DETERMINANTS OF INTERNAL RATINGS-BASED CREDIT RISK-WEIGHTED ASSETS IN EUROPE: 2015-2023

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Resumen

Los activos ponderados por riesgo (APR) y la densidad de APR (DPR) son métricas clave para evaluar el riesgo crediticio de los bancos y que permiten comparar bancos usando el método basado en calificaciones internas (IRB, por sus siglas en inglés). Con datos de la Autoridad Bancaria Europea, analizamos los niveles de IRB-DPR de distintos bancos y países, así como su evolución a lo largo del tiempo. Además, relacionamos el IRB-DPR con otros indicadores de riesgo crediticio, como la ratio de préstamos morosos, las provisiones, la probabilidad de impago y la pérdida en caso de impago. Los resultados muestran que las variables *dummy* específicas por país no son significativas para la mayoría de las carteras y países, y que las diferencias sistemáticas en las exposiciones nacionales sugieren que las carteras minoristas se benefician de un tratamiento más favorable.

DETERMINANTS OF INTERNAL RATINGS-BASED CREDIT RISK-WEIGHTED ASSETS IN EUROPE: 2015-23

Abstract

Risk-weighted assets (RWAs) and RWA density (RWD) are key metrics for assessing banks' credit risk and for enabling cross-bank comparisons under the internal ratings-based (IRB) approach. Using data from the European Banking Authority, we analyse IRB-RWD levels across banks and countries, as well as their evolution over time. We relate IRB-RWD to credit risk indicators such as the non-performing loans ratio, provisions, probability of default and loss given default. Our findings show that country-specific dummy variables are not significant for most portfolios and countries and that systematic differences in domestic exposures suggest retail portfolios benefit from favourable treatment.

Keywords: credit risk, risk-weighted assets, internal ratings-based approach.

1 Introduction

Banking regulation – specifically the Capital Requirements Regulation (CRR) and Capital Requirements Directive (CRD) (European Parliament and European Council, 2019; 2024) – aims to safeguard financial stability by requiring banks to hold a minimum level of own funds. Central to this framework is the principle of risk sensitivity: banks with riskier portfolios must maintain higher capital buffers. To operationalise this, regulators use RWAs, which adjust accounting exposures to reflect credit risk.

The CRR and CRD define three approaches for calculating credit RWAs. The standardised approach (SA) assigns fixed regulatory risk weights to balance sheet exposures and is designed for banks without internal risk models. Under the foundation internal ratings-based (F-IRB) approach, banks estimate the probability of default (PD) and the maturity (M), while the loss given default (LGD) and exposure at default (EAD) are prescribed by regulators.[1] In turn, the advanced internal ratings-based (A-IRB) approach allows banks to use internal estimates for all key parameters, subject to regulatory approval and compliance with both qualitative and quantitative requirements.

RWAs have become a key market indicator, reflecting the underlying credit risk of banks since both their levels and trends are closely monitored by market participants and supervisors. RWD, defined as the ratio of RWAs to EAD, is widely used as a proxy for portfolio credit risk. Bank profitability is often assessed using the return on RWAs, defined as the ratio of profit to RWAs. Credit rating agencies also rely on RWA and RWD metrics to evaluate a bank's

1 Specifically, credit conversion factors are provided for EAD estimation.

creditworthiness. These uses underscore the importance of understanding RWA and RWD levels and dynamics for all stakeholders.

RWAs and RWD are publicly disclosed through banks' Pillar 3 reports. To enhance transparency and comparability, the European Banking Authority (EBA) publishes harmonised bank-level metrics, with two main EBA datasets available, namely: (i) the annual EBA EU-wide transparency exercise, which has provided quarterly data[2] on RWAs and exposures by portfolio and institution since December 2014; and (ii) the EBA Risk Dashboard, which reports averages of IRB parameters (PD and LGD) at country level. These datasets support a wide range of comparative analyses, although bank-level IRB parameters are not publicly disclosed.

Under the A-IRB framework, RWAs should, in principle, depend exclusively on PD, LGD, EAD and M. Hence, additional factors, such as the bank's or the counterparty's country, should not affect RWA outcomes. Empirical evidence shows that RWD differs across countries and banks, even for comparable portfolios (Trucharte, Pérez Montes, Cristófoli, Ferrer and Lavín, 2015; Turk-Ariss, 2017), which raises the question of whether observed differences stem from risk parameters or other underlying drivers. Even if differences are attributable to risk parameters, it is relevant to investigate the underlying causes of cross-country disparities.

Several studies have explored this issue. Trucharte, Pérez Montes, Cristófoli, Ferrer and Lavín (2015) compare RWD across countries and portfolios using EBA data, distinguishing between the SA and IRB approaches. However, their findings are inconclusive. Indeed, Le Leslé and Avramova (2012) argue that regulatory frameworks allow for substantial RWD variability, while Cannata, Casellina and Chionsini (2020) find that RWD dispersion is comparable to that of other financial ratios. These contrasting results highlight ongoing debates regarding the consistency and comparability of RWD outcomes under the current regulatory framework.

This study contributes to the literature on RWD variability by: (i) examining its determinants across banks, portfolios and countries over time; (ii) incorporating explanatory variables, such as PD, LGD, non-performing loan (NPL) and provision coverage ratios based on EBA data; and (iii) exploiting the panel structure of the dataset to model RWD dynamics over time. Our results indicate that country-specific dummy variables are not significant for most portfolios and countries. Lastly, we identify a systematic difference in the treatment of domestic exposures: retail portfolios tend to benefit from favourable treatment, while wholesale portfolios appear to be penalised.

The remainder of this article is organised as follows. Section 2 reviews the empirical literature on RWA analysis. Section 3 describes the EBA dataset and its structure and presents some descriptive statistics for the most relevant portfolios and countries. Section 4 introduces the models used to obtain our results. Lastly, Section 5 summarises the main findings and outlines potential avenues for future research.

2 Initially published every six months.

2 Literature review

Over the past decades, RWAs and RWD have been extensively studied. Arroyo, Colomer, García Baena and Gónzalez Mosquera (2012) examine RWD as of 31 December 2010 for 16 European banks. Their analysis does not differentiate between portfolio types and proposes an alternative risk metric that incorporates both RWD and provisions. Due to data limitations, they conclude that robust inferences cannot be drawn. They suggest that the observed RWD variability may reflect differences in business models, such as portfolio composition and the use of the SA versus IRB approaches.

In the same year, Le Leslé and Avramova (2012) conducted a more comprehensive study, analysing a sample of 50 systemically important banks worldwide over the period 1998-2008. They document the evolution and dispersion of RWD, distinguishing between the SA and IRB approaches. Focusing on credit risk, they highlight the subjectivity inherent in RWD calculation, noting that differences arise not only from business models and methodologies but also from heterogeneous supervisory practices: *"... The current set-up for RWA calculation leaves considerable scope for subjectivity and interpretation ... Differences in RWAs are not only the result of banks' business model, risk profile, and RWA methodology (good or bad), but also the result of different supervisory practices ...".*

Bruno, Nocera and Resti (2014) develop two models: one to predict changes in RWD over time and another to estimate the extent of IRB coverage across banks. Using data from 50 large European banks over the period 2008-12, their analysis is based on aggregated RWD figures. Their models incorporate bank-specific variables such as size, deposit-to-asset ratio, retail and corporate loan shares and IRB coverage, in addition to country factors such as GDP growth.

