



BANCA D'ITALIA
EUROSISTEMA

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(Occasional Papers)

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how not to get lost

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INSIDE THE LABYRINTH OF BASEL RISK-WEIGHTED ASSETS: HOW NOT TO GET LOST

by Francesco Cannata, Simone Casellina and Gregorio Guidi ♦

Abstract

Many studies have questioned the reliability of banks' calculations of risk-weighted assets (RWA) for prudential purposes. The significant divergences found at international level are taken as indicating excessive subjectivity in the current rules governing banks' risk measurement and capital requirement calculations. This paper emphasises the need for appropriate metrics to compare banks' riskiness under a risk-sensitive framework (either Basel 2 or Basel 3). The ratio of RWA to total assets – which is widely used for peer analyses – is a valuable starting point, but when analysis becomes more detailed it needs to be supplemented by other indicators. Focusing on credit risk, we propose an analytical methodology to disentangle the major factors in RWA differences and, using data from Italian banks (given the inadequate degree of detail of Pillar 3 reports), we show that a large part of the interbank dispersion is explained by the business mix of individual institutions as well as the use of different prudential approaches (standardised and IRB). In conclusion we propose a simple data template that international banks could use to apply the framework suggested.

JEL Classification: G18, G21, G28.

Keywords: Basel Accord, risk-weighted assets, banking supervision, credit risk.

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♦ Bank of Italy, Regulation and Supervisory Policies Department.

“For every complex problem, there is a clear solution.

Simple and wrong.”

(George Bernard Shaw)

1. Introduction¹

Risk-taking is part and parcel of banking. The purpose of financial regulation is to ensure that risk is managed in a “sound and prudent” manner that helps maintain the stability of the financial system as a whole. The evolution of the regulatory framework over the last quarter-century has assigned a central role to the manner in which institutions measure risks, in that the requirement for capital – identified as the main defence against losses – has been linked to the type and magnitude of risks. The cornerstone of banking supervision is the solvency ratio, which measures the amount of supervisory capital vis-à-vis risk-weighted assets (RWA).

This link was introduced with the 1988 Capital Accord (Basel 1) and tightened in the following years, in order to overcome the shortcomings that the original crude measure revealed over time (i.e. vulnerability to arbitrage). Two main innovations have been introduced in this direction. First, the range of risks to be covered by capital has been broadened (market and operational risks under Pillar 1 and all other relevant risks under Pillar 2). Second, a more granular and accurate set of risk weights for the various asset classes has been developed, by allowing banks to use their internal metrics (for capital allocation and pricing, say) for prudential purposes as well. The main steps in this evolution have been the Market Risk Amendment (1996), Basel 2 (2004) and Basel 3 (2010).

More recently, authorities, banks and market analysts have been paying an increasing amount of attention to banks’ RWA.

¹ The opinions expressed here are those of the authors only and do not necessarily represent the views of the Bank of Italy. We are grateful to J. Carmassi, L. Condorelli, M. Gangeri, P. Grippa, F. Piersante, A. Pilati, A. Resti, L. Suardo and other participants in seminars at the Bank for their comments on a preliminary draft. We also thank C. Lucidi and R. Meservey for their language revision. Any remaining errors are our own responsibility.

First of all, the Basel 3 reform is designed for more comprehensive risk capture, especially when risk arises out of complex financial transactions (e.g. OTC derivatives, trading book transactions and securitisation exposures). With the introduction of the new rules, a sharp debate began, questioning how far the new rules for calculating RWA adequately reflect the actual risks posed by different business models (say, commercial banking vs. investment banking).

Secondly, given that the risk-based paradigm is retained within the post-crisis regulatory framework, it has been observed that unjustified divergences in banks' RWA could undermine homogenous implementation of the Basel 3 rules, thus jeopardising a true level playing field.

Third, in approaching the new capital targets, manoeuvres on RWA do represent a possible option for banks – especially those which already use or plan to use internal models – to increase their capital ratios, casting doubt on the role of supervisory rules and practices in determining capital requirements (first of all, by validating banks' internal models).

