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The Informational Content of Bank Risk Weights and the Role of Internal Ratings

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Abstract
We examine when a regulatory measure of bank asset risk, the ratio of risk-weighted assets to total assets (RWATA), aligns with a market-based measure of risk, namely the volatility of bank assets estimated using option-pricing techniques. We argue that the informational content of RWATA is conditional on the framework used to generate risk weights. Using a unique hand-collected dataset on the adoption and scope of internal ratings-based (IRB) models, we show that RWATA is unrelated to market-based asset risk on average, but becomes significantly associated with asset volatility among banks that use internal models. The relationship strengthens with the intensity of IRB adoption, particularly when advanced internal models are applied to corporate exposures, and persists among relatively weakly capitalized banks and during periods of financial stress.

Keywords: Bank risk, Asset volatility, Capital regulation, Internal ratings.

JEL Classification: G20, G21, G28, G32.

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1. Introduction

Risk-weighted assets (RWAs) lie at the core of modern bank capital regulation, embodying the principle that capital requirements should reflect the underlying riskiness of bank balance sheets. Since Basel I, regulatory risk has been measured through risk weights, and risk-weighted asset density, defined as the ratio of risk-weighted assets to total assets (RWATA), has become a widely used indicator of a bank's average balance-sheet risk. RWATA plays a central role in capital adequacy assessments, supervisory monitoring, and stress-testing exercises.

At the same time, financial markets continuously evaluate bank risk using forward-looking indicators such as equity prices and credit spreads.

An important question in banking is whether these two perspectives provide consistent signals about bank risk. If RWATA captures economically meaningful differences in risk, banks with higher RWATA should also exhibit higher market-based measures of risk. The existing literature, however, provides apparently conflicting evidence. Vallascas and Hagendorff (2013) find that RWAs display only limited sensitivity to market-based measures of bank risk. Related evidence from supervisory stress tests suggests that regulatory measures and market-based indicators often provide different assessments of bank vulnerability (Acharya et al., 2014). At the same time, other studies argue that internal ratings and model-based regulatory measures contain valuable information about underlying portfolio risk (Barakova and Palvia, 2014) and may improve the informational environment surrounding banks (Bruno et al., 2023). A separate strand of literature emphasizes instead the scope for discretion and strategic capital optimization for banks using internal ratings (Mariathasan and Merrouche, 2014; Behn et al., 2022), as well as the reduced comparability of RWATA across institutions (Le Leslé and Avramova, 2012).

In this paper, we argue that although apparently conflicting, these findings are not contradictory. Rather, they may reflect important features of regulatory risk measurement. Consequently, the relevant question is not whether RWAs are inherently good or bad measures of risk, but under which conditions they convey meaningful information about the underlying economic risk of banks. More generally, we argue that the relationship between regulatory and market-based risk measures is conditional and depends on the institutional framework through which risk weights are generated.

We compare RWATA with a market-based measure of asset risk, namely the volatility of bank asset returns derived from option pricing theory. Our starting point is that these measures are constructed very differently and therefore need not move together mechanically.

RWATA reflects how regulatory rules translate bank exposures into risk-weighted assets, based either on external ratings under the standardized approach (SA) or on internally estimated parameters under the internal ratings-based (IRB) approach. In particular, under the SA models, regulatory risk weights are determined primarily by externally assigned credit ratings and predefined regulatory risk buckets. Consequently, the information embedded in RWATA largely reflects public assessments of borrowers' creditworthiness and regulatory calibration choices. Under the IRB approach, by contrast, risk weights are based on banks' internal estimates of key credit risk parameters which incorporate a much richer set of borrower-specific, loan facility-specific, and macroeconomic information.

Finally, the market-based measure relies primarily on equity market valuations and equity return volatility to infer the market value and volatility of bank assets. Unlike both regulatory approaches, it reflects investors' forward-looking assessment of bank asset risk rather than supervisory or accounting information.

Precisely because these measures are conceptually distinct and rely on different information sets, any alignment between them is informative about whether regulatory risk weights capture economically meaningful differences in bank risk. If RWATA and market-based asset risk move together, this suggests that regulatory risk weights capture economically meaningful differences in bank risk. If they do not, this raises questions about the informational content of regulatory capital metrics.

A key condition shaping this alignment is the regulatory approach used to generate risk weights, particularly the distinction between the SA and IRB approaches. Internal models, in particular, were introduced to increase the risk sensitivity of capital requirements by allowing risk weights to reflect borrower- and portfolio-specific information more accurately than SA models. Compared with standardized risk weights based on external ratings and regulatory risk buckets, internal ratings may also react more quickly to changes in borrowers' credit quality and broader economic conditions, thereby enabling regulatory risk measures to adjust more promptly to evolving risk profiles. At the same time, they increase discretion, potentially reduce comparability across institutions, and may facilitate capital optimization. Internal models therefore embody a fundamental trade-off between comparability and risk sensitivity. Whether the additional flexibility embedded in IRB approaches weakens or strengthens the alignment between regulatory and market-based measures of risk is ultimately an empirical question.

Using a panel of European banks and detailed hand-collected information on the adoption and intensity of IRB usage, we examine whether the alignment between regulatory and market-based risk measures depends on the extent to which internal models are employed and on the portfolios to which they are applied.

We first document an important feature of the data: RWATA and asset volatility display very different sources of variation. RWATA is driven mainly by persistent cross-sectional heterogeneity at the bank and country level, with limited time variation, whereas asset volatility reflects both cross-sectional differences and time-varying country conditions. This distinction suggests that the relationship between regulatory and market-based risk cannot be fully understood from a purely within-bank perspective and motivates an empirical design that exploits cross-sectional heterogeneity while controlling for observable and unobservable differences across banks.

Our evidence points to a clear pattern. On average, RWATA is not significantly related to market-based asset volatility. However, this average effect masks substantial heterogeneity across regulatory approaches (IRB vs. standardized). The association becomes positive and economically significant for banks using internal models and strengthens as the intensity of IRB usage increases. Moreover, the effect is not uniform across portfolios. The stronger alignment is concentrated in corporate portfolios treated under advanced IRB approaches, where internal models are likely to incorporate richer borrower-specific information than standardized risk weights.

We further examine whether this relationship survives in settings where incentives for capital optimization are likely to be strongest (see, e.g., Plosser and Santos, 2018). Specifically, we investigate whether the alignment between RWATA and market-based risk remains present among capital-constrained IRB banks. We also explore whether the relationship changes during periods of heightened market stress, such as the global financial crisis, when market-based measures of risk may be particularly informative. Together, these analyses allow us to assess whether the informational content associated with internal models persists when incentives for capital optimization are stronger and when market conditions are particularly stressed.

Finally, we explore the supervisory implications of these findings using information from the 2014 EU-wide stress tests. Differences in RWATA and IRB usage are associated with economically and statistically significant variation in stress-test outcomes. At the same time, the relationship between RWATA, market-based asset risk, and supervisory outcomes becomes stronger when IRB usage is taken into account.

Our paper contributes to the literature in three ways. First, it introduces a conditional framework for understanding the informational content of regulatory risk measures. Rather than viewing the relationship between RWATA and market-based risk as an unconditional feature of regulatory capital measures, we show that it depends on the regulatory regime through which risk weights are generated and on the extent to which internal models are used. This perspective helps explain why previous studies have reached different conclusions regarding the ability of RWAs to reflect underlying risk.

Second, our results provide a unified interpretation of the debate surrounding internal models. The literature has largely emphasized either the discretion and potential for manipulation associated with IRB approaches (Mariathasan and Merrouche, 2014; Behn et al., 2022) or their informational benefits (Barakova and Palvia, 2014; Bruno et al., 2023). Our evidence suggests that these two views are not mutually exclusive. Internal models may simultaneously reduce average risk weights and strengthen the alignment between regulatory and market-based measures of risk.

Third, by exploiting detailed information on the scope of IRB adoption, we show that the informativeness of RWATA depends not only on whether banks use internal models, but also on where those models are applied. The stronger alignment between RWATA and market-based risk is concentrated in corporate portfolios, suggesting that the informational benefits of internal models are greatest in those segments where borrower heterogeneity and risk differentiation are most pronounced. Importantly, these findings are not confined to favorable conditions. The stronger alignment between RWATA and market-based risk remains visible among relatively weakly capitalized banks and during the global financial crisis, suggesting that the informational content associated with internal models persists when concerns about capital optimization and market stress are most relevant.

Our findings also speak to recent regulatory developments. Basel III finalization places tighter limits on the use of internal models and increases the reliance on standardized approaches in several exposure classes. While these reforms are intended to improve comparability and reduce model discretion, our results suggest that they may also affect the informational content of regulatory risk measures. To the extent that RWATA is most closely aligned with market-based risk when internal models are extensively used for corporate exposures, greater standardization may disproportionately affect precisely those portfolios for which risk-sensitive measurement appears most informative. More broadly, our evidence highlights a trade-off between comparability and informational content in the design of prudential regulation.

Overall, our findings suggest that the informational content of regulatory risk measures depends on how regulatory risk weights are constructed. This conditional perspective helps reconcile previous evidence and contributes to the broader debate on the design of bank capital regulation and the role of internal models.

The remainder of the paper proceeds as follows. Section 2 presents the institutional framework and reviews the relevant literature, from which we derive the testable implications. Section 3 describes the data and empirical methodology. Section 4 reports the results and Section 5 concludes.

2. Institutional framework, related literature, and testable predictions

2.1. Alternative measures of bank asset risk

This paper compares regulatory and market-based measures intended to capture the riskiness of bank assets. The regulatory measure is the risk-weighted asset density, which is constructed using either the SA or IRB methodologies under the Basel framework. The market-based measure is asset volatility derived from option-pricing theory. Although these approaches are all intended to capture the riskiness of bank assets, they rely on fundamentally different information sets and methodologies, and therefore need not produce identical assessments.

Prudential regulation requires banks to hold capital commensurate with the riskiness of their assets. Under the Basel framework, this principle is implemented through RWAs, which scale balance-sheet exposures by regulatory risk weights to determine minimum capital requirements. For credit risk – the largest source of risk for most banks[1] – the Basel framework allows institutions to calculate RWAs using either the SA or the IRB approach.

Under the SA, regulatory risk weights are assigned according to predefined supervisory rules based primarily on exposure classes, external credit ratings, and fixed regulatory parameters. Consequently, RWATA under the SA reflects standardized supervisory assessments of credit risk that rely primarily on publicly available information. While this framework promotes comparability across institutions, it offers only limited scope for incorporating borrower-specific information or differences in portfolio characteristics beyond those recognized by regulation.

Alternatively, subject to supervisory approval, banks may adopt the IRB approach**,** under which regulatory risk weights are based on internally estimated credit risk parameters, including the Probability of Default (PD), Loss Given Default (LGD), and Exposure at Default (EAD). These parameters are estimated using banks' internal rating systems and typically combine borrower-specific financial information, repayment histories, collateral characteristics, contractual features of individual exposures, industry conditions, and, increasingly, forward-looking macroeconomic information. The IRB framework was introduced to increase the risk sensitivity of capital requirements by allowing regulatory risk weights to respond more closely to differences in borrower and portfolio risk. Compared with the SA, internal models may therefore react more rapidly to changes in borrowers' financial conditions and macroeconomic developments (Bruno et al., 2017). At the same time, they introduce greater discretion because estimated risk parameters depend on bank-specific data, modeling assumptions, calibration choices, and supervisory judgment.