In contrast to earlier studies using aggregated data, Trucharte, Pérez Montes, Cristófoli, Ferrer and Lavín (2015) were the first to use RWD information disaggregated by portfolio, country and regulatory approach (standardised versus IRB), based on the 2014 EBA stress test. They identify substantial cross-country variation in IRB coverage and in the reductions in RWD achieved through IRB usage. Notably, IRB-RWD varies significantly across countries for the same portfolio types. Building on a similar granularity level, Turk-Ariss (2017) uses data from the EBA transparency exercise on 21 European countries to model IRB-RWD at portfolio and country level. Using a panel dataset covering two reference dates (December 2014 and June 2015), they include bank-level fundamentals and country fixed effects, achieving an explanatory power of approximately R^2 = 40%.

More recently, Bastos e Santos, Esho, Farag and Zuin (2020) analyse annual data for 76 banks over the period 2001-16 to model the ratio between accounting-based and market-implied RWD. The latter is derived from credit default swap data to estimate point in time (PiT) PDs.[3] They find that the divergence between the two RWA measures (accounting-based and market-implied) is influenced by the share of complex assets and country-specific factors. However,

3 Employing the F-IRB value of LGD.

they do not account for the use of PiT PDs rather than through-the-cycle (TtC) PDs, as required under regulatory capital rules.[4]

In turn, Cannata, Casellina and Chionsini (2020) challenge the financial industry's narrative of excessive volatility in RWD. They compare the volatility of RWD with that of other financial ratios and find it to be of a similar size. As in Arroyo, Colomer, García Baena and Gónzalez Mosquera (2012), they construct a composite risk measure that includes provisions.

Leogrande, Costantiello, Laureti and Matarrese (2023) and Böhnke, Ongena, Paraschiv and Reite (2024) have provided two recent contributions. The former use EBA data spanning 30 quarters and develop models with up to 139 candidate variables, reporting an R^2 of 99.99%, raising concerns about possible overfitting and limited model robustness. By contrast, the latter adopt a more rigorous methodology, using quarterly aggregated RWD data from 52 listed banks across 14 European countries over the period 2007-19. They estimate two models: one capturing the change in RWD during the transition from the SA to the IRB approach, and another modelling quarterly RWD changes. Their findings reveal a convergence in RWD levels over time. The initial IRB adoption by banks leads to a drop in RWD, followed by further declines in jurisdictions with more lenient supervisory practices and increases in stricter regulatory environments, particularly in recent years.

Compared with previous studies, the key contributions of this article are the use of bank, country, portfolio[5] and quarter-specific RWD data, similar in scope to Trucharte, Pérez Montes, Cristófoli, Ferrer and Lavín (2015), as well as the incorporation of country-level PD and LGD information disclosed by the EBA in its annual transparency exercises. To the best of our knowledge, this is the first study to model RWD at portfolio level using EBA PD/LGD data. Furthermore, the panel structure of the dataset enables the use of long-run averages as explanatory variables and supports the analysis of the evolution of RWD over time.

3 Data

The data used in this study are sourced from the EBA.[6] The primary dataset is the EU-wide transparency exercise, which provides information on RWAs from December 2013 to June 2023, initially at a half-yearly frequency, and quarterly from 2020 onwards.[7] From this dataset, we extract credit risk IRB-RWA data for the following regulatory portfolios: corporates, retail secured, retail qualifying revolving and other retail. We also include further breakdowns such as specialised lending, corporates-SME, corporates other, and SME/non-SME segments within retail secured and other retail. All portfolios are disaggregated by default status (defaulted versus

4 TtC PD estimates are based on sufficiently long time series that capture the likely range of default rate variability over an economic cycle.

5 Specifically, corporate, retail secured, retail qualifying revolving and other retail, along with their possible further disaggregation.

6 *EU wide transparency exercise*.

7 This change in the reporting frequency does not have an impact on our calculations as we have not used differences or lagged variables.

non-defaulted exposures). Additionally, we retrieve data on provisions and defaulted exposures from the same source,[8] enabling the construction of key risk indicators. The final dataset combines all reporting periods into a panel comprising approximately 130,000 observations covering the period from December 2013 to June 2023. Each observation is uniquely identified by the reporting bank, regulatory portfolio,[9] country of the reporting institution, country of the counterparty and reporting quarter. To ensure data quality, we exclude observations with negative values and those reporting RWD levels exceeding 1,250%.[10]

In addition, we incorporate PD and LGD data from the EBA Risk Dashboard,[11] which provides aggregated information by counterparty country, portfolio and quarter. Unlike the EU-wide transparency exercise, this dataset does not contain bank-level information. The portfolio classification is broadly aligned with the transparency exercise, though it does not distinguish between SME and non-SME exposures in the retail secured and other retail portfolios. Another limitation is that it only covers a subset of counterparty countries, focusing on the most relevant jurisdictions. Risk parameter data (PD and LGD) are available from June 2015 onwards.

The Risk Dashboard reports exposure-weighted averages for PDs (on non-defaulted exposures, referred to as "PD adjusted" in EBA terminology) and LGDs (also on non-defaulted exposures) provided by banks, along with the 25th, 50th, and 75th percentiles[12] offering a measure of distributional dispersion. All PD and LGD parameters are merged into the RWA database described above,[13] resulting in a unified dataset for the empirical analysis.

Table 1 reports the number of unique values for bank, exposure type, country of the bank, country of the exposure and reporting periods. Not all banks report data across all breakdown dimensions.

In turn, Charts 1 and 2 depict the evolution of the PD, LGD and RWD for the total database and for the five largest countries.[14] The analysis focuses on the corporates and retail secured by real estate portfolios. We only report the exposure-weighted average PD and LGD.

In the corporates portfolio, Chart 1.a shows the changes in RWD, with a value close to 45% for the total portfolio. Germany and Italy display a clear downward trend, while in Spain it initially decreased but has recently increased. RWD levels also vary considerably by country. Chart 1.b highlights cross-country differences in exposure-weighted PD levels: Italy declines from 12% to 3%, whereas Germany changes from 2% to 0.8%. Chart 1.c presents a more

8 These variables are used to compute NPL and provision coverage ratios for the IRB portfolios.

9 Defaulted and non-defaulted exposures are recorded in separate columns rather than separate rows, consistent with EBA reporting.

10 Multiplying the 1,250% RWD by the 8% minimum capital ratio results in a capital requirement greater than 100% of the loan amount.

11 *Risk dashboard*.

12 These percentiles reflect inter-bank variability, where PD and LGD values are weighted by exposure at bank and portfolio level.

13 We use a left join and maintain all the RWA data. We do so because the risk parameter information in the EBA Risk Dashboard does not cover all the portfolios-countries-quarters that are available in the EU-wide transparency exercise.

14 Defined based on the counterparties' location rather than the banks' headquarters. Exposures are measured using the IRB portfolios of corporates, retail qualifying revolving, retail secured by real estate and retail other, as of June 2023.

Table 1
Unique counts (a)

	Unique counts
Banks	96
Exposure type	14
Bank's country	16
Counterparty's country	68
Periods	28

SOURCE: Authors' calculations.

a Not all banks report information for each possible portfolio-country-period combination.

stable pattern for the exposure-weighted LGD, which ranges between 32% and 42% across most countries, except for the Netherlands, where it remains around 28%. Other than Spain, where it has clearly increased, there is no trend in the change in LGD over time.[15]

In the retail secured by real estate portfolio, Chart 2.a shows a decline in the RWD for the total portfolio followed by a recent increase. However, France exhibits a persistent downward trend, while Spain's RWD remains stable until a recent rise. The Netherlands displays a sawtooth pattern due to the half-yearly reporting of Rabobank. Chart 2.b indicates an exposure-weighted PD variability by country of 0.5%-1.8%, with sudden peaks in Germany and Spain not reflected in RWD. Chart 2.c shows largely stable or ever increasing LGDs in all the countries (notably in Spain) except for a sharp drop in the Netherlands in 2019, whose impact on RWD became visible only several years later.

