1}$	−0.819***	−1.090***	−0.664	−0.052
	(0.243)	(0.382)	(0.470)	(0.615)
$IRB_{i,j,t-1}$	1.059**	1.055**	1.129	2.409**
	(0.520)	(0.485)	(0.783)	(1.096)
$\Delta LOANS_{i,j,t-4}$	−0.028	−0.051	−0.039	−0.021
	(0.026)	(0.035)	(0.036)	(0.030)
$\Delta RETURN\_ON\_RWA_{i,j,t-4}$	0.379	0.915**	0.577	0.473
	(0.297)	(0.358)	(0.379)	(0.544)
$\Delta LLR_{i,j,t-4}$	−0.234	−0.243	−0.546	−0.336
	(0.462)	(0.473)	(0.472)	(0.704)
$\Delta EQUITY_{i,j,t-4}$	1.385***	0.913*	1.442**	1.838**
	(0.508)	(0.513)	(0.609)	(0.838)
$SIZE_{i,j,t-4}$	0.338	0.235	0.466	−0.270
	(0.412)	(0.487)	(0.545)	(1.796)
$DOMESTIC\_CREDIT_{j,t-4}$	0.005	0.017	−0.00004	0.021
	(0.005)	(0.011)	(0.008)	(0.013)
$\Delta GDP_{j,t-4}$	0.103	0.014	−0.030	0.129*
	(0.067)	(0.080)	(0.070)	(0.070)
q2	1.159	2.019***	0.806	−4.779***
	(1.024)	(0.774)	(0.718)	(1.248)
q3	0.105	2.100***	1.537	−5.366***
	(0.636)	(0.753)	(1.140)	(1.443)
q4	0.652	1.124	0.743	−4.827***
	(1.309)	(1.023)	(1.338)	(1.400)
Observations	2,395	1,644	1,788	1,108
R^2	0.112	0.126	0.132	0.148
Adjusted R^2	0.069	0.073	0.082	0.078
F Statistic	4.723***	5.071***	5.366***	5.214***
	(df = 61; 2282)	(df = 44; 1549)	(df = 48; 1689)	(df = 34; 1024)

This table reports regression results of the panel analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 6 in the main body of the paper.

Table E.17: Robustness test panel: banks' credit-default swap spreads to measure risk.

	Dependent variable: $\Delta RWAD_{i,j,t}$			
	(1)	**(2)**	**(3)**	**(4)**
	2007 Q1 – 2019 Q4	2009 Q3 – 2019 Q4	2007 Q1 – 2012 Q4	2013 Q1 – 2019 Q4
$LAX\_REGULATION_{j,t-1}$	−0.734**	−0.606*	2.401*	−0.628
	(0.325)	(0.344)	(1.257)	(0.592)
$STRICT\_SUPERVISION_{j,t-1}$	0.126	0.104	−0.527	1.059**
	(0.224)	(0.262)	(0.536)	(0.449)
$CDS\_BANK_{i,j,t-1}$	−0.751***	−0.947***	−0.740*	−0.415
	(0.257)	(0.254)	(0.429)	(0.444)
$IRB_{i,j,t-1}$	0.886	0.694	1.336	
	(0.847)	(0.656)	(1.087)	
$\Delta LOANS_{i,j,t-4}$	−0.018	−0.005	−0.032	0.012
	(0.024)	(0.028)	(0.029)	(0.028)
$\Delta RETURN\_ON\_RWA_{i,j,t-4}$	0.462	0.951**	0.168	0.675
	(0.339)	(0.412)	(0.458)	(0.571)
$\Delta LLR_{i,j,t-4}$	−0.679	−0.992**	0.980	−1.530***
	(0.459)	(0.394)	(0.601)	(0.265)
$\Delta EQUITY_{i,j,t-4}$	1.656***	1.464**	1.564***	2.456*
	(0.586)	(0.709)	(0.485)	(1.295)
$SIZE_{i,j,t-4}$	0.574	0.664	0.440	2.512*
	(0.596)	(0.699)	(2.135)	(1.484)
$DOMESTIC\_CREDIT_{j,t-4}$	0.010*	0.018**	0.013	0.027**
	(0.005)	(0.007)	(0.027)	(0.012)
$\Delta GDP_{j,t-4}$	0.128**	0.086	0.113	0.062
	(0.062)	(0.053)	(0.345)	(0.057)
q2	0.738	1.498	1.134	−1.178
	(1.388)	(0.938)	(2.590)	(1.718)
q3	−0.051	1.927	−0.305	−2.707*
	(0.943)	(1.226)	(1.454)	(1.560)
q4	2.628	2.848*	3.277**	0.164
	(1.615)	(1.633)	(1.487)	(2.066)
Observations	1,442	1,188	651	791
R^2	0.203	0.223	0.198	0.227
Adjusted R^2	0.148	0.165	0.111	0.158
F Statistic	5.617***	6.095***	4.392***	5.753***
	(df = 61; 1348)	(df = 52; 1104)	(df = 33; 586)	(df = 37; 725)