Finally, after a few years of implementation of Basel 2, it is interesting to look at banks' RWA in a comparative way, in order to assess to what extent divergences across institutions are an intended outcome of the risk-based paradigm rather than the effect of undesired factors, such as possibly unjustified differences in banking and supervisory practices and rules. To this end, many recent analyses on the publicly available data (Pillar 3) have highlighted the factors behind these differences and sought to determine their nature and magnitude. Most of these works argue that risk-weighted assets cannot be compared across jurisdictions and do not properly reflect actual risk. They all accordingly call for greater convergence of supervisory rules and practices.

As mentioned, the attention of authorities is also shifting to RWA. Dedicated workstreams have recently been set up at the Basel Committee and European Banking Authority, with the common objective of investigating magnitude and nature of divergences across institutions and assessing the scope for further convergence of supervisory practices. This paper contributes to this strand of research by dispelling possible confusion in looking at banks' RWA and proposing a methodological framework for more in-depth analysis.

The analysis starts from two ideas. First, risk-weighted assets constitute a complex phenomenon, and in a risk-sensitive prudential framework this complexity derives largely from the complexity of the underlying financial business. Therefore, given the very large number of variables in play in the prudential rules, measuring banks' riskiness with oversimple proxies is not always easy or even desirable: proper understanding of a complex phenomenon requires the right glasses, to avoid mistaken or misleading conclusions. Secondly, the ultimate objective of risk-based capital regulation is more accurate allocation of capital among institutions, penalising those with low-quality portfolios and offering adequate capital incentives to those with high-quality assets. Thus, to some extent divergences in banks' RWA represent an intended, desired effect of regulation. The problem is the unintended, undesired differences, which are likely to jeopardise a true level playing field among banks and jurisdictions.

In light of the foregoing, this paper pursues three objectives:

- i) correct identification of the problem, i.e. adopting appropriate indicators as the analysis becomes more detailed;
- ii) an analytical methodology for decomposing the main factors in potential RWA divergences for credit risk, with precise quantification of their magnitude and contribution to the overall difference;
- iii) a data template to be adopted at international level to allow meaningful and informative comparison across institutions.

The paper does not treat some issues that, though important, would further complicate the first stage of the discussion. That is, the analysis focuses on credit risk only, it is limited to the static dimension of RWA (cross section), it does not compare the prudential metrics and the actual risk profile of banks' portfolios (backtesting), and it does not address jurisdictional differences in prudential rules and validation criteria. Some of these issues could be taken up in future research, relying also on the outcomes of the international workstreams.

* * *

The paper is organised as follows. Section 2 reviews the main mechanisms of the Basel 2 rules for credit risk, noting the large number of interacting factors. Section 3 provides a critique of the main recent reports on RWA. Section 4 discusses the properties that indicators need to have for this type of analysis and proposes a set of metrics to be applied according to what data are available. Section 5 sets out a methodology for decomposition to disentangle the main factors in divergences of RWA, and Section 6 reports on a simulation using actual data from Italian banks, in an analysis that is much richer than that on European banks, given the insufficient comparability and detail of Pillar 3 reports. Accordingly, Section 7 suggests a simple data template to be disclosed by banks to allow full implementation of the proposed methodology at international level. Section 8 concludes.

2. A recap of the Basel rules on credit risk

The Basel rules require banks to compute RWA for all relevant types of risk: some (credit/counterparty, market, and operational) are governed by the Pillar 1 minimum requirements, others (interest rate, concentration, reputational) are part of the Pillar 2 review process. Focussing on Pillar 1, for each of the three types the regulatory framework offers a set of alternative methodologies that require a large number of inputs for calculation. Our analysis accordingly looks at credit risk², which continues to constitute the main risk for most banks in many countries.

In the present section we summarise the current methodologies for the calculation of capital requirements against credit risk: the Standardised and the Internal Ratings-Based (IRB) Approaches, both introduced by Basel 2. A common feature of these approaches is the allocation of exposures across different portfolios (“asset classes”), typically differentiated by type of counterparty (e.g. corporate, retail), to which different risk weights are assigned. In general terms, the definition of these portfolios is broadly similar if not identical in the two approaches.

² As stated in Arroyo et al. (2012), due to the very different ways in which the capital requirements are calculated, it is hard to devise a sound metric to encompass all three Pillar 1 risks (credit, market, operational).