Therefore, it is clear that for both portfolios RWD and the PD and LGD parameters show different levels and more importantly different trends over time by country. RWD tends to stay stable over time while PD and LGD show quarterly variability and trends. From a general perspective, given that regulatory PDs are estimated on a through-the-cycle basis and LGDs on a downturn basis, these parameters should remain relatively stable over time, unless: (i) there are changes in the risk profile of the portfolios; (ii) the scope of portfolios under the IRB approach changes; or (iii) parameter estimation methodologies are revised (e.g. due to new regulatory guidance or supervisory interventions). However, because country-level PDs and LGDs are averages across multiple institutions, such effects should be partially diluted, and any significant shift should also be reflected in RWD levels, which, in contrast, behave in a more stable manner. Sudden quarterly jumps in PDs are therefore difficult to justify. For example, in the corporates portfolio in the Netherlands during 2016, the exposure-weighted PD rises sharply from 3.3% to 5% in June, before falling back to 2.6% by year-end. Such inconsistencies may reflect reporting errors by banks. We recommend that the EBA strengthen its data validation procedures[16] to enhance reporting quality as well as the public availability of its bank-level data, i.e. bank-level PDs and LGDs.

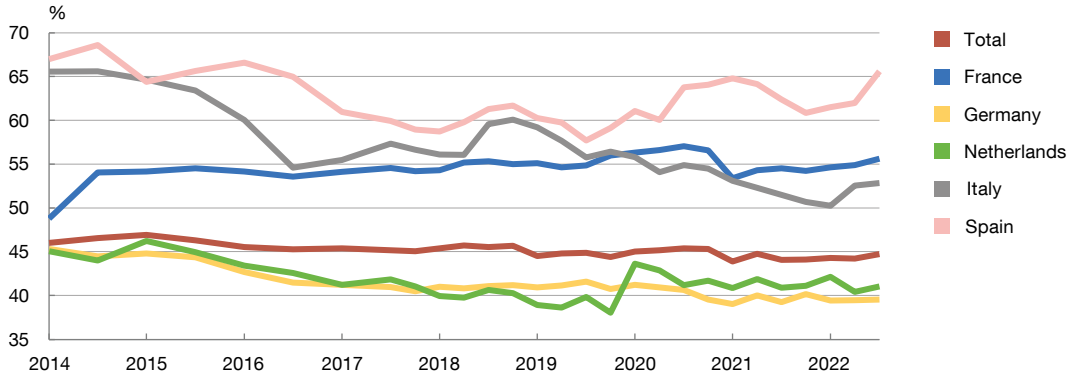
15 Figures for the average percentile parameters are available upon request.

16 This may include the detection of changes in PDs, LGDs and RWDs or inconsistencies in their changes.

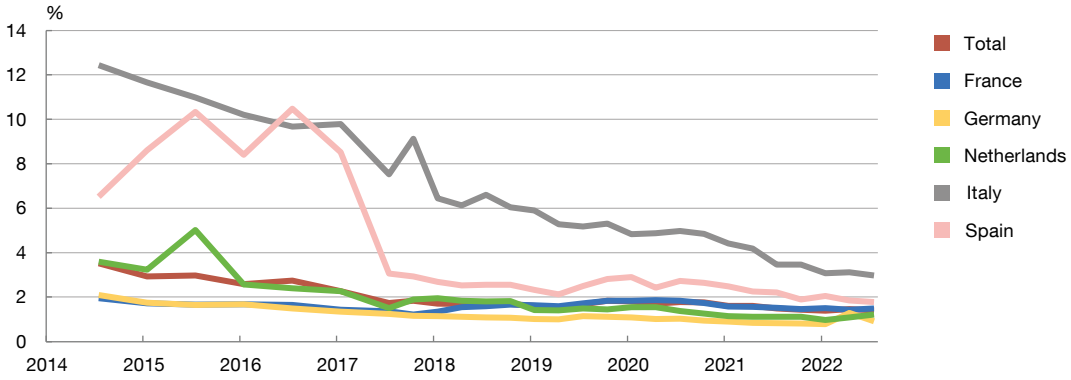
Chart 1

Corporates portfolio. Change in RWD, PDs and LGDs over time (a)

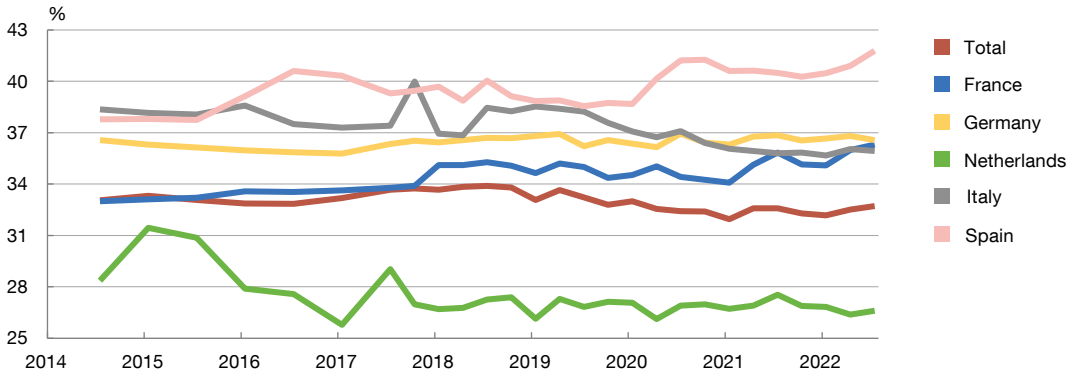
1.a RWD (non-defaulted)



1.b PD (weighted average)



1.c LGD (weighted average)



SOURCE: Authors' calculations.

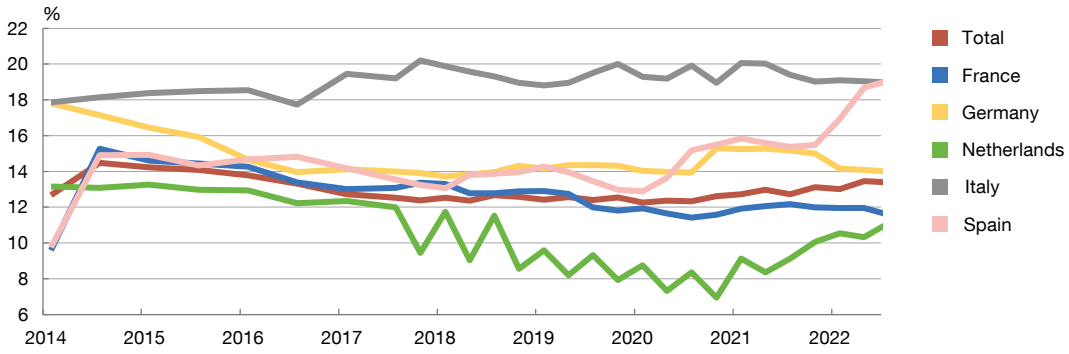
a Only weighted-average PDs and LGDs are plotted.