In practice, IRB adoption is costly and gradual. Banks typically begin by applying internal models to selected portfolios with sufficient historical data and subsequently expand their use across business lines according to a supervisory-approved rollout plan. Basel rules also allow for permanent partial use of SA for certain non-material exposures. As a result, banks differ not only in whether they use IRB models, but also in the scope and intensity of their application across credit portfolios.

[1] In our sample, average credit RWAs account for 83% of total RWAs, a share fully consistent with the 82% reported in EBA supervisory statistics (EBA, 2024).

The market-based estimate of asset risk is derived from the structural model *à la* Merton. In this framework, bank equity is viewed as a call option on the value of the bank’s assets, allowing the market value and volatility of assets to be inferred from observable equity prices, equity return volatility, liabilities, and the risk-free interest rate. Unlike regulatory measures, this approach does not rely on accounting information or supervisory risk parameters. Instead, it extracts a forward-looking assessment of asset risk from financial market prices and therefore reflects investors' expectations regarding the future evolution of banks' asset values.

Because these approaches exploit different information sets – external ratings and regulatory parameters under the SA, proprietary bank information under the IRB approach, and market information under the Merton framework – they need not produce identical assessments of bank risk. Whether the richer information embedded in IRB models improves the alignment between regulatory and market-based measures of risk is the central question addressed in this paper.

2.2. Related literature on the informativeness of RWATA

The differences in the information sets underlying the SA, the IRB approach, and market-based measures discussed above have important implications for the extent to which RWATA reflects underlying economic risk.

Studies based on international samples indicate that RWATA is only weakly related to market-based measures of asset risk, such as asset or equity volatility (Vallascas and Hagendorff, 2013). Similarly, evidence from supervisory stress tests shows that rankings of bank vulnerability based on RWAs are weakly correlated with market-based benchmarks, whereas measures based on unweighted assets tend to identify fragile institutions more effectively (Acharya et al., 2014). Overall, these findings suggest that regulatory capital measures may only imperfectly reflect changes in the underlying economic risk of bank portfolios.

One explanation is that the informativeness of RWAs depends on the regulatory framework through which risk weights are generated rather than being an intrinsic property of the measure itself. Böhnke et al. (2023), for example, show that banks' RWA densities tend to converge over time following the adoption of internal models despite persistent differences in underlying risk profiles across countries and institutions. Although part of this convergence reflects changes in portfolio composition and macroeconomic conditions, their findings suggest that regulatory risk measures are also shaped by institutional factors, including supervisory practices and regulatory environments. More generally, their evidence indicates that the informativeness of RWAs is unlikely to be uniform, even within the IRB framework, but may depend on how and where internal models are implemented.

Beyond institutional differences, another explanation for the heterogeneous informational content of RWAs concerns the use of internal models themselves. On the one hand, the flexibility embedded in the IRB framework may weaken the comparability of regulatory risk measures across institutions by allowing banks discretion in the estimation of key credit-risk parameters (Mariathasan and Merrouche, 2014). These concerns have motivated several regulatory reforms, including the introduction of leverage ratios and output floors under the Basel III framework (BCBS, 2017). On the other hand, evidence based on supervisory and accounting data suggests that internally generated risk measures can be informative along certain dimensions. Barakova and Palvia (2014) show that IRB risk parameters are more closely aligned with accounting-based measures of credit risk than standardized Basel I risk weights. Using European stress test data, Korsgaard (2019) finds that average risk weights explain a substantial fraction of projected credit losses and are positively associated with market-implied asset volatility. Taken together, these studies suggest that internal models may simultaneously reduce comparability while improving the risk sensitivity of regulatory capital measures.

The informational consequences of these differences extend beyond regulatory measurement. Delis et al. (2021) show that discrepancies between market-based measures of asset risk and regulatory measures based on RWAs have economically significant effects on banks' lending decisions. Complementary evidence also suggests that internal ratings improve the information environment surrounding banks. Market-based indicators, such as equity prices and asset volatility, provide forward-looking assessments of banks' exposure to aggregate shocks and have been shown to predict crisis-period losses and stress-test outcomes (Acharya et al., 2012, 2017). Bruno et al. (2023) further show that banks relying more extensively on internal credit ratings exhibit lower opacity, as reflected in smaller analyst forecast errors and lower forecast dispersion. Their findings suggest that the richer information embedded in IRB models may enhance not only the risk sensitivity of regulatory capital measures but also their informational content.

To sum up, the existing literature suggests that regulatory risk measures differ in their ability to capture underlying economic risk and that internal models play a central role in shaping this relationship. However, it remains unclear whether the richer information embedded in IRB models translates into regulatory risk measures that are more closely aligned with the forward-looking assessments of risk provided by financial markets. Our paper addresses this question by examining whether the relationship between RWATA and market-based asset risk depends on the regulatory framework used to construct risk weights and on the intensity with which internal models are applied across credit portfolios.

2.3. Testable predictions

Taken together, this literature points to a central tension. While RWAs are designed to provide a risk-sensitive measure of bank exposures for regulatory purposes, their ability to reflect economically relevant risk – as perceived by markets – depends critically on how they are constructed and applied, and may vary both across banks and over time. In particular, variation in the use and scope of IRB models may play a key role in shaping the informativeness of RWAs. Also, the informational contribution of IRB models is likely to differ across portfolio types. For sovereign exposures, regulatory risk weights exhibit limited dispersion and are only weakly responsive to underlying risk, leaving little scope for internal models to enhance risk measurement. Retail portfolios, such as mortgages, are characterized by relatively homogeneous exposures and highly standardized modeling frameworks, which limit cross-bank variation in estimated risk parameters. By contrast, corporate portfolios are more heterogeneous and information-intensive, with borrower risk depending on firm-specific characteristics and forward-looking assessments that are difficult to capture through fixed regulatory risk weights. In this context, internal ratings are more likely to incorporate information that improves the alignment between regulatory and market-based measures of risk.

Building on these considerations, we formulate the following testable predictions.

Prediction 1a (Common-risk view). RWATA is positively associated with market-based measures of bank asset risk. Although regulatory and market-based measures are constructed differently, both aim to capture the underlying riskiness of bank assets. To the extent that RWATA reflects economically meaningful variation in bank risk, banks with higher asset risk should exhibit both higher RWATA and higher market-based asset volatility.

Prediction 1b (Distinct-measure view). RWATA is not systematically associated with market-based measures of bank asset risk. Because RWATA is a regulatory construct shaped by supervisory rules, risk-weight formulas, and model choices, while market-based asset risk reflects investors' forward-looking assessment of economic risk, the two measures may capture different dimensions of risk and therefore need not be systematically related.

Prediction 2a (Risk-sensitivity view). Greater adoption of IRB models strengthens the association between RWATA and market-based measures of asset risk because internal models increase the risk sensitivity of regulatory capital requirements.

Prediction 2b (Discretion view). Greater adoption of IRB models weakens or fails to strengthen the association between RWATA and market-based measures of asset risk because the additional discretion embedded in internal models may reduce the alignment between regulatory and market-based assessments of risk.

Prediction 3 (Portfolio composition, conditional on *2a*). If the risk-sensitivity channel in Prediction *2a* holds, its strengthening effect on the RWATA–asset volatility relationship should be more pronounced for banks with greater IRB exposure to corporate portfolios, where internal models rely more heavily on borrower-specific and forward-looking information than in other asset classes.

3. Data and methodology

3.1. Sample and data sources

We construct a cross-country panel of large, publicly listed European banking groups. The initial sample consists of the 50 largest listed banking groups ranked by total assets. After excluding banks with incomplete information, the final sample includes 298 bank-year observations from 43 banks headquartered in 17 European countries (Appendix A reports the list of sample banks). Italy accounts for the largest share of observations (16.4%), followed by the UK and Spain, which account for 11.7% and 10.7% of the sample, respectively. Together, the banks in our sample hold more than 60% of total European banking assets. We focus on the 2008–2014 period, which precedes the Basel Committee reforms introduced between 2017 and 2019 to curb the misuse of internal models.

We combine data from several sources. Annual consolidated balance-sheet data are obtained from Moody's Analytics BankFocus, while stock return data come from Bloomberg. We hand-collect detailed information on banks' use of IRB models from Pillar III disclosures. From these disclosures, we collect the share of credit exposures – measured using banks' own estimates of exposure at default – covered by the IRB approach, the split of loan portfolios between retail and corporate segments, and the types of credit portfolios (government, retail, and corporate) for which banks apply internal rating systems. Although Pillar III disclosures are mandatory, banks reported this information using non-standardized formats until the introduction of a common reporting template in 2019, which required us to manually extract and harmonize the data.

3.2. Methodology

Our empirical strategy aims to assess whether regulatory RWATA reflects banks' underlying asset risk as perceived by financial markets, and whether this relationship depends on the use of IRB models for the calculation of capital requirements.

As a market-based measure of bank risk, we use *asset_volatility*, defined as the implied volatility of bank assets derived from the Black–Scholes–Merton option-pricing framework. Following Ronn and Verma (1986), Flannery and Sorescu (1996), Flannery and Rangan (2008), Vallascas and

Hagendorff (2013), and Delis et al. (2021), we model bank equity as a call option on the underlying value of bank assets and jointly estimate both the market value and the volatility of bank assets using information on equity market values, equity return volatility, total liabilities, and the risk-free rate. The resulting measure captures the market assessment of the overall riskiness of a bank's asset portfolio and provides a forward-looking assessment of bank risk that incorporates market expectations about future asset values. An important advantage of asset volatility is that it reflects changes in both on- and off-balance-sheet risk exposures and, unlike measures of default risk, is not mechanically linked to a bank's capitalization level. Higher values of $asset\_volatility$ therefore indicate greater market-perceived portfolio risk.

The empirical design is intended to examine whether banks with systematically higher regulatory risk also exhibit systematically higher market-based risk. As shown in Section 4.1.1, RWATA is highly persistent within banks and largely reflects stable differences in business models, portfolio composition, and regulatory measurement practices. By contrast, market-implied asset volatility exhibits substantially greater time-series variation. Bank fixed effects explain approximately 93.5% of the variation in RWATA, compared with only 55.6% of the variation in asset volatility, indicating that RWATA is primarily a cross-sectional measure, whereas market-based risk varies more over time. Consistent with this evidence, our baseline specification exploits the cross-sectional variation in RWATA by conditioning on a parsimonious set of observable bank characteristics selected through a Shapley decomposition of the explained variation in RWATA (see Section 4.1.2). Specifically, we control for bank size, loan intensity, and liquid asset holdings, and include year fixed effects to absorb common macroeconomic, financial, and regulatory shocks. This approach preserves the cross-sectional variation that is central to our research question while controlling for the principal observable sources of heterogeneity across banks.

We therefore estimate the following baseline empirical model:

$$RWATA_{i,t} = \alpha + \beta\, asset\_volatility_{i,t} + \xi' X_{i,t} + \mu_t + \varepsilon_{i,t} \tag{1}$$

In this equation, $RWATA_{i,t}$ denotes the risk-weighted asset density of bank i in year t, defined as the ratio of total risk-weighted assets to total assets.