A second feature of the current rules that cannot be neglected in reading prudential data on credit risk is the possibility for banks of using both approaches simultaneously, though on different portfolios and/or portions and only for a certain amount of time. Notwithstanding the general principle that the option for IRB must be a strategic decision for a financial institution, it is widely accepted in national regulations that full IRB coverage at group level can be phased-in fairly gradually (over 7 years for Italian banks, for instance), so as to allow all group members to become familiar with the more advanced metrics. The idea is that internal ratings need to be processed and accepted by the branch network, especially to satisfy the ‘use test’ requirement. Also, the standardised approach can be used by an IRB institution on a permanent basis for a limited portion of total assets where the size of the portfolio or the availability of data make the implementation of a sound IRB system inconvenient or impossible.

i) Standardised Approach (SA)

Under this approach, risk weights depend on the external ratings provided by an External Credit Assessment Institution (ECAI). The number of risk buckets is relatively small (corporate exposures, for instance, are weighted at 20%, 50%, 100% or 150%); for unrated exposures, a fixed 100% risk weight is used. As in Basel 1, off-balance-sheet items are converted into on-balance-sheet exposures in order to contribute to the RWA calculation (as ‘credit equivalent’).

Specific risk weights are assigned to ‘high-risk categories’ and to past due loans, which are a distinct asset classes. For past-due loans some degree of discretion can be exercised by national authorities in reducing the risk weight according to the degree of provisioning for each loan.

Some of the reports appear not to notice that even under the Standardised Approach the weights may vary. “Mortgages,” for instance, can have three different risk weights: 35% for residential mortgages and 50% or 100% for other mortgages. The average for this particular asset class, accordingly, will range from 35% to 100% depending on share and type of non-residential mortgages.

ii) IRB Approach

Under the IRB approach, the allocation of exposures to portfolios follows the same rules as in the SA approach, except that the number of asset classes is higher (greater risk-sensitivity requires a more granular recognition of the risk profile of the different exposure and/or transaction types, such as revolving credit or specialised lending). One major difference is the large number of factors in the capital requirement calculation and the possibility/requirement for institutions to use internal estimates of risk parameters for prudential purposes.

The risk parameters are the inputs needed to estimate the credit risk of a single loan: probability of default (PD), i.e. the probability that the counterparty (or transaction) will not fail to repay within 1 year; loss-given-default (LGD), i.e. the amount expected not to be recovered in case of default; exposure to default (EAD), which measures the exposure amount at time of default (for on-balance-sheet items, the nominal amount; for off-balance-sheet items, a figure derived from an estimation process); and finally, the maturity (M) of the loan. The PD must always be provided by the banks, whereas LGD, EAD and M can either be provided by the regulation itself (Foundation IRB) or estimated by banks and validated by supervisors (Advanced IRB). Unlike the SA, defaulted exposures are not a distinct asset class but belong to the original portfolio with a set PD of 100%.

The conversion into risk weights derives from analytical formulae that link capital requirements to the unexpected component of credit losses (UL), the idea being that the expected loss component (EL) is already covered by provisions. Unlike the SA, risk weights are a continuous function of the risk parameters. A UL-only approach has also required regulators to account for the portion of expected loss that is not fully covered by provisions, on a loan-by-loan basis: the difference between EL and provision (Regulatory Calculation Difference, RCD), if positive, has to be deducted from capital and, if negative, can be computed in Tier 2 capital within specific limits.

The final significant feature of the IRB approach is the role of the supervisory authorities. Any IRB system requires supervisory validation and formal authorisation for use to calculate capital requirements. As we shall see further on, the validation criteria range from data and modelling requirements to organisational principles.

3. A review of possible factors in RWA divergences

The introduction of the Basel 2 rules in 2008, with the consequent lack of a long time series, explains why the economic literature on RWA is still scanty, but the recently renewed attention to the topic on the part of regulators and market participants is confirmed by a large number of papers, mostly by market analysts, comparing RWA across institutions and jurisdictions. Notwithstanding the methodological differences, most of them argue that banks' RWA measurements contain an excessive degree of subjectivity and are therefore not readily comparable across institutions; in addition, some of them claim that risk-weighted assets do not even properly reflect the actual risk in banks' balance sheets. As a way forward, they all call for stronger action by authorities to enhance the convergence of supervisory rules and practices.