Following our analysis of the dataset, Chart 3 presents the average values of the PD and LGD parameters reported between 2015 and 2023 for the corporates and retail secured by real estate properties portfolios and across the total and top five counterparty countries. Within this group, Italy and Spain exhibit significantly higher exposure-weighted PDs during the early

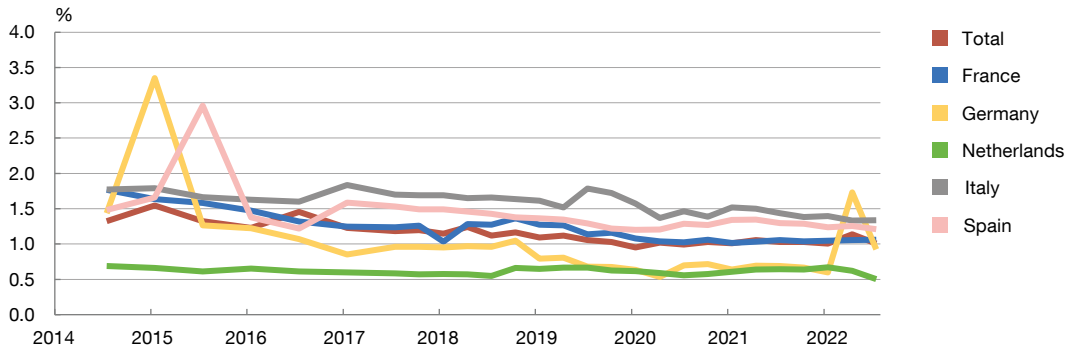
Chart 2

Retail secured by real estate portfolio. Change in RWD, PDs and LGDs over time (a)

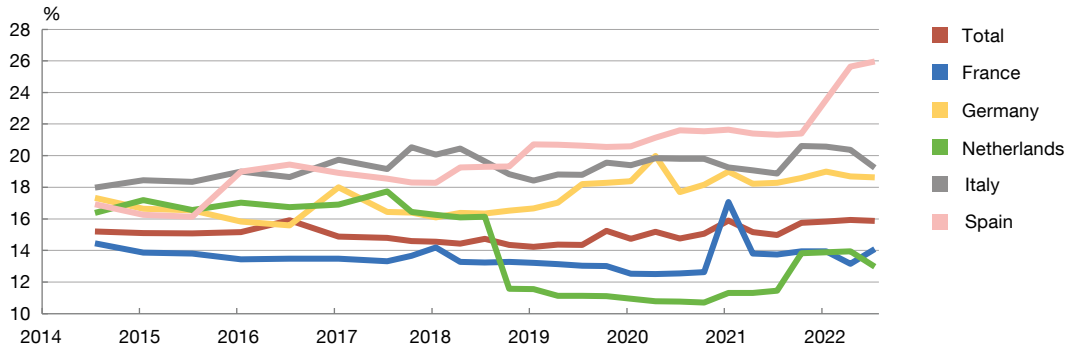
2.a RWD (non-defaulted)



2.b PD (weighted average)



2.c LGD (weighted average)



SOURCE: Authors' calculations.

a Only weighted-average PDs and LGDs are plotted.

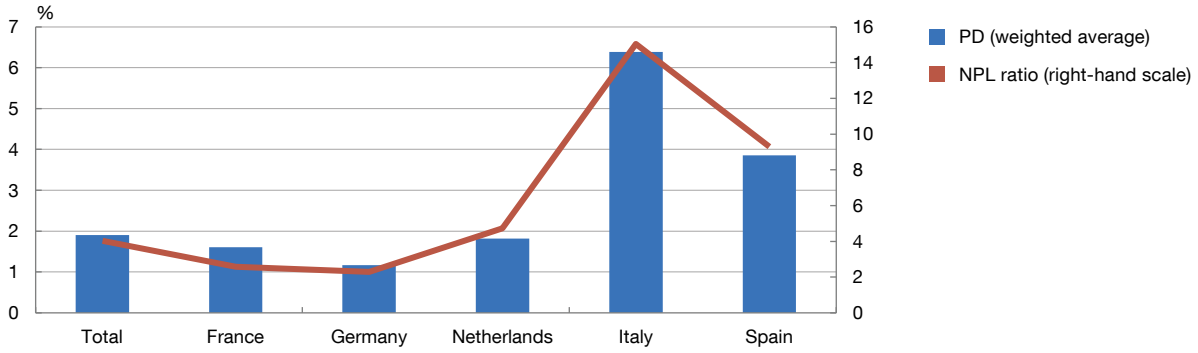
years of the time period available for the corporates portfolio, resulting in elevated exposure-weighted PDs compared with other countries. Overall, PDs exhibit greater relative variability across countries than LGDs. Chart 3 also reports the NPL ratio[17] and the provision coverage

17 Defined as the ratio of defaulted exposure to total exposure.

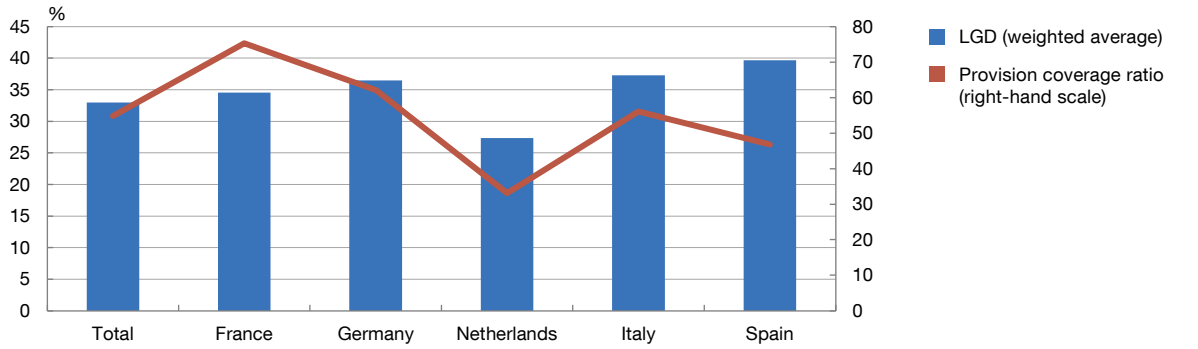
Chart 3

Average PD, LGD, NPL ratio and provision coverage ratio reported by the EBA over the period 2015-2023 (a)

3.a PD versus NPL ratio (corporates)



3.b LGD versus provision coverage ratio (corporates)



SOURCE: Authors' calculations.

a Simple average over time of all ratios.

ratio,[18] both of which are standard metrics disclosed in banks' financial reports, which are indicators closely monitored by investors to assess credit quality, with higher values typically associated with increased credit risk. Unlike PD and LGD, which are derived from banks' internal models, the NPL ratio and the provision coverage ratio are accounting-based metrics drawn from audited financial statements. The NPL ratio is expected to be positively related to the PD level,[19] while the provision coverage ratio may serve as a proxy for LGD.[20] Indeed, for the corporates portfolio countries with higher exposure-weighted PDs clearly tend to report higher NPL ratios, but this is not so obvious for the retail secured by real estate portfolio. By contrast, the relationship between LGD and the provision coverage ratio appears to be even less clear. To further explore the relationship between PD and LGD and the accounting variables, we compute all the possible correlations in Table 2 using the analogous country-level