The variable $asset\_volatility_{i,t}$ captures banks' asset risk as assessed by financial markets and is measured by the implied volatility of bank assets derived from option pricing theory. The coefficient β therefore summarizes the average association between regulatory risk weights and market-based assessments of bank asset risk.

The vector $X_{i,t}$ includes the ratio of loans to its total assets (*loans*); the ratio of liquid assets to total assets (*liquid_assets*); and the logarithm of total assets (*size*), which are the bank-level characteristics identified by the Shapley decomposition as the most important structural determinants of RWATA. All specifications include year fixed effects, μ_t, which absorb common macroeconomic conditions, regulatory changes, and financial market developments affecting all banks in a given year. Standard errors are clustered at the bank level to account for serial correlation and heteroskedasticity within banks over time. This specification controls for the main observable determinants of RWATA while preserving the persistent cross-sectional variation in regulatory risk documented in Section 4.1.1. Including bank fixed effects would absorb most of this variation and therefore remove the primary source of identification for the relationship between RWATA and market-based asset risk.

An important source of cross-bank heterogeneity stems from the methodology used to compute risk-weighted assets. As discussed in Section 2, IRB models are designed to produce more granular and risk-sensitive assessments of credit risk than the SA, but they also introduce greater discretion because risk weights depend on banks' internal estimates of credit risk parameters. Consequently, the relationship between RWATA and market-based measures of asset risk may differ systematically depending on the regulatory approach used to construct risk weights.

To account for this heterogeneity, we extend the baseline specification by explicitly modeling the interaction between regulatory risk-weighted assets and IRB adoption. Specifically, we augment equation (1) by including a measure of IRB usage and its interaction with asset volatility:

$$\begin{aligned} RWATA_{i,t} = \alpha &+ \beta_1\, asset\_volatility_{i,t} + \beta_2\, IRB\_adoption_{i,t} \\ &+ \beta_3\, asset\_volatility_{i,t} \times IRB\_adoption_{i,t} + \xi' X_{i,t} + \mu_t + \varepsilon_{i,t} \end{aligned} \tag{2}$$

In this specification, the coefficient β_1 captures the association between RWATA and asset volatility for banks that do not use IRB models, while β_3 measures the differential sensitivity of RWATA to market-based asset risk among banks that adopt IRB models. This formulation allows us to test whether internal ratings-based approaches enhance the alignment between regulatory risk weights and market-based assessments of bank asset risk.

To examine the implications of internal model adoption for the relationship between RWATA and asset volatility, we employ alternative specifications of the variable $IRB\_adoption$, corresponding to two distinct dimensions of analysis. In the first analysis, which focuses on the extensive margin, we use a binary indicator equal to one if a bank applies IRB models to at least part of its credit exposures (*d_IRB*). This variable captures whether the bank has adopted internal models, irrespective of the intensity of their use.

The subsequent analyses instead focus on the intensive margin of IRB adoption and are conducted on the subsample of observations corresponding to banks that have adopted internal models, namely observations for which $d\_IRB = 1$. In this case, $IRB\_adoption$ is alternatively measured using a set of continuous variables defined as: (i) IRB_weight, namely the share of total credit exposures, measured in terms of exposure at default, treated under the IRB approach; (ii) $AIRB\_weight$, namely the share of total credit exposures treated under the advanced IRB approach; and (iii) $AIRB\_corp\_weight$ ($AIRB\_ret\_weight$), namely the share of corporate (retail) credit exposures assessed under the advanced IRB approach over total corporate (retail) credit exposures.

These variables capture the intensity of IRB and advanced IRB adoption, both overall and within the two main categories of bank credit exposures. They allow us to examine whether the sensitivity of RWATA to asset volatility varies with the extent to which internal models – and especially their advanced versions – are employed.

3.3. Descriptive statistics

Table 1 presents descriptive statistics for the main variables used in the analysis. RWATA has an average value of 44%, with substantial dispersion across observations, ranging from a minimum of 15% to a maximum of over 80%. The market-based measure of asset volatility also exhibits considerable variation, with a mean of 1.26 and a standard deviation of 1.07.

In terms of balance-sheet characteristics, bank size – measured as the logarithm of total assets – has a mean of 12.5 and exhibits moderate variation across the sample. Loans account, on average, for 54% of total assets, confirming the central role of lending activity, although the wide p10–p90 range (from 28% to 74%) highlights substantial heterogeneity in banks' business models. Liquid assets represent approximately 12.5% of total assets on average, again with considerable variation across observations.

On average, approximately one third (34.3%) of banks' credit exposures are directed toward corporate clients, slightly less than one third (31.5%) toward retail clients, while the remaining share (34.2%) consists of other types of exposures.

Regarding the adoption of internal models for the computation of capital requirements, the dummy variable d_IRB indicates that the vast majority of banks (approximately 81% of observations) use the IRB approach. IRB banks apply internal models, on average, to 67% of their total credit exposures (IRB_weight). This percentage declines to 57.8% when considering only exposures treated under the advanced IRB approach ($AIRB\_weight$). The latter figure is very close to the average share of corporate exposures assessed through advanced internal models ($AIRB\_corp\_weight$). Indeed, banks adopting internal models typically apply them first and most extensively to corporate exposures. The fact that the average share of retail exposures assessed through advanced internal models (*AIRB_ret_weight*) exceeds the average value of *AIRB_weight* is due to the fact that for retail exposures managed in pools, Basel II does not distinguish between foundation and advanced IRB approaches; instead, banks using IRB must estimate PD, LGD, and EAD for these exposures (BCBS, 2006). Consequently, all IRB retail exposures are classified as advanced.

Insert Table 1 approximately here

4. Results

4.1. Risk-weighted asset density and asset volatility

4.1.1. Cross-sectional vs. time-series drivers of RWATA and asset volatility

We begin by examining the relative importance of time, country, and bank-specific factors in explaining variation in RWATA and asset volatility. To this end, Table 2 reports the R^2 from a set of regressions in which each variable (*RWATA*, in Columns 1-5, and *asset_volatility*, in Columns 6-10) is regressed on alternative combinations of fixed effects, including year effects, country effects, and bank fixed effects.

The first specifications (Columns 1 and 6) include only year fixed effects, without additional controls, in order to capture common macroeconomic, regulatory, and financial conditions affecting all banks simultaneously. The purpose of this specification is to assess whether fluctuations in RWATA and asset volatility are primarily driven by aggregate time-varying shocks. The second specifications (Columns 2 and 7) include only country fixed effects, again without additional controls. These fixed effects absorb time-invariant structural heterogeneity across countries, reflecting stable cross-country differences in regulatory frameworks, supervisory practices, and financial systems. We then estimate two additional specifications in which we include both year and country fixed effects (Columns 3 and 8) or their interactions (Columns 4 and 9). The final specifications (Columns 5 and 10) include only bank fixed effects in order to absorb time-invariant structural heterogeneity across banks. These fixed effects capture persistent differences in banks' business models, asset composition, portfolio risk profiles, and internal risk-management practices. The table serves to motivate and support the baseline specification adopted in the subsequent analysis.

The results reveal striking differences between the two measures. RWATA is driven primarily by cross-sectional heterogeneity. Country effects alone explain a substantial share of its variation (R^2 = 0.77), while adding year effects yields only a marginal increase (R^2 = 0.79). Allowing for country-year interactions raises R^2 to 0.82. By contrast, bank fixed effects account for most of the variation (R^2 = 0.935), whereas year effects alone have negligible explanatory power (R^2 = 0.02).

Asset volatility displays a more pronounced time-series component. Country effects explain a sizable fraction of the variation (R^2 = 0.51), but year effects are also relevant (R^2 = 0.10), especially when compared with their role in explaining RWATA. Their combination increases the R^2 to 0.61. Notably, country-year interactions explain a very large share of the variation (R^2 = 0.90), indicating an important role for time-varying country-level factors. Bank fixed effects account for a more limited portion of the variation (R^2 = 0.56).

Insert Table 2 approximately here

Overall, the two measures exhibit markedly different patterns of variation. RWATA is largely shaped by persistent cross-sectional heterogeneity, whereas asset volatility is more responsive to time-varying factors. This evidence points to fundamental differences between regulatory and market-based measures of risk.

Building on this distinction, Figure 1 further illustrates the dispersion of the coefficient of variation of RWATA and asset volatility across banks. Across the full sample, RWATA appears markedly less variable than asset volatility, confirming its more stable nature. Since the purpose of this analysis is to examine whether the differences between the two risk measures depend on the use of internal rating models in the computation of RWATA, Figure 1 reports the distribution of the coefficient of variation of RWATA and asset volatility separately for IRB and non-IRB banks.

The same general pattern emerges across both groups, with RWATA consistently exhibiting lower variability than asset volatility. However, differences across bank types are also evident. IRB banks display somewhat higher variability in RWATA and lower variability in asset volatility relative to non-IRB banks. Consequently, although asset volatility remains more dynamic than RWATA in both subsamples, the disparity in variability between the two measures is less pronounced among IRB banks.

Insert Figure 1 approximately here

4.1.2. RWATA determinants

Motivated by the dominant role of cross-sectional heterogeneity in RWATA, we next examine which observable bank characteristics account for these persistent differences. To this end, we implement a Shapley decomposition of the R^2 from a baseline regression of RWATA on a broad set of bank characteristics.[2] The Shapley approach attributes the overall explanatory power of the model to individual regressors by averaging their marginal contributions across all possible model orderings. The results (not reported in detail but available upon request) show that three variables, bank size, loan intensity, and liquid asset holdings, account for the majority of the explained variation, jointly contributing more than 70% of the model's R^2. Based on this evidence, we retain these variables as the core set of observable characteristics and use them in the subsequent analysis as observable proxies for the bank-specific heterogeneity captured by fixed effects.

Table 3 reports regressions of RWATA on the three key balance-sheet variables selected on the basis of the Shapley decomposition: *size* (the logarithm of total assets), *loans* (the ratio of loans to total assets), and *liquid_assets* (the ratio of liquid assets to total assets). We estimate three specifications, none of which includes bank fixed effects: Column 1 excludes all fixed effects, Column 2 adds year fixed effects, and Column 3 adds both year and country fixed effects. The R^2 value ranges from 0.60 to 0.88, suggesting that these balance-sheet characteristics, together with time and country fixed effects, explain a substantial share of the variation in RWATA without fully absorbing cross-sectional information. Across all specifications, bank size and reliance on lending activity are statistically significant predictors of RWATA at least at the 5% level, with smaller banks and those more heavily engaged in lending exhibiting higher risk-weighted asset density. Notably, both the magnitude and the statistical significance of the coefficients on size and loans remain stable across specifications, while the R^2 increases with the inclusion of year and, especially, country fixed effects. This pattern suggests that the relationship between RWATA and these balance-sheet characteristics is robust and not driven by omitted time- or country-specific factors, although such factors – particularly country-specific ones – contribute to explaining additional variation in RWATA.