What is clear enough is that market distrust of the RWA reported by banks is likely to have consequences, such as: re-calculation by banks themselves of capital ratios and disregard of regulatory ratios; greater reliance on measures similar to leverage ratios; higher capital ratios requested by the market to compensate for the perceived unreliability of the denominator (Le Leslé and Avramova, 2012).

In the present section we offer a critique of this strand of work, with a selective survey of the most representative studies to date in order to classify all potential factors behind RWA. This is, in our view, a necessary step towards establishing some order in the current debate and focusing attention on a few key issues.

A preliminary clarification concerns the dimension of the analysis. RWA can be investigated either in a static way (cross-section) or dynamically (time series). As regards the latter, i.e. looking at the pro-cyclicality of capital rules, the question is whether and to what extent risk-based capital requirements, especially those based on internal models (i.e. internal ratings for credit risk), tend to increase in recession and decrease during economic expansions, in line with the creditworthiness of the borrowers. The argument is that if banks are not able to meet regulatory ratios (and if their borrowers cannot switch to other sources of finance), they might tighten their lending policies, especially when the cost of raising new capital is higher (as in downturns).

The evidence is mixed. Some authors (Repullo and Suarez, 2009) identify a link between the Basel 2 capital ratios and the credit supply; others (Cannata *et alii*, 2011) argue for disentangling myth and reality as regards the cyclical nature of capital regulation: they find that capital requirements did not increase very much in 2008-09, since the increase in borrowers' defaults led to higher provisions and lower capital charges (as a consequence of the Basel 2 mechanisms) and several banks adopted dynamic portfolio strategies. More recent research also highlights that in spite of the recession there has been a downward trend in European banks' RWA. One factor in this trend (Barclays Capital, 2011) is that banks are moving from SA to IRB and are continuing to "refine" their IRB models (e.g., RBS: "data cleansing"; Lloyds: "model changes"; Santander, Unicredit and Nordea: "optimisation"; Danske and Commerzbank: "parameter update").

As regards the static dimension of RWA, the main factors in RWA divergences across banks can be classified into two groups:

- i) desired effects;
- ii) undesired effects.

- i) Desired effects

Desired effects recognise that the main objective of risk-based regulation is proper differentiation of banks by risk profile: the evolution from Basel 1 to Basel 2 was mainly justified by the need to redistribute capital between the 'high-quality' portfolio banks and the others, keeping its overall amount at global level constant. Therefore, RWA differences among institutions represent a desired outcome when they are justified by different: a) risk profiles of the assets; b) business models.

- a. Risk profile

As mentioned, diversification of the risk profiles of banks' balance sheets is the most strongly desired effect of RWA divergences across institutions.

First of all, macroeconomic and other 'external' factors do clearly matter in a bank's risk position (e.g. growth and volatility of GDP and interest rates, the fiscal

sustainability of public finances, legal and institutional frameworks). As an example, Keefe, Bruyette and Woods (2011) observe that the low risk weights for the mortgage portfolios of Nordic banks can be justified by the strong social security system in those countries; also, an above-average LGD for Italian banks could be justified by longer period required for resolution in this jurisdiction. Le Leslé and Avramova (2012) note that the existence in the United States of government-sponsored entities enables US banks to offload most of their mortgage books and so reduce their total assets and RWA.

The specific risk profile of banks' portfolios obviously plays a key role. As far as credit risk is concerned, the idiosyncratic risk profile of either the obligor or the transaction are driven by a number of factors, such as balance-sheet data, the credit history of the single counterparties with the bank, the transaction type and the presence of any form of risk mitigation.

b. Business model

Every financial institution can be described by its particular mix of business/geographical/product decisions, known as the business model. Focusing on the business mix, a valuable starting point for investigating possible differences in RWA is the widely-used taxonomy set out, among others, in Le Leslé and Avramova (2012). Investment banks are mostly exposed to market risk, retail banks to credit risk, universal banks to both types of risk. Given the different prudential treatment of these risks, different groups of institutions are likely to have – other things being equal – different RWA.