18 Calculated as the ratio of provisions to total defaulted exposure.

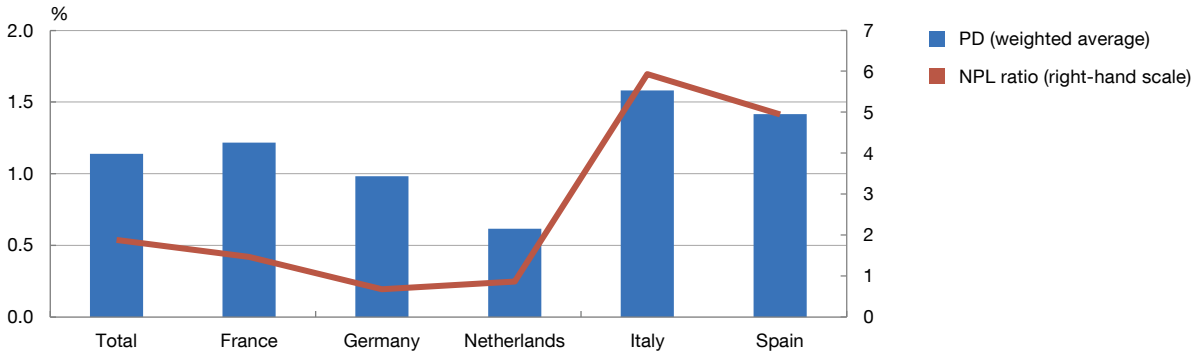
19 The NPL ratio measures the stock of defaulted assets while PD measures the flow to default, meaning that as PD increases so too will the stock of defaulted assets.

20 Provisions can be seen as a proxy of the expected loss calculated as EAD x PD x LGD and the NPL stock as a proxy of EAD x PD, meaning that their ratio can be seen as a proxy of LGD.

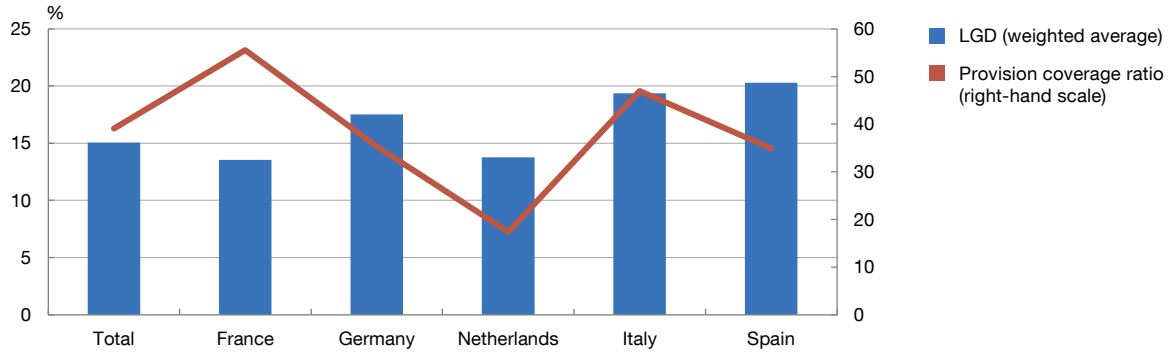
Chart 3

Average PD, LGD, NPL ratio and provision coverage ratio reported by the EBA over the period 2015-2023 (a) (cont'd)

3.c PD versus NPL ratio (retail secured by real estate property)



3.d LGD versus provision coverage ratio (retail secured by real estate property)



SOURCE: Authors' calculations.

a Simple average over time of all ratios.

Table 2

Correlation between risk parameters and accounting variables for the largest 30 countries. The correlation is more relevant for the PD parameter and the corporates portfolio

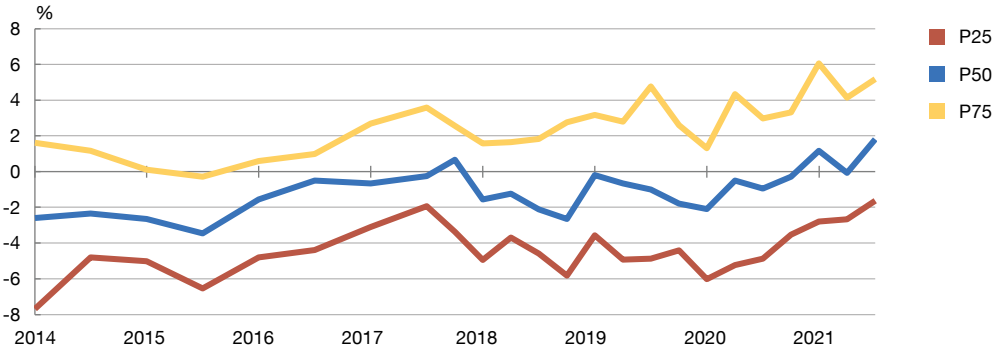
%

	Corporates	Retail secured by real estate
PD (weighted average) and NPL ratio	91.93	74.76
PD (weighted average) and provision coverage ratio	1.52	47.02
LGD (weighted average) and NPL ratio	34.76	63.01
LGD (weighted average) and provision coverage ratio	36.65	43.08

SOURCE: Authors' calculations.

data used in Chart 3 for the top 30 biggest countries. As shown in the results, the correlation between PD and the NPL ratio is relevant for both portfolios. However, the correlation between LGD and the accounting variables is low. This is also true for the provision coverage ratio. One possible explanation for this low correlation with the provision coverage ratio might be the

Chart 4
Yearly distribution of relative RWD changes in 12 months



SOURCE: Authors' calculations.

introduction of the International Financial Reporting Standard 9 provisioning rules, which require banks to provision the one-year expected loss in some cases but the lifetime expected loss in others. International Financial Reporting Standard 9 rules also require banks to estimate a PiT expected loss based on PiT parameters, therefore reducing the correlation with the TtC PD and downturn LGD used for capital requirements purposes.

To conclude this section, we examine the variability over time of banks' RWD. Specifically, we compute the relative change in RWD over a 12-month horizon.[21] First, RWD is calculated for each bank, and the relative 12-month variation is subsequently derived. Using data from all available periods, we find that the median relative change in RWD is -1.1267%, with the 25th and 75th percentiles at -4.48% and 2.83%, respectively, during the period 2015-23. These findings indicate that RWD exhibits non-negligible variation over a 12-month horizon.[22]

Chart 4 shows the evolution of the percentiles of 12-month RWD changes over time. The interquartile range (Q1-Q3) remains broadly stable for most of the period; however, from 2021 the distribution shifts upwards. Several factors could account for the variability of RWD over time: (i) changes in banks' risk appetite; (ii) correlations between internal model outputs and macroeconomic conditions, potentially inducing volatility; (iii) the annual recalibration of internal models; (iv) regulatory developments and their supervisory implications; (v) the introduction or removal of supervisory RWD add-ons; and (vi) changes in the scope of internal models.[23] Because the chart aggregates data across countries, banks and portfolios, idiosyncratic effects are largely smoothed out. Consequently, explanations (i), (iii), (v) and (vi) appear less likely, as they are primarily driven by bank-specific factors. Moreover, since PD estimates are intended to be through-the-cycle and LGD estimates downturn-adjusted, they should not be directly affected by cyclical economic fluctuations, making explanation (ii) less plausible. By contrast, explanation (iv) – adjustments to internal models in response to new

21 For consistency, we compare the same IRB portfolios within each country and bank over a 12-month period, thereby isolating effects from transitions between the SA and IRB approaches.

22 As the data end in June 2023, the last available 12-month relative variation in RWD that can be calculated is that of June 2022.