In samples such as ours, where several countries are represented by only a small number of banks, the inclusion of country fixed effects may be problematic, as country effects may effectively capture bank-specific characteristics.[3] In such cases, country fixed effects overlap conceptually with bank fixed effects. For this reason, we select Column 2 – which includes year fixed effects and balance-sheet controls, but excludes country and bank fixed effects – as the baseline specification adopted in

[2] Following Bruno et al. (2023), we capture the bank asset composition by including loans to total assets (*loans*); corporate credit exposures to the sum of corporate and retail credit exposures (*corporate_exposure*); liquid assets to total assets (*liquid_assets*); securities to total assets (*securities*); and derivatives to total assets (*derivatives*). We also include the logarithm of the total assets (*size*) and the share of non-performing loans over total gross loans (*NPLs*).

[3] For some countries (e.g. Poland, Ireland, and the Netherlands), the sample includes only one bank, making the inclusion and interpretation of country fixed effects potentially misleading.

the remainder of the paper. This approach provides a balance between explanatory power (R^2 = 0.61) and identification, preserving cross-sectional variation while controlling for common time effects.

Insert Table 3 approximately here

4.2. RWATA and asset volatility: IRB banks vs non-IRB banks

Table 4 reports the results of estimating equations (1) and (2) using ordinary least squares regressions and examines the relationship between risk-weighted asset density, asset volatility, and the use of IRB models.

We begin by estimating baseline equation (1) and exploring, within a multivariate setting, the relationship between RWATA and asset volatility for the average bank, irrespective of its IRB adoption policy. The coefficient on *asset_volatility* is not statistically significant, indicating that higher market-based asset risk is not systematically associated with higher RWATA when differences in regulatory approaches are not taken into account (consistent with Prediction *1b* rather than *1a*). Among the control variables, *size* and the share of loans to total assets are statistically significant at the 10% level, suggesting that smaller banks and banks more heavily engaged in lending activities tend to exhibit higher regulatory risk weights.

In Column 2, we introduce a dummy variable identifying banks that use IRB models (*d_IRB*) together with its interaction with asset volatility. The coefficient on *d_IRB* is negative and statistically significant at 1%, indicating that IRB banks exhibit substantially lower RWATA relative to non-IRB banks, on average. This result is consistent with the characteristics of IRB models, which are more risk-sensitive and flexible than SA models and allow banks to exploit greater granularity in their credit portfolios, thereby achieving lower average risk weights as IRB usage increases. At the same time, the interaction term between asset volatility and *d_IRB* is positive and statistically significant, indicating that the sensitivity of RWATA to asset volatility is higher for IRB banks (consistent with Prediction *2a* rather than *2b*). The *F*-test confirms that the combined effect of asset volatility for IRB banks is positive and statistically different from zero.

To assess the economic significance of the *d_IRB*, we evaluate the predicted RWATA at the sample mean of asset volatility for each group. Non-IRB banks display a predicted RWATA of approximately 58%, while IRB banks display a predicted RWATA of approximately 42%, yielding a difference of 16 percentage points. This gap, equivalent to approximately 0.92 standard deviations of RWATA, suggests that IRB adoption is associated with an economically substantial reduction in reported risk-weighted assets.

The remaining specifications in Table 4 are estimated on the subsample of IRB banks. In Column 3, we estimate the same specification as in Column 1 using only IRB observations. The coefficient on $asset\_volatility$ is equal to 4.39 and statistically significant at the 5% level. This estimate is very close to the implied marginal effect for IRB banks obtained from the interacted specification in Column 2, namely the sum of the coefficients on $asset\_volatility$ and $asset\_volatility{\times}d\_IRB$ (4.21). Overall, these results provide consistent evidence of a positive association between RWATA and asset volatility among IRB banks.

In Columns 4 and 5, we examine the effect of internal model adoption along the intensive margin by enriching the previous specification with variables capturing the intensity of internal model usage overall (IRB_weight, in Column 4) and in its advanced version ($AIRB\_weight$, in Column 5), together with their interactions with $asset\_volatility$. The coefficients on IRB_weight and $AIRB\_weight$ are negative and statistically significant, indicating that greater reliance on (advanced) IRB models is associated with lower average RWATA. By contrast, the interactions between asset volatility and IRB_weight ($AIRB\_weight$) are not statistically significant.

Insert Table 4 approximately here

As emphasized by Brambor et al. (2006), however, interaction effects cannot be fully assessed by inspecting the interaction coefficient alone, since the marginal effect of asset risk depends on the level of (A)IRB usage.[4] Figure 2 therefore provides a graphical assessment of the marginal effect of market-based asset risk on RWATA across different values of IRB_weight ($AIRB\_weight$). The solid lines report the estimated marginal effects. Specifically, the first partial derivative, $\frac{\partial RWATA}{\partial asset\_volatility}$, is equal to $\beta_1 + \beta_2 \cdot IRB\_weight$ and $\beta_1 + \beta_2 \cdot AIRB\_weight$ in Panel A and Panel B, respectively. The green dashed, blue dotted, and red dash-dot lines denote the 90%, 95%, and 99% confidence intervals, respectively.

The figure shows that the association between $RWATA$ and market-based asset risk becomes positive and statistically significant only at sufficiently high levels of (A)IRB usage. In particular, the marginal effect of $asset\_volatility$ on $RWATA$ is statistically significant at the 10% level for values of IRB_weight above approximately 43%. Moreover, the positive slope of the marginal-effect curve indicates that, beyond this threshold (which includes slightly less than 90% of the observations), increases in IRB intensity are associated with a stronger sensitivity of RWATA to underlying asset risk. This pattern is consistent with the institutional design of IRB models, under which regulatory

[4] Similarly, the absence of statistical significance for a range of values of the interacted variable is also possible despite the significance of the reported coefficient.

risk weights are explicitly intended to respond more closely to changes in economic risk as a larger share of exposures is treated under internal models.

The effect of internal model adoption appears even stronger and more statistically significant when the reference is to advanced internal models. The marginal effect of *asset_volatility* on RWATA is statistically significant at the 10% level for values of *AIRB_weight* above approximately 26% (a condition satisfied by approximately 90% of the observations) and at the 5% level for values of *AIRB_weight* above approximately 31%. These results suggest that the adoption of internal models influences the link between RWATA and asset volatility along both the extensive and intensive margins and that, in the latter case, the intensity of advanced IRB usage appears to be particularly important.

Insert Figure 2 approximately here

While the intensity of (A)IRB usage captures how extensively internal models are applied across a bank's credit exposures, it does not fully reflect the scope of portfolios to which these models are applied. In practice, (A)IRB adoption under the Basel framework occurs gradually and at the portfolio level. Banks typically begin by applying internal models to specific credit portfolios for which sufficient historical data are available and subsequently extend (A)IRB coverage to additional portfolios according to supervisory-approved rollout plans. As a result, banks may differ not only in the share of exposures treated under (A)IRB, but also in the share of different credit portfolios covered by internal ratings.

A key advantage of our empirical setting is that the sample period covers the early years following the implementation of Basel II, when large European banks gradually adopted the IRB approach for the calculation of risk weights and capital requirements (see Bruno et al. (2023) for a discussion of the phased implementation of IRB models). During this transition, banks display substantial heterogeneity not only in the share of overall exposures covered by IRB models, but also in the share of the main credit portfolios subject to advanced internal ratings, as documented in Table 1.

We exploit this additional variation to assess whether the implementation of advanced internal models affects the relationship between RWATA and market-based asset risk differently depending on the intensity of AIRB adoption within the two main credit portfolios: corporate and retail. To this end, we estimate a modified version of equation (2), replacing the continuous AIRB intensity measure with two variables: *AIRB_corp_weight* and *AIRB_ret_weight*, which represent the corporate and retail AIRB coverage ratios and measure the share of corporate (retail) credit exposures assessed under the advanced IRB approach over total corporate (retail) credit exposures. Each variable is interacted with *asset_volatility* to allow the sensitivity of RWATA to asset risk to vary with the relevance of advanced internal models for the assessment of risk in corporate and retail credit portfolios.

The results, reported in Column 6, indicate that, among IRB banks, the sensitivity of RWATA to asset volatility depends significantly on the composition of AIRB exposures. Evaluated at the sample means of corporate and retail AIRB coverage, a one-unit increase in asset volatility raises RWATA by approximately 4.27 percentage points.

However, this sensitivity is heterogeneous across banks. The interaction between asset volatility and the corporate AIRB coverage ratio is positive (12.427) and highly significant, indicating that banks with a larger share of corporate exposures modeled under AIRB exhibit a stronger pass-through of asset volatility into risk-weighted assets (consistent with Prediction *3*). This likely reflects the greater ability of corporate IRB models to incorporate borrower-specific and forward-looking information that is also reflected in market-based asset volatility. This finding complements one of the contributions of Bruno et al. (2023), who show that improvements in bank transparency are more pronounced when the advanced IRB approach is more extensively applied.

By contrast, the interaction with the retail AIRB coverage ratio is negative (–14.3) and statistically significant at the 5% level, suggesting that retail AIRB coverage dampens the relationship between asset volatility and RWATA, consistent with the granularity and diversification adjustments embedded in Basel retail (A)IRB formulas. Notably, the level coefficient of *AIRB_ret_weight* (2.139) is not statistically significant, indicating that retail coverage has no discernible direct effect on RWATA independently of asset volatility, and that its role operates exclusively through moderating the asset volatility channel. This interpretation is consistent with the institutional features of retail IRB models. Although retail exposures are treated under advanced IRB approaches, their portfolio-based modeling framework relies on segmented and largely backward-looking risk estimates. This contrasts with corporate IRB models, which incorporate borrower-specific and more forward-looking information.

To visualize these dynamics in a representative setting, Figure 3 plots the marginal effects while setting the alternative exposure variable at its actual sample mean.

Panel *A* displays the marginal effect of asset volatility across the range of corporate AIRB coverage, holding retail advanced coverage fixed at its sample mean of 76.1%. Under this conditioning scenario, the marginal effect is initially statistically indistinguishable from zero at low levels of *AIRB_corp_weight* but becomes positive and statistically significant at the 5% level once *AIRB_corp_weight* exceeds approximately 47%. Since a substantial majority of observations lie above this value, the figure indicates that, for most banks in the sample, greater reliance on corporate AIRB models is associated with a stronger positive relationship between RWATA and asset volatility.

Panel *B* traces the marginal effect across different levels of retail advanced coverage, holding corporate advanced coverage fixed at its sample mean of 57.5%. In this case, the marginal effect of asset volatility on RWATA remains positive throughout the entire range of the retail coverage ratio, implying that the positive contribution associated with the average level of corporate AIRB coverage more than offsets the dampening effect generated by retail AIRB adoption. Nevertheless, the marginal effect declines monotonically as *AIRB_ret_weight* increases. It first loses statistical significance at the 1% level once *AIRB_ret_weight* exceeds approximately 73%, a threshold above which roughly two-thirds of the sample observations fall. Beyond this point, the effect remains significant at 5% or 10% level up to approximately 85%, before becoming statistically indistinguishable from zero at the highest values of retail coverage. This pattern is consistent with a gradual, rather than abrupt, attenuation of the pass-through.