Focussing on the differences between European and US banks, BernsteinResearch (2011) and Citi (2011) observe that a significant source of divergence between these two banking models is the assessment of assets external to investment banking, i.e. retail or commercial banking business. RWA/Asset ratios are quite similar between, say, JPMorgan and Deutsche Bank in the investment banking business, but they differ significantly in the retail exposures. In particular, US banks have on average a higher share of mortgages and consumer credit as well as a lower share of corporate loans than European institutions; in addition, they rely more on

securitisation for mortgage exposures and tend to remove high-quality (and low-RW) assets, therefore making the average risk weight of their portfolio greater than that of the European banks. Also, their greater credit card business, with its higher regulatory risk weight, contributes to the divergence.

ii) Undesired effects

Undesired effects capture all the elements that, taking the aforementioned factors into account, may still undermine full comparability of RWA: a) different rules (both accounting and prudential) and b) different supervisory practices.

a. Rules

Accounting rules have a direct impact on prudential metrics: balance-sheet items and accounting valuations are fully part of the mechanisms behind the calculation of capital requirements for prudential purposes. The issue comprises a twofold problem: the interaction between accounting and prudential frameworks, and the current lack of convergence amongst accounting regimes (IFRS in Europe, GAAP in the U.S.). This lack of convergence is a major explanation for RWA divergences, especially between European and US institutions. As Le Leslé and Avramova (2012) remark, accounting is likely to have its greatest impact on the denominator of the ratio between RWA and total assets.

BNP (2011) confirms this intuition with some numerical examples. Looking at the summary balance sheet of Deutsche Bank, published under both US and European accounting regimes, the conversion from IFRS to GAAP reduces total assets by 37 per cent. In particular, the different treatment of netting shrinks the derivatives book by 90 per cent. This conversion, when applied in the same fashion also to other banking groups, seems to suggest that with a few adjustments for key differences in accounting principles and business mix, the ratio of RWA to total assets is not significantly dissimilar.

Focusing on prudential rules and not considering which legal basis has been adopted so far in given jurisdictions (Basel 2 has not been applied yet in the US),

international regulation has left considerable discretion to national authorities and technical options to banks, in order to properly account for national specificities and/or different banking practices. Looking only at the Basel 2 framework for credit risk, the national discretionary powers for authorities and the options for institutions themselves are numerous in both the Standardised and the IRB methodologies, running from different risk weights under specific conditions to the definition of defaulted exposures for the calculation of capital requirements³. Building on the experience of the first years of implementation of Basel 2, the work at international (mainly European) level seeks to reduce the scope for divergent implementation.

b. Supervisory practices

Even assuming fully harmonised rules on the calculation of capital requirements, there is still room for the possible, and in some cases unavoidable, divergence of RWA between jurisdictions owing to supervisory practices. Some examples are the supervisory attitudes to model changes, capital add-ons, and validation criteria. Another example is the difference between the through-the-cycle (TTC) and point-in-time (PIT) approaches to IRB systems: given that the regulation does not explicitly impose one approach or the other, the banks' option has been driven in part by the supervisory attitude during the validation and follow-up process.

A last driver behind RWA differences, which can assume both a positive and a negative value, is risk management.

Indeed, the influence of risk management practices on RWA calculation is a direct consequence of the key role that risk measurement plays in the Basel framework. As Haldane (2011) notes, a variety of modelling choices is likely to determine possible differences across banks, even when other things are equal: “to determine the regulatory capital ratio of a bank, the number of calculations has risen from single figures to over 200 million”. The quality and quantity of the data used for the estimation of risk parameters, the estimation methodology, the combination of quantitative and qualitative

³ In a survey of member countries in 2008 on the CRD, the CEBS counted a total of 152 discretionary powers for national authorities and options for institutions.

variables, the degree of freedom for qualitative override, and the calibration of risk parameters are amongst the major choices a risk manager has to make.

As an example, the probability of default (PD) – the main risk parameter introduced in Basel 2 for measuring capital requirements for credit risk under the advanced methodologies – may by itself determine significant variations in capital requirements because of several factors, e.g. a ‘point-in-time’ versus a ‘through-the-cycle’ IRB philosophy, differences in historical data, mapping with external ratings (Le Leslé and Avramova, 2012).