23 For example, portfolios may migrate from the SA to the IRB approach over time.

regulatory requirements, such as the new definition of default (EBA, 2016), the *EBA Guidelines on PD and LGD estimation* (EBA, 2018) and the *ECB Guidelines on Internal Models* (first issued in 2017, see European Central Bank (2025) for the latest version) – is more consistent with the observed upward shift. Lastly, the latest data show a median 12-month relative change in RWD of approximately 2%.[24]

The 12-month variability of RWD is a relevant metric for supervisors and banks alike. Regulators may use this measure to assess the annual change in RWD at both bank and portfolio level, which may also serve as a benchmark when evaluating Pillar 2 Requirements and Pillar 2 Guidance buffers, while for banks, monitoring 12-month RWD variability is essential for defining internal capital adequacy assessment processes, designing capital plans and determining the appropriate size of management buffers.

4 Methodology and results

4.1 Accounting variables

Our objective is to examine the evolution of credit RWD under the IRB approach over time and its relationship with key risk parameters. Since RWD is intended to capture long-term TtC credit risk,[25] its association with cyclical indicators such as the NPL and provision coverage ratios may be subject to timing mismatches and lag effects. These accounting-based measures are typically considered PiT indicators, as they fluctuate with the economic cycle. To account for these dynamics, we define $RWD_{B,C,P,t}$ as the PiT RWD for bank B, country C, portfolio P and time t, along with its corresponding average $\overline{RWD}_{B,C,P}$ over time. Similarly, the NPL ratio is denoted as $NPLratio_{B,C,P,t}$, with its time average represented by $\overline{NPLratio}_{B,C,P}$. The provision coverage ratio is expressed as $ProvCov_{B,C,P,t}$, and its average as $\overline{ProvCov}_{B,C,P}$.

Based on these definitions, we estimate the following two model specifications:

$$RWD_{B,C,P,t} = \alpha_P + \beta_{1,P} \times NPLratio_{B,C,P,t} + \beta_{2,P} \times ProvCov_{B,C,P,t} \quad (1)$$

$$\overline{RWD}_{B,C,P} = \alpha_P + \beta_{1,P} \times \overline{NPLratio}_{B,C,P} + \beta_{2,P} \times \overline{ProvCov}_{B,C,P} \quad (2)$$

We estimate the regression models using weighted least squares, where portfolio exposure is used as the weighting factor. This approach reflects the assumption that the relationship between RWD and the explanatory variables may be more pronounced in larger portfolios.[26] Table 3 reports the estimated coefficients, corresponding p-values and the adjusted R^2 for both model specifications across portfolio types.

24 We also compute the 12-month range of RWD variability by exposure class. While RWD percentiles differ across portfolio types, the interquartile range (Q1-Q3) remains stable, between 10% and 12%.

25 IRB models employ TtC PDs and downturn LGDs to generate structural risk estimates that are less sensitive to short-term economic fluctuations.

26 It is reasonable to assume that risk parameter estimates and, consequently, RWD values are more robust for larger exposures, due to better data quality, improved model calibration and closer portfolio monitoring.

Table 3
Estimated coefficients, corresponding p-values and the adjusted R^2 for both model specifications across portfolio types

	Equation (1)					Equation (2)				
	#	Const	NPLratio	ProvCov	R^2Adj (%)	#	Const	NPLratio	ProvCov	R^2Adj (%)
Corp.	8582	0.39***	1.31***	0.02***	21	269	0.34***	1.82***	0.05**	27
Corp. Other	6112	0.40***	1.63***	0.01***	18	181	0.39***	2.13***	0.01	26
Corp. SME	5005	0.38***	1.14***	0.003	19	158	0.30***	1.42***	0.09	20
Corp. Specialised lending	4164	0.38***	1.16***	0.03***	11	121	0.31***	1.20**	0.11***	12
Ret.	9908	0.11***	0.98***	0.06***	27	330	0.07***	1.23***	0.12***	38
Ret. Other	8573	0.13***	0.79***	0.15***	15	290	0.08***	1.10***	0.18***	21
Non-SME	8341	0.05***	2.92***	0.17***	32	282	-0.02	3.36***	0.22***	40
SME	5229	0.22***	0.34***	0.05***	7	170	0.19***	0.46***	0.07**	9
Ret. Qual.	4629	0.09***	1.82***	0.09***	24	150	-0.13***	2.62***	0.23***	67
Ret. Sec. RE	7853	0.10***	1.03***	0.03***	30	259	0.10***	1.32***	0.03*	39
Non-SME	7763	0.10***	1.17***	0.02***	29	254	0.09***	1.56***	0.02	37
SME	3098	0.19***	0.56***	0.03***	8	98	0.19***	0.59**	0.03	7

SOURCE: Authors' calculations.

a The first five columns report regression results using quarterly observations, while the last five columns present results based on time-averaged variables. Significance levels: (*) $p < 0.05$, (**) $p < 0.01$, (***) $p < 0.001$.

The following conclusions can be drawn from the regression results:

- The coefficients of both *NPLratio* and *ProvCov* exhibit the expected signs and are statistically significant in most portfolios across both specifications, with only a few exceptions.

- The adjusted R^2 of equation (2) exceeds that of equation (1), which is consistent with the notion that RWD captures long-term TtC credit risk estimates.

We extend the baseline models by including country-specific dummy variables[27] to explore potential cross-country differences. Table 4 reports the adjusted R^2, the estimated coefficients and significance levels of the dummies for a subset of countries.[28] Overall, most of the country dummies are not statistically significant, except in the case of the total corporates portfolio. In this specification, corresponding to equation (1), for the corporates portfolio the dummies for France and Spain are positive, whereas those for Germany, the Netherlands and Italy are negative. These results suggest the presence of implicit support or penalisation mechanisms, potentially driven by an array of variables including supervisory or institutional practices.[29] Additionally, we conducted a joint significance test of the country dummies, which rejected the null hypothesis that all coefficients are equal to zero across exposure types and both model specifications, at the 1% significance level.

27 A similar analysis using quarter dummies rather than country dummies was conducted, but it did not yield a material improvement in model performance or provide additional insights.

28 For simplicity, we report results only for the five countries with the largest portfolio exposures.

29 Previous papers, such as Turk-Ariss (2017) and Böhnke, Ongena, Paraschiv and Reite (2024) had measured the effect of country dummies on RWD levels, controlling for macroeconomic variables but not for PDs and LGDs.

Table 4
Estimated coefficients and significance levels of country-specific dummy variables for a selected group of countries (a)