Insert Figure 3 approximately here

4.3. Additional tests

4.3.1. RWATA-asset volatility relationship in low capitalized banks and during the crisis

One concern with the positive relationship between RWATA and asset volatility documented for IRB banks in Table 4 is that it may not persist when incentives to reduce regulatory capital requirements are particularly strong. Previous studies argue that internal ratings may be used opportunistically by banks facing capital constraints, especially when raising external capital is costly and regulatory requirements become more binding (Plosser and Santos, 2018; Behn et al., 2022). In particular, Bruno et al. (2023) suggest that the informational benefits associated with internal models may be weaker among poorly capitalized banks, which have stronger incentives to understate portfolio risk. If such incentives affect the construction of risk weights, the RWATA–asset volatility relationship should be weaker for these institutions.

To investigate this possibility, Columns 1 and 2 of Table 5 augment the baseline specification for IRB banks reported in Column 3 of Table 4 by introducing indicators for low capitalization and their interactions with asset volatility. Specifically, we define two time-invariant dummy variables based on banks' Tier 1 capital ratios in 2008: *d_tier1_p10*, which identifies banks with Tier 1 ratios below the first decile of the distribution (7.0%), and *d_tier1_p25*, which identifies banks with Tier 1 ratios below the first quartile (8.0%).

The results do not support this hypothesis. In both specifications, the coefficient on *asset_volatility* remains positive and statistically significant, while the interaction terms with the low-capitalization indicators are not statistically significant. Moreover, the corresponding *F*-tests indicate that the overall relationship between RWATA and asset volatility remains positive and statistically significant even among the least-capitalized banks in the sample. Thus, although poorly capitalized banks may have stronger incentives to economize on regulatory capital, we find no evidence that low capitalization weakens the alignment between regulatory and market-based measures of risk.

Column 3 examines whether the RWATA–asset volatility association changed during the global financial crisis. The crisis years of 2008 and 2009 were characterized by exceptionally high levels of uncertainty and increases in market-implied asset volatility. At the same time, concerns emerged regarding the credibility of risk-weighted capital measures, particularly among banks using internal models (Le Leslé and Avramova, 2012; Turk-Ariss, 2017; Bruno et al., 2023). To assess whether the risk sensitivity of RWATA in IRB banks deteriorated during this period, we augment the baseline specification with a crisis dummy, *d_crisis*, equal to one in 2008 and 2009, and its interaction with asset volatility. The interaction between asset volatility and the crisis indicator is not statistically significant, indicating that the RWATA–asset volatility relationship was not materially different during the crisis years. The corresponding *F*-test further confirms that the overall effect of asset volatility remains positive and statistically significant during this period.

Taken together, the results in Table 5 suggest that the positive association between RWATA and asset volatility documented for IRB banks is stable, persisting both among relatively weakly capitalized banks and during a period of severe financial stress.

Insert Table 5 approximately here

4.3.2. RWATA, asset volatility, and capital shortfall

The 2014 EU-wide stress test, conducted by the European Banking Authority (EBA) to assess the resilience of major European banks to adverse macroeconomic scenarios, provides an additional opportunity to compare regulatory and market-based measures of bank asset risk.

Bank resilience was measured in terms of its capital shortfall, that is the amount of additional Common Equity Tier 1 (CET1) capital required for the bank to meet the minimum CET1 ratio thresholds under two macroeconomic scenarios, a baseline scenario, reflecting the European Commission’s forecast, and an adverse scenario, representing a severe deterioration in macroeconomic and financial conditions. For each bank, the EBA started with its 2013 CET1 ratio[5] and generated two projected CET1 ratios at the end of the stress test horizon (2014–2016): one under the baseline scenario and one under the adverse scenario. For each scenario, the capital shortfall was computed by comparing the projected CET1 ratio with the corresponding minimum hurdle rate set by the EBA, 8% for the baseline scenario and 5.5% for the adverse scenario. If a bank's projected CET1 ratio fell below the relevant threshold, the shortfall was calculated as the amount of additional CET1 capital required to raise the ratio to the hurdle rate, given the projected level of risk-weighted assets.

Thirty-eight of the 43 banks in our sample participated in the 2014 EU-wide stress test.[6] For these banks, we collect the starting-point Common Equity Tier 1 ratio in 2013 (*CET1_Ratio_2013*) as well as its projected values for 2016 under the baseline (*CET1_Ratio_Baseline*) and adverse (*CET1_Ratio_Adverse*) scenarios.[7] Following the EBA methodology, we compute the difference between the 8% hurdle rate and the 2016 CET1 ratio under the baseline scenario (*shortfall_baseline*), as well as the difference between the 5.5% hurdle rate and the 2016 CET1 ratio under the adverse scenario (*shortfall_adverse*). We classify a bank as being in a shortfall condition (*d_shortfall* = 1) if at least one of these differences is positive. We also construct a continuous measure of capital shortfall (*shortfall*), defined as the maximum of the two differences, to capture the severity of the projected CET1 ratio inadequacy.

To examine whether and to what extent the two asset-risk measures used in this study explain the results of the 2014 EU-wide stress test, we estimate the following model:

$$\begin{aligned} Stress\_test\_outcome_i = \alpha + \beta_1\, asset\_risk_{i,t} + \beta_2\, d\_IRB_{i,t} + \beta_3\, asset\_risk_{i,t} \times d\_IRB_{i,t} + \\ + \gamma\, equity\_ratio_{i,t} + \delta\, loans\_deposits\_ratio_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{3}$$

The dependent variable, $Stress\_test\_outcome$, is measured once for each bank and captures the outcome of the 2014 EU-wide stress test. It is alternatively defined as the dummy variable $d\_shortfall$ or the continuous measure $shortfall$. The main explanatory variable, $asset\_risk$, is alternatively measured by the regulatory indicator $RWATA$ or the market-based measure $asset\_volatility$.

Because our main analysis reveals differences between the regulatory and market-based measures of asset risk, we also control for banks' adoption of internal models (*d_IRB*) and include the

[5] The 2013 CET1 ratios used in the 2014 stress test can differ from those externally reported by banks (see later).
[6] The 2014 exercise covered 123 banking groups across the European Union, including Norway. Two Swiss banks, one French bank (Crédit Industriel et Commercial SA – CIC), one Spanish bank (Caixabank, S.A.), and one UK bank (Standard Chartered Plc) represent the only institutions in our sample that did not participate in the EU-wide stress test.
[7] Source: https://www.eba.europa.eu/risk-and-data-analysis/risk-analysis/eu-wide-stress-testing.

interaction term $asset\_risk \times d\_IRB$ to examine whether the relation between asset risk and the stress test outcome differs between IRB and non-IRB banks. Accordingly, the coefficient β_1 captures the association between the asset risk measure and the stress test outcome for non-IRB banks, while the corresponding association for IRB banks is given by $\beta_1 + \beta_3$. We further control for the ratio of equity to total assets (*equity_ratio*) and the ratio of total loans to customer deposits (*loans_deposits*), which capture additional dimensions of bank capitalization and funding risk.

The explanatory variables are observed annually over the 2008–2013 period, so that each bank contributes multiple observations corresponding to its characteristics in the years preceding the 2014 stress test. To account for the fact that observations closer to the stress test are likely to be more informative, regressions are estimated using analytic weights that linearly downweight earlier observations and assign progressively larger weights to observations closer to the stress test. For each stress test outcome measure (*d_shortfall* and *shortfall*) and each asset risk measure ($RWATA$ and *asset_volatility*), we estimate two specifications: one excluding and one including the interaction term.

Results are reported in Table 6. Without accounting for the use of IRB models, only the regulatory risk measure is positively and statistically associated with the stress-test outcome, whereas the market-based measure is unrelated. This result likely reflects the fact that the stress test is constructed around RWAs, which constitute both the denominator of the CET1 ratio and the numerator of RWATA.

When we distinguish between IRB and non-IRB banks, we find that IRB banks are, on average, less likely to experience a capital shortfall and tend to face smaller shortfalls when they occur. Moreover, allowing the coefficients of asset risk to vary by regulatory approach we find substantial heterogeneity in the information content of RWATA and asset volatility. In particular, neither RWATA nor asset volatility is correlated with the stress-test outcome for non-IRB banks. RWATA retains its predictive power only for banks using internal models. For these banks, asset volatility also appears to play some role: it is positively associated with the likelihood, but not the magnitude, of a capital shortfall. This finding may reflect the closer relationship between RWATA and asset volatility documented in Section 4.2.

The absence of a correlation between RWATA and the stress-test outcome for banks using the SA is less straightforward. Our explanation is that the outcome of the 2014 EU-wide stress test reflects the combined effect of the stress test itself and the Asset Quality Review (AQR) conducted beforehand. The AQR can affect the stress-test data in two ways. First, changes in asset classification and valuation can alter the starting values used in the stress test, for example, the starting capital ratio may change due to revised loan classifications and provisioning. Second, the projections under the stress scenario may also be affected. As a result, the data reported for the 2013 starting point may already incorporate adjustments stemming from the AQR and may therefore differ from the figures externally reported by banks. Consequently, the RWATA reported by banks may be weakly correlated with the stress-test outcome to the extent that it deviates from the adjusted values used in the stress test. A larger misalignment between reported and adjusted RWATA for non-IRB banks could therefore explain why RWATA does not correlate with the stress-test outcome for such banks.

Insert Table 6 approximately here

To investigate if this is the case, we compare the CET1 ratio used as the 2013 starting point for the stress test ($CET1\_Ratio\_2013$) with the one externally reported by banks ($CET1\_Ratio\_2013\_acc$) for both IRB and non-IRB banks in our sample. We construct two comparison measures: the simple difference between $CET1\_Ratio\_2013$ and $CET1\_Ratio\_2013\_acc$ ($stresstestadjustment$) and the ratio of this difference to $CET1\_Ratio\_2013\_acc$ ($stresstestadjustment\_ratio$). Table 7 reports the mean and standard deviation of these measures for the two groups, together with tests for differences in means. As expected, non-IRB banks exhibit larger average stress-test adjustments than IRB banks, both in absolute terms and relative to the reported CET1 ratio. The differences in means are statistically significant for both measures, indicating that reported values for banks using the SA are subject to larger adjustments prior to the stress test as a result of the preliminary asset quality review.

Insert Table 7 approximately here

5. Conclusions

This paper shows that the relationship between regulatory and market-based measures of bank risk depends on how regulatory risk weights are generated. The informational content of RWATA is therefore conditional rather than universal: whether RWATA reflects market-based assessments of risk depends on the use of internal models in the calculation of capital requirements.

The association between RWATA and asset volatility emerges only after banks adopt IRB models (the extensive margin) and strengthens as the intensity of IRB usage increases (the intensive margin), particularly when advanced internal models are applied to corporate exposures. Taken together, these results support Prediction *1b* on average, Prediction *2a* over *2b* along both the extensive and intensive margins of IRB adoption, and Prediction *3* regarding the greater informativeness of advanced models applied to corporate portfolios.

This pattern is consistent with the institutional design of the IRB framework, under which regulatory risk weights are intended to respond more closely to the underlying economic risk of credit portfolios. Although regulatory and market-based measures are conceptually distinct and constructed differently, the greater granularity and risk sensitivity of internal ratings may allow regulatory risk weights to better capture some of the same underlying risk characteristics that are reflected in market-based assessments of bank risk.