On the one hand, the prudential framework has introduced incentives for banks to strengthen their risk management tools and, other things being equal, offered capital benefits to those institutions which demonstrate a sound measurement framework. On the other hand, in the light of the mentioned complexity of the rules, it cannot be excluded that sub-optimal methodological choices might lead to a underestimation of capital requirements.

4. Using the right glasses

4.1 Requirements for an appropriate metric

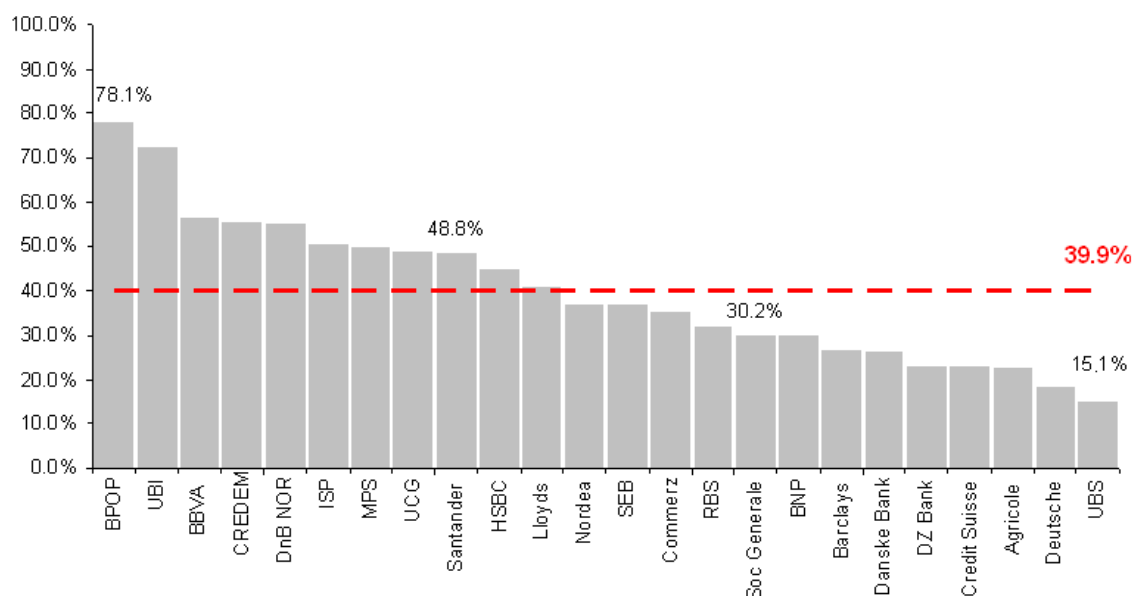
A proper investigation of the potential divergences in banks’ RWA requires the right glasses. The great complexity of the RWA calculations that the Basel framework requires banks to perform and the large number of variables in play require the use of synthetic indicators to reduce the complexity and conduct comparative analysis. As discussed in Section 2, risk-weighted assets for credit risk reflect an articulated set of rules: different methodologies, the possibility of using them in a combined way, risk parameters, expected loss and provisions for IRB institutions.

Our idea is that the oversimplification of the prudential rules could lead to confusion and misunderstandings. Therefore, it is essential to identify the criteria that an indicator needs in order to adequately serve the purpose of a deep understanding of banks’ RWA. We supplement the framework proposed by Arroyo *et alii* (2012) as follows:

- i. consistency (in the case of a ratio, this requires that the risks included in the numerator have a corresponding ‘counterpart’ in the denominator);
- ii. completeness (which requires that all exposures that generate RWA be included in the denominator);
- iii. decomposability; given the complexity of the phenomenon under investigation, this is the most important criterion, making it possible to break down the observed variations in RWA between banks into the major factors and, at the same time, to identify and measure the links between them within a consistent framework.

As noted, the Basel framework for credit risk contemplates a large number of rules and algorithms to compute RWA, especially under the advanced methodologies. However, some compact measures for the riskiness of the balance sheet are still possible as well as desirable, given the market’s need to elaborate financial information quickly and efficiently. One of the most intuitive and widely used indicators is the ratio between the RWA and total assets (TA), often referred to as ‘RWA density’. Most of the public reports that deal with RWA rely on this highly intuitive ratio in their analyses.