This table reports regression results of the panel analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 6 in the main body of the paper.

Table E.18: Robustness test panel: IRB approach coverage.

	Dependent variable: $\Delta RWAD_{i,j,t}$			
	(1)	**(2)**	**(3)**	**(4)**
	2007 Q1 – 2019 Q4	2009 Q3 – 2019 Q4	2007 Q1 – 2012 Q4	2013 Q1 – 2019 Q4
$LAX\_REGULATION_{j,t-1}$	−0.566**	−0.459*	1.968	−0.544
	(0.271)	(0.274)	(1.228)	(0.355)
$STRICT\_SUPERVISION_{j,t-1}$	0.161	0.286	−0.341	0.765**
	(0.194)	(0.231)	(0.446)	(0.302)
$CDS\_SOVEREIGN_{j,t-1}$	−0.724***	−1.088***	−0.778**	0.099
	(0.241)	(0.365)	(0.329)	(0.713)
$IRB\_COVERAGE_{i,j,t-1}$	−0.142	−0.079	0.821	−0.706
	(0.752)	(0.835)	(1.277)	(1.164)
$\Delta LOANS_{i,j,t-4}$	−0.029	−0.039	−0.041	−0.012
	(0.026)	(0.033)	(0.031)	(0.029)
$\Delta RETURN\_ON\_RWA_{i,j,t-4}$	0.408	0.667*	0.365	0.387
	(0.312)	(0.374)	(0.409)	(0.499)
$\Delta LLR_{i,j,t-4}$	−0.339	−0.572	0.372	−0.601
	(0.465)	(0.449)	(0.606)	(0.581)
$\Delta EQUITY_{i,j,t-4}$	1.598***	1.474**	1.613***	1.865**
	(0.530)	(0.607)	(0.462)	(0.872)
$SIZE_{i,j,t-4}$	0.340	0.139	0.875	1.832**
	(0.448)	(0.453)	(1.821)	(0.901)
$DOMESTIC\_CREDIT_{j,t-4}$	0.005	0.012*	0.016	0.010
	(0.005)	(0.007)	(0.021)	(0.009)
$\Delta GDP_{j,t-4}$	0.107	0.025	0.145	0.067
	(0.068)	(0.066)	(0.210)	(0.061)
q2	0.633	0.711	0.533	−1.302
	(1.111)	(0.718)	(2.196)	(1.276)
q3	−0.020	2.471**	−0.498	−1.927
	(0.666)	(1.021)	(1.093)	(1.290)
q4	0.746	0.685	2.264*	−1.080
	(1.378)	(1.393)	(1.184)	(1.665)
Observations	2,282	1,878	1,040	1,242
R^2	0.121	0.135	0.116	0.137
Adjusted R^2	0.076	0.087	0.041	0.075
F Statistic	4.912***	5.334***	3.821***	4.851***
	(df = 61; 2169)	(df = 52; 1778)	(df = 33; 957)	(df = 38; 1157)

This table reports regression results of the panel analysis with robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive variable descriptions are provided in Table 6 in the main body of the paper.