We also find that this association remains present among relatively weakly capitalized banks and during the global financial crisis, suggesting that the alignment between regulatory and market-based measures of risk persists even when incentives for strategic capital optimization are stronger and concerns about the credibility of internal models are most pronounced.

We further show that the conditional informativeness of RWATA extends to supervisory assessments of bank resilience. Although IRB banks are, on average, less likely to experience capital shortfalls and tend to incur smaller stress-induced capital losses, both RWATA and asset volatility are significantly associated with the likelihood and severity of capital shortfalls within this group. By contrast, neither measure is related to stress-test outcomes for banks using SA models.

Taken together, the results point to important differences in the informational content of RWATA across regulatory regimes. Under the IRB framework, RWATA appears more closely aligned with both market-based assessments of risk and realized stress-test outcomes, whereas SA risk weights are inherently less sensitive to cross-sectional differences in underlying risk. This pattern likely reflects the more mechanical nature of SA models, which relies on relatively broad regulatory categories and therefore captures less variation in borrower- and portfolio-specific risk characteristics.

More broadly, our findings contribute to the policy debate on the trade-off between simplicity and risk sensitivity in bank capital regulation. While internal models are associated with lower average risk weights and higher reported capital ratios, they also produce regulatory measures that are more closely aligned with underlying economic risk and stress vulnerability. These results caution against treating RWATA as a fully comparable measure of risk across banks operating under different regulatory approaches and highlight the importance of complementary risk indicators, particularly when assessing SA banks.

Appendix A. Banks in the sample

Bank	Country
Dexia SA	BELGIUM
KBC Groep NV/ KBC Groupe SA-KBC Group	BELGIUM
Danske Bank A/S	DENMARK
Jyske Bank A/S	DENMARK
OP Corporate Bank plc-OP Yrityspankki Oyj	FINLAND
BNP Paribas	FRANCE
Crédit Agricole S.A.	FRANCE
Crédit Industriel et Commercial SA - CIC	FRANCE
Société Générale SA	FRANCE
Commerzbank AG	GERMANY
Deutsche Bank AG	GERMANY
Alpha Bank AE	GREECE
Eurobank Ergasias SA	GREECE
National Bank of Greece SA	GREECE
Piraeus Bank SA	GREECE
OTP Bank Plc	HUNGARY
Bank of Ireland-Governor and Company of the Bank of Ireland	IRELAND
BPER Banca S.P.A.	ITALY
Banca Carige SpA	ITALY
Banca Monte dei Paschi di Siena SpA-Gruppo Monte dei Paschi di Siena	ITALY
Banca Popolare di Milano SCaRL	ITALY
Intesa Sanpaolo	ITALY
UniCredit SpA	ITALY
Unione di Banche Italiane Scpa-UBI Banca	ITALY
ING Groep NV	NETHERLANDS
DnB ASA	NORWAY
Powszechna Kasa Oszczednosci Bank Polski SA - PKO BP SA	POLAND
Banco Comercial Português, SA-Millennium bcp	PORTUGAL
Banco Bilbao Vizcaya Argentaria SA-BBVA	SPAIN
Banco Santander SA	SPAIN
Banco de Sabadell SA	SPAIN
Bankinter SA	SPAIN
Caixabank, S.A.	SPAIN
Skandinaviska Enskilda Banken AB	SWEDEN
Svenska Handelsbanken AB	SWEDEN
Swedbank AB	SWEDEN
Credit Suisse Group AG	SWITZERLAND
UBS AG	SWITZERLAND
Barclays Plc	UNITED KINGDOM
HSBC Holdings Plc	UNITED KINGDOM
Lloyds Banking Group Plc	UNITED KINGDOM
Royal Bank of Scotland Group Plc (The)	UNITED KINGDOM
Standard Chartered Plc	UNITED KINGDOM

Appendix B. Variable definitions

Variables	Unit	Definition	Source
asset_volatility	%	Implied annualized volatility of bank assets estimated using the Black–Scholes–Merton model following Ronn and Verma (1986), Flannery and Rangan (2008), Vallascas and Hagendorff (2013), and Delis et al. (2021).	Authors' calculation
AIRB_weight	%	Share of credit exposures, in terms of EAD, covered by advanced internal ratings-based models.	Banks' Pillar III reports
AIRB_corp_weight	Ratio	Share of corporate credit exposure under advanced internal ratings-based over total corporate credit exposure	Authors' calculation (based on banks' Pillar III reports)
AIRB_ret_weight	Ratio	Share of retail credit exposure under advanced internal ratings-based over total retail credit exposure	Authors' calculation (based on banks' Pillar III reports)
AIRB_other_weight	Ratio	Share of other credit exposures under advanced internal ratings-based over total other credit exposures	Authors' calculation (based on banks' Pillar III reports)
CET1_Ratio_2013	%	The (2013) starting-point Common Equity Tier 1 ratio in the 2014 EU-wide stress test.	European Banking Authority (EBA)
CET1_Ratio_2013_acc	%	The reported Common Equity Tier 1 ratio for the 2013 fiscal year.	Banks' Pillar III reports
CET1_Ratio_Adverse	%	The projected value of the Common Equity Tier 1 ratio for 2016 under the adverse scenario in the 2014 EU-wide stress test.	European Banking Authority
CET1_Ratio_Baseline	%	The projected value of the Common Equity Tier 1 ratio for 2016 under the baseline scenario in the 2014 EU-wide stress test.	European Banking Authority
corp_exposure	Ratio	Share of corporate credit exposure over total credit exposure	Banks' Pillar III reports
d_IRB	0/1	Dummy variable taking value 1 if the share of credit exposures, in terms of EAD, covered by internal ratings-based models is higher than zero.	Authors' calculation (based on banks' Pillar III reports)
d_shortfall	0/1	Dummy variable taking value 1 if the value of shortfall is positive	Authors' calculation (based on EBA data)
IRB_weight	%	Share of credit exposures, in terms of EAD, covered by internal ratings-based models.	Banks' Pillar III reports
equity_ratio	%	= 100×(Equity/Total assets).	BankFocus
liquid_assets	%	= 100×(Liquid assets/Total assets).	BankFocus
loans	%	= 100×(Total loans/Total assets).	BankFocus
loans_deposits	%	= 100×(Total loans/Customer deposits).	BankFocus
other_exposure	Ratio	Share of other credit exposures over total credit exposures	Banks' Pillar III reports
ret_exposure	Ratio	Share of retail credit exposure over total credit exposure	Banks' Pillar III reports
RWATA	%	= 100×(Total risk-weighted assets/Total assets).	Authors' calculation (based on banks' Pillar III reports)
size	Log-points	= ln(Total assets).	BankFocus
shortfall	%	= Max[(8% − CET1_Ratio_Baseline); (5.5% − CET1_Ratio_Adverse)]	Authors' calculation (based on EBA data)

References

Acharya, V. V., Engle, R., Pierret, D. (2014). Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights. *Journal of Monetary Economics* 65, 36–53.

Acharya, V. V., Engle, R., Richardson, M. (2012). Capital Shortfall: A New Approach to Ranking and Regulating Systemic Risks. *American Economic Review* 102(3), 59–64.

Acharya, V. V., Pedersen, L. H., Philippon, T., Richardson, M. (2017). Measuring Systemic Risk. *Review of Financial Studies* 30(1), 2–47.

Barakova, I., Palvia, A. (2014). Do Banks' Internal Basel Risk Estimates Reflect Risk? *Journal of Financial Stability* 13, 167–179.

Basel Committee on Banking Supervision. (2006). International Convergence of Capital Measurement and Capital Standards: A Revised Framework - Comprehensive Version. https://www.bis.org/publ/bcbs128.htm

Basel Committee on Banking Supervision. (2017). Basel III: Finalising Post-Crisis Reforms. https://www.bis.org/bcbs/publ/d424.htm

Behn, M., Haselmann, R., Vig, V. (2022). The Limits of Model-Based Regulation. *Journal of Finance* 77(3), 1635–1684.

Böhnke, V., Ongena, S., Paraschiv, F., Reite, E. J. (2023). Back to the Roots of Internal Credit Risk Models: Does Risk Explain Why Banks' Risk-Weighted Asset Levels Converge Over Time? *Journal of Banking and Finance* 156, 106992.

Brambor, T., Clark, W. R., Golder, M. (2006). Understanding Interaction Models: Improving Empirical Analyses. *Political Analysis* 14(1), 63–82.

Bruno, B., Marino, I., Nocera, G. (2023). Internal Ratings and Bank Opacity: Evidence from Analysts' Forecasts. *Journal of Financial Intermediation* 56, 101062.

Bruno, B., Nocera, G., Resti, A. C. (2017). Are Risk-Based Capital Requirements Detrimental to Corporate Lending? Evidence from Europe. CEPR Discussion Paper No. 12007. CEPR Press, Paris and London. https://cepr.org/publications/dp12007

Delis, M. D., Kim, S. J., Politsidis, P. N., Wu, E. (2021). Regulators vs. markets: Are lending terms influenced by different perceptions of bank risk? *Journal of Banking and Finance* 122, 105990.

European Banking Authority (2024). Risk Assessment Report of the European Banking Authority. https://www.eba.europa.eu/publications-and-media/publications/risk-assessment-report-july-2024

Flannery, M. J., Rangan, K. P. (2008). What Caused the Bank Capital Build-up of the 1990s? *Review of Finance* 12(2), 391–429.

Flannery, M. J., Sorescu, S. (1996). Evidence of Bank Market Discipline in Subordinated Debenture Yields: 1983–1991. *Journal of Finance* 51(4), 1347–1377.

Korsgaard, S. (2019). Risk and Risk Weights. Danmarks Nationalbank Working Paper No. 145.

Le Leslé, V., Avramova, S. (2012). Revisiting Risk-Weighted Assets. IMF Working Paper No. 12/90, International Monetary Fund, Washington, DC. https://doi.org/10.5089/9781475502657.001

Mariathasan, M., Merrouche, O. (2014). The Manipulation of Basel Risk-Weights. *Journal of Financial Intermediation* 23(3), 300–321.

Plosser, M.C., Santos, J.A. (2018). Banks' Incentives and Inconsistent Risk Models. *Review of Financial Studies* 31 (6), 2080–2112.

Ronn, E. I., Verma, A. K. (1986). Pricing Risk-Adjusted Deposit Insurance: An Options-Based Model. *Journal of Finance* 41(4), 871–895.

Turk-Ariss, R. (2017). Heterogeneity of Bank Risk Weights in the EU: Evidence by Asset Class and Country of Counterparty Exposure. IMF Working Paper No. 17/137, International Monetary Fund, Washington, DC. https://doi.org/10.5089/9781484302958.001

Vallascas, F., Hagendorff, J. (2013). The Risk Sensitivity of Capital Requirements: Evidence from an International Sample of Large Banks. *Review of Finance* 17(6), 1947–1988.

Tables and figures

Table 1. Descriptive statistics

This table reports summary statistics for the main characteristics of the banks in various samples. Variables are defined in Appendix *B*.