Chart 1: RWA / TA, December 2010



Source : Pillar 3 reports

Chart 1 shows the observed variation of RWA density for a sample of 24 large European banking groups at the end of 2010. The range of variation is approximately 60 percentage points. Such wide dispersion certainly gives rise to doubt about the ratio's effective ability to discriminate banks on their riskiness.

First of all, the numerator includes the RWA generated by the entire range of risks under Pillar 1 (not only credit risk but also operational and market risks, besides the possible add-on for the Basel transitional floor and possible bank-specific capital measures), while no equivalent of any of these items is reflected in the denominator (*consistency*). Secondly, a plain-vanilla definition of total assets does not include off-balance-sheet items, which are certainly likely to generate RWA to be included in the numerator (*completeness*). Finally prudential rules for different risk types do assign different weights to banking assets, especially under Basel 2. Therefore, a compact measure of RWA for the whole balance sheet is strongly influenced, on top of any other driver, by the business model of the single institutions. This would require the decomposition of the indicator but, as we shall see further on, the lack of consistency between numerator and denominator precludes this type of analysis (*decomposability*).

In summary, even though it represents a valuable proxy for a preliminary assessment of banks' riskiness, the RWA density does not appear to be equally effective as a basis for a detailed investigation of the major factors in RWA divergences.

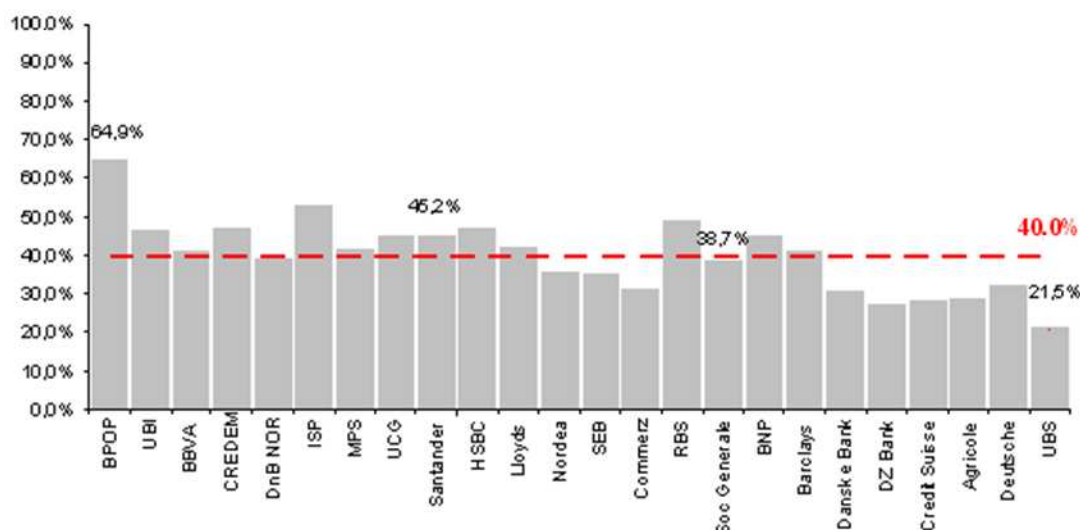
4.2 Consistency

One way to ensure criterion *i*) is to restrict the analysis to the RWA coming from one risk type only and adopt a consistent denominator. Below and throughout this paper, we focus on credit risk (for the Italian banking groups, credit risk accounts for some 85% of total RWA). The Basel rules require institutions to use a measure of the exposure that includes both on- and off-balance-sheet items: undrawn exposures, such as guarantees and derivatives, are converted into balance-sheet credit equivalent and then summed up to drawn exposures to get the Exposure-at-Default (EAD). Therefore, a more comprehensive measure of the average risk weight requires these items to be considered in the denominator, in order to compare the RWA with the exposure value that has generated them (for the Italian groups, the credit equivalent of off-balance-sheet

exposures is about 12% of total EAD). Consider the example of two banks with the same amount of total assets (say €100) and different RWA: €30 and €40. Comparing the RWA/TA ratio for the two banks we will conclude that bank 1 has lower average risk weight (30% against 40%), but if it does not have off-balance-sheet exposures while bank 2 has, say, €30 of off-balance-sheet credit-equivalent exposures and we calculate the RWA / (total assets + off-balance-sheet items) we find that the average risk weights for the two banks are nearly the same.