	Equation (1)								Equation (2)							
	NPLratio	ProvCov	France	Germany	Netherl.	Italy	Spain	R^2Adj (%)	NPLratio	ProvCov	France	Germany	Netherl.	Italy	Spain	R^2Adj (%)
Corp.	0.74***	0.01***	0.04**	-0.10***	-0.11***	-0.03*	0.07***	57	1.37***	0.04**	0.05	-0.09**	-0.11***	-0.10*	0.04	62
Corp. Other	0.85***	0.01***	0.02	-0.09***	-0.07***	-0.02	0.06**	50	1.21**	0.01	0.03	-0.09*	-0.06	-0.04	0.05	59
Corp. SME	0.80***	0.02***	0.09	-0.19	-0.18	-0.12	-0.01	61	1.53***	0.13**	0.13**	-0.13*	-0.14*	-0.20**	-0.02	61
Corp. Specialised lending	0.82***	0.02***	-0.17**	-0.12*	-0.27***	-0.08	0.08	39	0.52	0.05	-0.16	-0.14	-0.27*	-0.07	0.07	28
Ret.	0.30***	0.04***	-0.09	-0.04	-0.11	-0.01	-0.04	62	0.72***	0.10***	-0.09	-0.03	-0.07	-0.03	-0.04	70
Ret. Other	0.16***	0.06***	-0.24	-0.09	-0.09	-0.07	0.01	57	0.25	0.13***	-0.13	0.014	0.02	0.02	0.11	48
Non-SME	2.20***	0.07***	-0.23	-0.03	-0.02	-0.03	-0.003	65	3.08***	0.15***	-0.11	0.07	0.10	0.00	0.07	60
SME	0.28***	0.06***	-0.12	-0.10	-0.01	-0.09	0.05	50	0.32*	0.09***	-0.10	-0.07	-0.01	-0.08	0.07	50
Ret. Qual.	1.74***	0.00	-0.10	-0.13	-0.03	0.13	-0.07	81	1.82***	0.02	-0.04	-0.11	-0.05	0.16	-0.02	89
Ret. Sec. RE	0.51***	0.01***	-0.06	-0.03	-0.07	-0.01	-0.05	63	1.01***	0.03**	-0.05	-0.02	-0.06	-0.03	-0.06	77
Non-SME	0.55***	0.01***	-0.07	-0.02	-0.07	-0.01	-0.05	63	1.01***	0.03*	-0.07	-0.02	-0.06	-0.03	-0.06	78
SME	0.20***	0.02***	-0.04	-0.21	-0.02	-0.06	-0.06	53	0.20	0.05*	-0.08	-0.16	-0.06	-0.11	-0.08	51

SOURCE: Authors' calculations.

a Country dummy coefficients in equations (1) and (2). Only the five largest countries by portfolio exposure are reported. Significance levels: (*) $p < 0.05$, (**) $p < 0.01$, (***) $p < 0.001$.

Lastly, we examine the effect of a dummy variable indicating whether the reporting bank and the counterparty are located in the same country, i.e. whether the exposure is domestic. We denote this dummy variable as *Nac,* which might capture several factors including potential supervisory bias in the treatment of domestic exposures, or differences in portfolio composition or in loan maturity, among other factors. Table 5 reports the estimated coefficients and p-values for this variable under both model specifications. Notably, the *Nac* dummy is negative and statistically significant for retail portfolios, while it is positive and significant for corporate portfolios. This pattern is consistent across both specifications, suggesting a differential treatment of domestic exposures across portfolio types. This suggests a relatively adverse treatment of domestic corporate exposures and a more favourable treatment of retail portfolios.

4.2 PD and LGD variables

We extend our analysis by estimating a novel model that incorporates country-level credit risk parameters. Specifically, we use the quarterly values of $PD_{C,P,t}$ and $LGD_{C,P,t}$, defined for each country C, portfolio P and time t. As detailed in Section 3, two versions were available for each parameter: an exposure-weighted average and an unweighted average based on the percentiles published quarterly by the EBA at country level. Empirical testing showed that the exposure-weighted averages yielded better explanatory power; therefore, we report results based on these parameters. Specifically, the estimated model is specified as:

$$RWD_{B,C,P,t} = \alpha_P + \beta_{1,P} \times LGD_{C,P,t} \times f\left(PD_{C,P,t}\right) \quad (3)$$

Table 5
Effect of the domestic exposure dummy (Nac) on equations (1) and (2) (a)

	Equation (1)					Equation (2)				
	Const	NPLratio	ProvCov	Nac	R^2Adj (%)	Const	NPLratio	ProvCov	Nac	R^2Adj (%)
Corp.	0.37***	1.18***	0.02***	0.06***	24	0.33***	1.67***	0.05**	0.05**	29
Corp. Other	0.37***	1.39***	0.01***	0.08***	25	0.36***	1.74***	0.01	0.08***	34
Corp. SME	0.34***	1.09***	0.01	0.06***	21	0.27***	1.35***	0.10*	0.05	21
Corp. Specialised lending	0.35***	1.12***	0.03***	0.07***	13	0.30***	1.16**	0.11**	0.03	12
Ret.	0.15***	1.02***	0.06***	-0.05***	34	0.10***	1.23***	0.12***	-0.05***	46
Ret. Other	0.26***	0.85***	0.12***	-0.14***	27	0.24***	1.18***	0.13***	-0.15***	38
Non-SME	0.18***	2.83***	0.14***	-0.14***	41	0.17***	3.24***	0.15***	-0.16***	52
SME	0.27***	0.36***	0.05***	-0.06***	11	0.23***	0.5***	0.08**	-0.06***	15
Ret. Qual.	0.24***	1.67***	0.07***	-0.15***	34	0.03	2.44***	0.20***	-0.07**	68
Ret. Sec. RE	0.12***	1.04***	0.03***	-0.03***	35	0.11***	1.33***	0.04**	-0.03***	44
Non-SME	0.12***	1.17***	0.03***	-0.04***	35	0.11***	1.55***	0.03*	-0.03***	42
SME	0.20***	0.56***	0.03***	-0.01	8	0.20***	0.60**	0.03	-0.01	6

SOURCE: Authors' calculations.

a Estimated coefficients and significance levels of the Nac dummy variable, which equals one when the bank and the counterparty are domiciled in the same country. Significance levels: (*) $p < 0.05$, (**) $p < 0.01$, (***) $p < 0.001$.

The term $LGD_{C,P,t} \times f\left(PD_{C,P,t}\right)$ corresponds to the regulatory formula used to compute RWD, as defined under the CRR and CRD frameworks (European Parliament and European Council, 2019; 2024).

Table 6 reports the estimated coefficients, associated p-values and adjusted R^2 values for each portfolio. Based on these results, we draw the following conclusions:

- The constant term is positive and statistically significant in most specifications, suggesting that RWD may be strictly positive even when regulatory risk parameters approach zero.[30]
- The coefficient in the regulatory RWD formula deviates substantially from one, indicating a potential gap between observed RWD levels and those implied by the capital requirements function.
- The adjusted R^2 values are relatively low, which may reflect the limitation of using country-level averages for PD and LGD, rather than bank-specific internal estimates. Indeed, the R^2 values are comparable to or lower than those reported in the previous section.

It is important to emphasise that the regulatory capital formula is not linear but concave in PD.[31] As a result, computing capital using average input parameters does not generally yield

30 However, due to the concavity of the capital requirements formula, this hypothesis cannot be fully tested unless more detailed PD and LGD data are provided.

31 The PD used in the capital requirements formula needs a count-based PD, meaning that using an exposure-weighted or percentiles-based PD is a deviation from the regulatory framework.

Table 6
RWD as a function of the regulatory capital formula (a)

	#	Const	LGD x f(PD)	R^2Adj (%)
Corp.	7893	0.15***	0.47***	34
Corp. Other	5538	0.20***	0.31***	26
Corp. SME	4668	0.20***	0.39***	35
Corp. Specialised lending	3170	0.14***	0.47***	11
Ret.	9140	0.03***	0.58***	46
Ret. Other	7903	0.02***	0.60***	46
Non-SME	7696	-0.08***	0.81***	50
SME	4936	0.16***	0.28***	25
Ret. Qual.	4124	0.07***	0.40***	28
Ret. Sec. RE	7404	0.05***	0.37***	46
Non-SME	7296	0.05***	0.38***	44
SME	3000	0.15***	0.39***	7

SOURCE: Authors' calculations.

a Regression results using the IRB regulatory formula LGD x f(PD) as the explanatory variable for RWD. The table reports estimated coefficients, p-values and adjusted R^2 for each portfolio. Significance levels: (*) p < 0.05, (**) p < 0.01, (***) p < 0.001.