	No. of obs.	Mean	Std. Dev.	p10	p50	p90
Entire sample						
RWATA	298	43.717	17.289	21.999	42.332	70.513
asset_volatility	298	1.252	1.069	0.393	0.966	2.214
size	298	12.534	1.316	10.711	12.504	14.318
loans	298	53.668	17.010	28.306	57.541	74.040
liquid_assets	298	12.527	7.152	5.004	10.496	22.728
corp_exposure	298	0.343	0.102	0.218	0.333	0.465
ret_exposure	298	0.315	0.123	0.134	0.321	0.463
other_exposure	298	0.342	0.140	0.199	0.309	0.525
d_IRB	298	0.815	0.389	0	1	1
IRB banks						
IRB_weight	243	0.670	0.172	0.424	0.709	0.867
AIRB_weight	243	0.578	0.228	0.264	0.611	0.832
AIRB_corp_weight	243	0.575	0.367	0	0.702	0.940
AIRB_ret_weight	243	0.761	0.232	0.470	0.824	0.974
AIRB_other_weight	239	0.326	0.343	0	0.213	0.886
Relevant observations for 38 banks participating in the 2014 EU-wide stress test						
shortfall	38	-2.379	4.780	-8.100	-2.800	5.600
d_shortfall	38	0.237	0.431	0	0	1
equity_ratio	228	5.624	2.812	2.772	5.534	9
loans_deposits	228	164.480	160.446	95.961	137.357	222.819

Table 2. Sources of variation in risk-weighted asset density and asset volatility

This table reports the coefficient estimates of OLS regressions of bank asset volatility on various fixed effects. The dependent variables are the risk-weighted asset density (*RWATA*), in Columns 1-5, and the asset volatility (*asset_volatility*), in Columns 6-10. Robust standard errors are clustered at the bank level and are shown in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	RWATA					asset_volatility				
Constant	46.951***	29.206***	32.523***	31.632***	26.109***	1.420***	0.795*	0.964**	0.808***	0.607***
	(3.069)	(5.451)	(5.594)	(7.516)	(0.000)	(0.196)	(0.412)	(0.419)	(0.293)	(0.000)
No. of obs.	298	298	298	298	298	298	298	298	298	298
R^2	0.0210	0.7730	0.7950	0.8180	0.9360	0.1050	0.5060	0.6110	0.8980	0.5600
Adj. R^2	0.0003	0.7600	0.7790	0.6980	0.9250	0.0861	0.4780	0.5800	0.8310	0.4870
Year F.E.	Yes	No	Yes	No	No	Yes	No	Yes	No	No
Country F.E.	No	Yes	Yes	No	No	No	Yes	Yes	No	No
Country×Year F.E.	No	No	No	Yes	No	No	No	No	Yes	No
Bank F.E.	No	No	No	No	Yes	No	No	No	No	Yes

Table 3. Bank-specific determinants of risk-weighted asset density

This table reports the coefficient estimates of OLS regressions of bank risk-weighted asset density on various balance sheet items. The dependent variable is the risk-weighted asset density (*RWATA*). Explanatory variables: the natural logarithm of the bank total assets (*size*), the ratio of the bank total loans to total assets (*loans*), and the ratio of the bank liquid assets to total assets (*liquid_assets*). Robust standard errors are clustered at the bank level and are shown in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
size	-3.529**	-3.590**	-3.739**
	(1.494)	(1.509)	(1.467)
loans	0.427**	0.422**	0.364***
	(0.172)	(0.174)	(0.122)
liquid_assets	-0.473	-0.461	-0.059
	(0.298)	(0.301)	(0.144)
Intercept	70.949**	74.000**	61.458**
	(27.825)	(28.159)	(23.630)
No. of obs.	298	298	298
R^2	0.603	0.612	0.882
Adj. R^2	0.599	0.6	0.871
Year F.E.	No	Yes	Yes
Country F.E.	No	No	Yes

Table 4. Risk-weighted asset density, asset volatility, and usage of internal ratings-based models

This table reports the coefficient estimates of OLS regressions of bank risk-weighted asset density on the asset volatility and the usage of internal ratings-based models. The dependent variable is the risk-weighted asset density (*RWATA*). The main explanatory variables are: the asset volatility (*asset_volatility*); a dummy variable taking value 1 if the share of credit exposures, in terms of EAD, covered by internal ratings-based models is higher than zero (*d_IRB*), in Column 2; the share of credit exposures, in terms of EAD, covered by internal ratings-based models (*IRB_weight*), in Column 4; the share of credit exposures, in terms of EAD, covered by advanced internal ratings-based models (*AIRB_weight*), in Column 5; the share of corporate credit exposure under advanced internal ratings-based over total corporate credit exposure (*AIRB_corp_weight*) and the share of retail credit exposure under advanced internal ratings-based over total retail credit exposure (*AIRB_ret_weight*) in Column 6; the interaction between *asset_volatility* and *d_IRB*, in Column 2, or *IRB_weight*, in Column 4, or *AIRB_weight*, in Column 5, or *AIRB_corp_weight* and *AIRB_ret_weight*, in Column 6. Control variables include *size*, *loans*, and *liquid_assets* (defined in Appendix *B*). Regressions in Columns 3-6 are performed on the subsample of the IRB banks only. All specifications include year fixed effects. Robust standard errors are clustered at the bank level and are shown in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Entire sample		IRB banks			
asset_volatility	1.861 (1.471)	-0.613 (1.916)	4.393** (1.721)	-2.072 (2.147)	-0.382 (1.841)	8.012* (3.973)
d_IRB		-22.099*** (4.490)				
IRB_weight				-44.274*** (10.416)		
AIRB_weight					-24.884** (10.246)	
AIRB_corp_weight						-12.918** (5.743)
AIRB_ret_weight						2.139 (9.149)
asset_volatility×d_IRB		4.823** (2.342)				
asset_volatility×IRBweight				9.263 (5.613)		
asset_volatility×AIRBweight					9.001 (5.485)	
asset_volatility×AIRB_corp_weight						12.427*** (3.721)
asset_volatility×AIRB_ret_weight						-14.300** (6.572)
Constant	-2.995** (1.431)	-0.460 (1.239)	-1.176 (1.214)	-0.345 (0.929)	-0.227 (1.173)	-1.473 (0.993)
Observations	298	298	243	243	243	243
R^2	0.622	0.697	0.535	0.671	0.578	0.634
Adj. R^2	0.609	0.685	0.515	0.654	0.556	0.611
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
F-test (H_0: $\beta_{asset\_volatility} + \beta_{asset\_volatility \times d\_IRB} = 0$)		6.68**				

Table 5. Risk-weighted asset density and asset volatility in IRB banks (focus on low capital banks and great financial crisis years)

This table reports the coefficient estimates of OLS regressions of bank risk-weighted asset density on the asset volatility performed on the subsample of the IRB banks only. The dependent variable is the risk-weighted asset density (*RWATA*). The main explanatory variables are: the asset volatility (*asset_volatility*); a dummy variable taking value 1 if the Tier 1 capital over risk weighted assets in 2008 is below the 10th percentile (*d_tier1_p10*), in Column 1; a dummy variable taking value 1 if the Tier 1 capital over risk weighted assets in 2008 is below the 25th percentile (*d_tier1_p25*), in Column 2; a dummy variable taking value 1 if the observation refers to 2008 or 2009 (*d_crisis*), in Column 3; the interaction between *asset_volatility* and *d_tier1_p10*, in Column 1, or *d_tier1_p25*, in Column 2, or *d_crisis*, in Column 3. Control variables include *size*, *loans*, and *liquid_assets* (defined in Appendix *B*). All specifications include year fixed effects. Robust standard errors are clustered at the bank level and are shown in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
		IRB banks	
asset_volatility	4.478**	4.254**	3.527*
	(1.793)	(1.638)	(1.912)
d_tier1_p10	3.708		
	(4.221)		
d_tier1_p25		8.587*	
		(4.260)	
asset_volatility×d_tier1_p10	4.470		
	(3.446)		
asset_volatility×d_tier1_p25		0.761	
		(3.085)	
d_crisis			0.698
			(2.224)
asset_volatility×d_crisis			2.224
			(1.509)
Constant	41.971	42.641*	33.546
	(25.274)	(24.753)	(24.755)
Observations	243	243	243
R^2	0.564	0.61	0.538
Adj. R^2	0.541	0.59	0.516
Controls	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
F-test (H_0: $\beta_{asset\_volatility} + \beta_{asset\_volatility \times d\_tier1\_p10} = 0$)	7.02**		
F-test (H_0: $\beta_{asset\_volatility} + \beta_{asset\_volatility \times d\_tier1\_p25} = 0$)		3.17*	
F-test (H_0: $\beta_{asset\_volatility} + \beta_{asset\_volatility \times d\_crisis} = 0$)			10.26***

Table 6. Bank asset risk measures and shortfall under the 2014 EU-wide stress test

This table reports the coefficient estimates of OLS regressions of the outcome of the 2014 EU-wide stress test on bank asset risk measures. The dependent variables are: a dummy variable taking value 1 if the bank outcome of the stress test resulted in a shortfall (*d_shortfall*, in Columns 1-4) and the max between (*i*) the differences between the 8% hurdle rate and the 2016 CET1 ratio under the baseline scenario and (*ii*) the difference between the 5.5% hurdle rate and the 2016 CET1 ratio under the adverse scenario (*shortfall*, in Columns 5-8). The main explanatory variables are: the risk-weighted asset density (*RWATA*, in odd-numbered columns), the asset volatility (*asset_volatility*, in even-numbered columns); a dummy variable taking value 1 if the share of credit exposures, in terms of EAD, covered by internal ratings-based models is higher than zero *(d_IRB*, in Columns 3-4 and 7-8); the interaction between *RWATA* and *d_IRB*, in Columns 3 and 7, and between *asset_volatility* and *d_IRB*, in Columns 4 and 8. Control variables include the ratio of the bank total equity to total assets (*equity_ratio*) and the ratio of the bank total loans to customer deposits (*loans_deposits*). The dependent variable is bank-specific and time-invariant. Regressions are estimated using analytic weights that linearly downweight observations from earlier years, assigning larger weights to observations closer to 2013, the year in relation to which the 2014 EU-wide stress test was conducted. Robust standard errors are clustered at the bank level and are shown in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	d_shortfall				shortfall			
RWATA	0.015***		-0.003		0.133***		-0.107	
	(0.003)		(0.007)		(0.037)		(0.100)	
asset_volatility		0.077		-0.033		0.389		-0.615
		(0.066)		(0.054)		(0.725)		(0.549)
d_IRB			-1.382***	-0.808***			-19.174**	-5.967**
			(0.440)	(0.222)			(7.968)	(2.276)
RWATA×d_IRB			0.017**				0.307**	
			(0.008)				(0.118)	
asset_volatility×d_IRB				0.173**				1.832*
				(0.081)				(0.985)
equity_ratio	-0.050***	-0.035	-0.072***	-0.059***	-0.646***	-0.438	-0.839***	-0.563**
	(0.016)	(0.026)	(0.016)	(0.017)	(0.221)	(0.261)	(0.247)	(0.220)
loans_deposits	0.001***	0.001***	0.001***	0.001***	0.001	0.000	0.002	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)
Constant	-0.247**	0.248**	1.216***	1.022***	-4.721***	-0.329	12.729	4.837*
	(0.119)	(0.121)	(0.431)	(0.240)	(1.688)	(1.445)	(7.931)	(2.655)
No. of obs.	228	228	228	228	228	228	228	228
R^2	0.382	0.109	0.469	0.367	0.24	0.05	0.35	0.152
Adj. R^2	0.373	0.0974	0.457	0.353	0.23	0.0373	0.336	0.133
Year weighting	Linear	Linear	Linear	Linear	Linear	Linear	Linear	Linear
F-test (H_0: RWATA+RWATA×d_IRB=0)			12.48***				12.65***	
F-test (H_0: asset_volatility+asset_volatility×d_IRB=0)				3.54*				1.48

Table 7. Comparison of stress test adjustments of CET1 ratio between IRB and Non-IRB banks

This table reports the mean and standard deviation (in parentheses) of the adjustment of the CET1 ratio in absolute terms (*stresstestadjustment*) and as a ratio of the accounting value (*stresstestadjustment_ratio*) occurred before the 2014 stress test for IRB and non-IRB banks. The last two rows present the difference in means between the two groups and the corresponding *t*-statistics from two-sample *t*-tests. Number of observations for each group is reported in brackets.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	stresstestadjustment	*stresstestadjustment_ratio*
No IRB	-0.032	-0.259
[7]	(0.00713)	(0.07241)
IRB	-0.002	-0.011
[31]	(0.00315)	(0.02903)
Mean (No IRB) - Mean (IRB)	-0.030	-0.247
t-stat	-4.063***	-3.539***

Figure 1. Within-bank variability of *RWATA* and *asset_volatility*

This figure reports boxplots of the coefficient of variation of *RWATA* and *asset_volatility* across banks, for the full sample and separately for IRB and non-IRB banks.

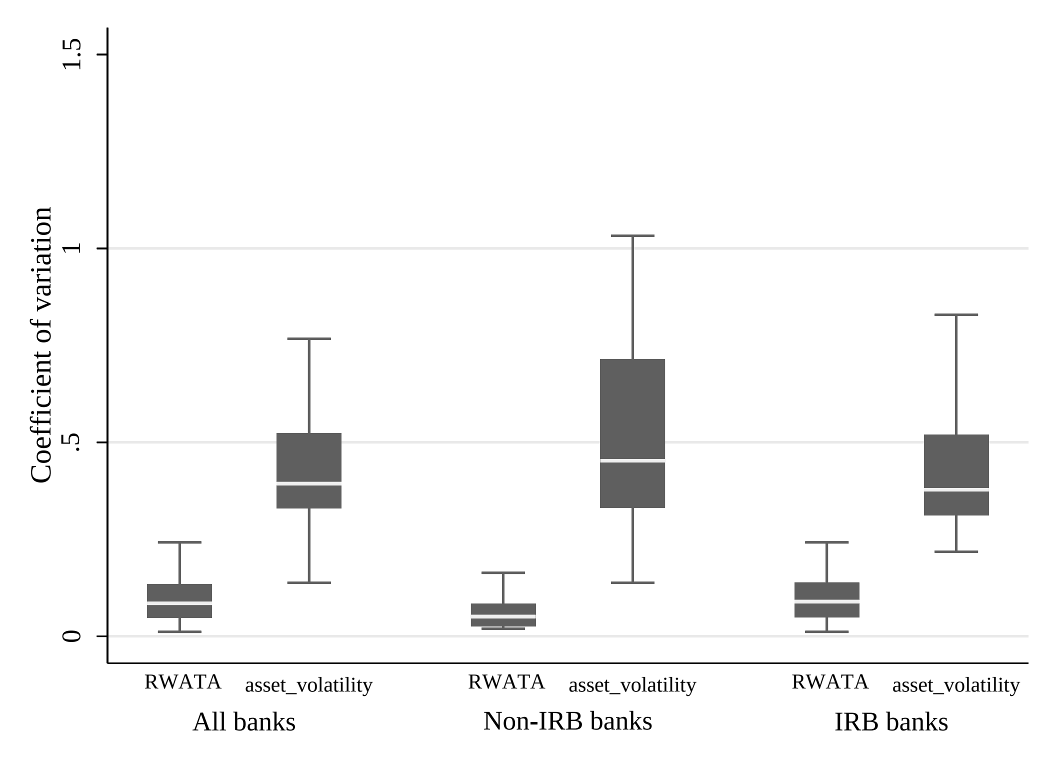
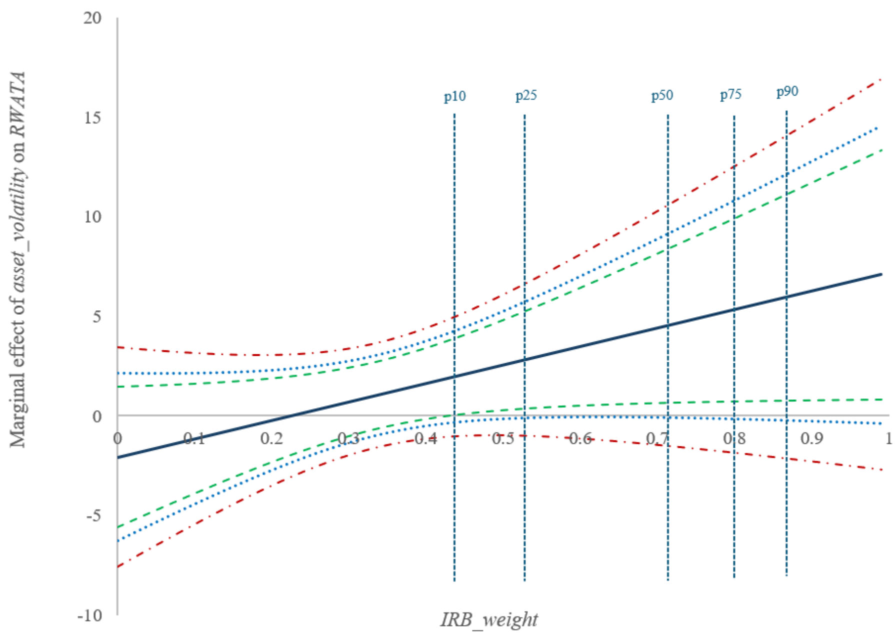


Figure 2. Marginal effect of *asset_volatility* on *RWATA* for different levels of *IRB_weight* and *AIRB_weight*

This figure displays point estimates (solid line) and 90%, 95%, and 99% confidence intervals (green dashed, blue dotted, and red dash-dot lines, respectively) for the marginal effect of *asset_volatility* on *RWATA*, across *IRB_weight* (Panel *A*) and *AIRB_weight* (Panel *B*) as in regressions 4 and 5 of Table 4. Vertical lines correspond to percentiles in the distribution of *IRB_weight* and *AIRB_weight*.

Panel A



Panel B

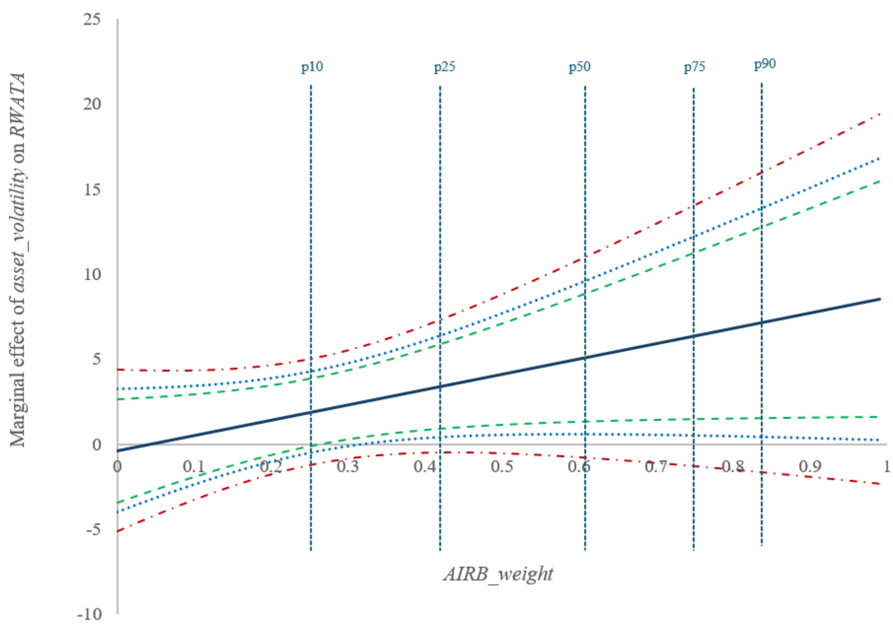
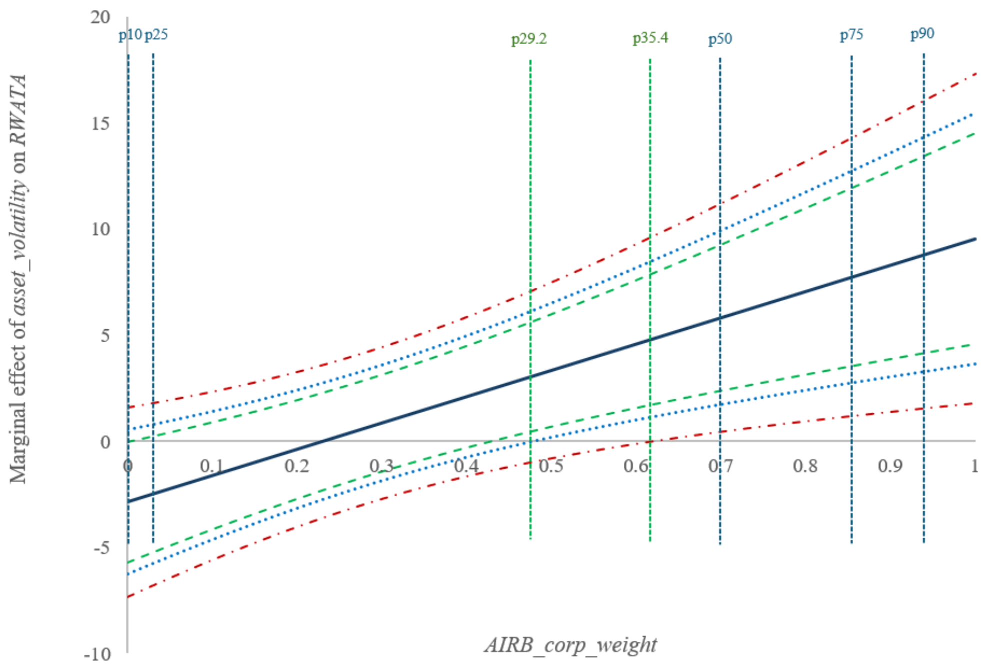


Figure 3. Marginal effect of *asset_volatility* on *RWATA* for different levels of *AIRB_corp_weight* and *AIRB_ret_weight*

This figure displays point estimates (solid line) and 90%, 95%, and 99% confidence intervals (green dashed, blue dotted, and red dash-dot lines, respectively) for the marginal effect of *asset_volatility* on *RWATA*, across *AIRB_corp_weight* (with *AIRB_ret_weight* at its mean value, Panel *A*) and *AIRB_ret_weight* (with *AIRB_corp_weight* at its mean value, Panel *B*) as in regression 6 of Table 4. Vertical lines correspond to percentiles in the distribution of *AIRB_corp_weight* and *AIRB_ret_weight*.

Panel A



Panel B