Table 7
Country dummy coefficients in equation (3) (a)

	Const	LGD x f(PD)	France	Germany	Netherl.	Italy	Spain	R_2Adj (%)
Corp.	0.42***	0.18*	0.02	-0.12***	-0.10***	-0.04***	0.04***	55
Corp. Other	0.48***	0.08*	0.00	-0.12***	-0.07**	-0.02	0.04*	47
Corp. SME	0.40***	0.20*	0.10	-0.16*	-0.08	-0.09	0.02	59
Corp. Specialised lending	0.29	0.45	-0.13	-0.20	-0.20	-0.04	0.09	29
Ret.	0.16***	0.24***	-0.05**	-0.03	-0.07***	0.01	-0.04*	55
Ret. Other	0.30***	0.16*	-0.14***	-0.03	-0.04	-0.02	0.04	56
Non-SME	0.22***	0.34*	-0.15***	-0.04	-0.06*	0.03	0.02	58
SME	0.31	0.13*	-0.10	-0.14	-0.03	-0.10	0.01	46
Ret. Qual.	0.21	0.18***	-0.07	-0.12	-0.04	0.12	-0.09	45
Ret. Sec. RE	0.14***	0.14***	-0.04	-0.03	-0.06*	0.002	-0.04	62
Non-SME	0.14***	0.14***	-0.06*	-0.02	-0.06*	0.001	-0.04	62
SME	0.26*	0.24***	-0.03	-0.21	0.002	-0.06	-0.06	53

SOURCE: Authors' calculations.

a Estimated coefficients and significance levels of country-specific dummy variables for a selected subset of countries. Only the five largest countries by portfolio exposure are shown. Significance levels: (*) p < 0.05, (**) p < 0.01, (***) p < 0.001.

the same outcome as calculating it on a loan-by-loan basis because of the concavity of the capital function, the use of average parameters tends to produce upward-biased (i.e., conservative) estimates. Furthermore, employing average PD and LGD values does not account for potential correlations between these two variables. Consequently, capital requirements computed at individual loan level are likely to be higher than those derived from portfolio level averages when PD and LGD are positively correlated. In wholesale portfolios,

Table 8
Effect of the domestic exposure dummy (Nac) on equation (3) (a)

	Const	LGD x f(PD)	Nac	R^2Adj (%)
Corp.	0.14***	0.44***	0.06***	38
Corp. Other	0.19***	0.27***	0.09***	34
Corp. SME	0.16***	0.37***	0.07***	36
Corp. Specialised lending	0.14***	0.43***	0.05***	13
Ret.	0.06***	0.57***	-0.03***	50
Ret. Other	0.10***	0.55***	-0.08***	50
Non-SME	0.02*	0.74***	-0.08***	53
SME	0.18***	0.27***	-0.02***	26
Ret. Qual.	0.13***	0.39***	-0.07***	32
Ret. Sec. RE	0.07***	0.37***	-0.02***	48
Non-SME	0.07***	0.38***	-0.03***	48
SME	0.15***	0.39***	-0.001	7

SOURCE: Authors' calculations.

a Estimated coefficients and significance levels of country-specific dummy variables for a selected subset of countries. Only the five largest countries by portfolio exposure are shown. Significance levels: (*) $p < 0.05$, (**) $p < 0.01$, (***) $p < 0.001$.

adjustments for company size and loan maturity also affect RWD. In this analysis, we assume sales to be €5 million and a maturity of 2.5 years, as this information is not disclosed by the EBA.

Similar to the previous section, we extend the model by including country[32] and domestic-exposure dummy variables to assess the role of jurisdiction-specific effects. Table 7 reports the results with the inclusion of country dummies. Notably, their introduction substantially increases the value of the constant term while reducing both the size and significance of the regulatory formula coefficient. As in the previous analysis (Table 4), in the corporates portfolio the country dummies for Germany, the Netherlands and Italy are negative and statistically significant, whereas the dummy for Spain is positive and significant. In the retail portfolio, the only significant country dummies are those for France and the Netherlands, both of which are negative. These findings support the presence of cross-country differences that may reflect institutional factors, such as variations in regional supervisory practices or support mechanisms, which could influence the calibration or reporting of RWD. Lastly, as with the accounting variables, the joint significance test for the country dummies rejects the null hypothesis that all coefficients are equal to zero across exposure types, at the 1% significance level.

Table 8 shows a similar pattern for the domestic exposure dummy *(Nac)* as that observed in the previous section. The *Nac* variable is associated with a negative and statistically significant effect for retail portfolios. Conversely, for wholesale portfolios, the coefficient is positive and significant.

32 As in the previous section, the inclusion of quarter dummy variables neither improved model performance materially nor provided additional insights.

5 Conclusion

RWD is a key indicator for market participants, particularly in cross-bank and cross-country assessments of credit risk. However, drawing robust conclusions remains challenging due to the limited availability of granular, publicly disclosed data. This article offers a systematic comparison of RWD across countries and banks over time, using data published by the EBA on RWD and key credit risk parameters – namely, PD and LGD.

We begin with a descriptive analysis of the levels of and change over time in RWD and its underlying risk parameters. We then compare the long-term average PD and LGD across countries for two representative portfolios. Additionally, we analyse the distribution of 12-month relative changes in RWD, revealing that RWD can exhibit substantial variation over short horizons, underscoring the importance of understanding its underlying drivers.

We then estimate two regression models to explain RWD, using both quarterly and time-averaged accounting variables. In both specifications, the explanatory variables exhibit the expected signs and are statistically significant, including a positive and significant constant term. As expected, the model based on average values outperforms the one using quarterly data, reflecting the through-the-cycle nature of RWD.

When introducing country-specific dummy variables, statistically significant effects are observed only for the corporates portfolio. In this case, the dummies for Spain and France exhibit positive coefficients, suggesting relatively higher RWD levels than in other countries. More notably, the inclusion of a dummy variable indicating whether the reporting bank and the counterparty are domiciled in the same country reveals a distinct pattern: it is associated with a negative and statistically significant effect for retail portfolios and a positive effect for wholesale portfolios, which might suggest the presence of a potential bias in the RWD treatment across portfolio types.

We extend the analysis by modelling RWD as a function of internal risk parameters (PD and LGD). The results again show a positive and statistically significant constant term, suggesting that RWD remains strictly positive even when estimated risk parameters approach zero. When including country-specific and domestic-exposure dummies, we observe patterns consistent with previous specifications: Spanish corporate portfolios are associated with relatively higher RWD, while retail (wholesale) portfolios exhibit a negative (positive) and statistically significant effect when the exposure is (is not) domestic. These findings could point to persistent cross-country differences and potential biases in the calibration or reporting of RWD.

Lastly, we find that the EBA databases provide valuable opportunities for further research, particularly in the analysis of parameter cyclicality and its correlation with macroeconomic variables. However, a fundamental limitation in the publicly available data constrains the depth of such analyses. Specifically, PD and LGD values are disclosed only at portfolio and country level. As a result, model performance is constrained by the inability to capture bank-specific risk parameters. Greater data granularity, particularly the disclosure of PD and LGD at bank

level, would significantly enhance the ability of researchers and supervisors to understand the determinants of RWD and to assess cross-bank and cross-country differences more accurately. For those reasons, we encourage regulators, especially the EBA, to expand the scope of public disclosures in order to support more robust and transparent analyses.

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