Chart 2 shows that, for the same sample of banks, if we consider the RWA for credit risk divided by EAD, the range of variation is reduced by 20 percentage points (from 63 to 44 percentage points)⁴.

Chart 2 : RWA / EAD, December 2010



Source : Pillar 3 reports

4.3 Completeness

As we recalled in section 2, a crucial difference between the IRB and SA approaches lies in the treatment of defaulted assets. Under IRB, defaulted assets generally do not produce RWA. Under a UL-only approach, what matters is the

⁴ It is fair to acknowledge that Pillar 3 data are not necessarily fully comparable in all respects. As an example, not all the institutions in the sample have properly defined the EAD.

Regulatory Calculation Difference (RCD), i.e. the difference between expected loss and provisions, which is detracted from or added to supervisory capital. Thus under IRB defaulted assets influence the solvency ratio only via the numerator.

In such a framework, the RCD may represent a significant portion of capital requirements, so drawing an exhaustive picture of the cost of risk in terms of capital requires including the RCD in any analysis of RWA. A simple way to do this is to transform the RCD into equivalent RWA and add it to the numerator. Accounting for the RCD in this way gives us the following ratio:

$$(RWA + 12.5 * RCD) / EAD \quad (1)$$

Taking 8 per cent of the numerator, it is possible to derive the minimum capital required against credit risk. Thus the proposed indicator can be seen as a measure of the average capital requirement. As an example, at December 2011 for the 71 Italian banking groups the ratio between RWA and EAD under the IRB approach was 39.3%, whereas including RCD the average IRB risk weight becomes 43%.

4.4 Decomposability

As noted, a third property that a proper tool for RWA analysis should have is the possibility of decomposing the main factors. The large number of factors in RWA calculations requires disentangling them in an orderly way and if possible quantifying them within an analytical framework. Indeed, it is of the utmost importance to provide analysts with a tool that can assign a specific weight to each factor and direct attention to the most important ones accordingly.

A similar approach can be found in several works, but we also try to address the concern that “[...] you can have a big, granular approach looking at it parameter by parameter. That is probably too granular to let you understand what is happening”⁵. We try to provide a measure of the relative importance of each component in explaining the

⁵ Risk.net (2011).

overall phenomenon. In this way, we seek to identify the leading factors among a large set of components.

As regards the factors in a valid decomposition exercise, we use both i) the bank's portfolio mix and ii) the roll-out, i.e. the combined use of different methodologies for computing capital requirements. In our experience, both are possible major drivers of RWA divergences. And the same framework can be easily extended to other variables.

i) Portfolio mix

Under both the Standardised and the IRB approaches to credit risk, different risk weights are associated with different asset classes, according to their specific risk profile: for example, in the Standardised approach the risk weight for residential mortgages is 35% and that for other retail exposures is 75%. Therefore, the size of each asset class (i.e. portfolio) is a key to better understanding the level of risk weights for the individual bank. Following the same example, other things being equal a retail institution will report a lower risk weight than a bank doing mainly corporate business.

ii) Roll-out

The combined use of IRB and SA approaches within the same banking group suggests that differences in the average risk weight for credit risk across institutions may depend on the allocation of assets between the two approaches. To investigate this hypothesis, we computed an "SA share" for each of the 24 European banks in the sample, defined as the ratio of EAD counted under the standardised approach to total EAD.

Chart 3 shows that the "SA share" variable explains more than one third of the observed variation in average risk weights. Moreover, the comparison of average risk weights should clearly involve banks with similar levels of SA share. For example, if we focus on the cluster of banks with a share of 20%- 30% or 40%-50%, the range of variation of average risk weight is less than 30 percentage points.

The idea is to disentangle the role of these three components in explaining the variation in overall average risk weight, but, as equation (2) shows, the relation between the average risk weight and its components is simple but not linear. In particular, the effect of SA share on the aggregate average risk weight depends on the difference in average between the SA and IRB approaches. For instance, if for a given bank no difference in average risk weights between SA and IRB is observed, the roll-out effect is negligible. Conversely, if this difference increases, the roll-out effect also increases.

5. A framework for meaningful analysis of RWA

5.1 The roll-out effect

In the present section we provide an analytical framework for quantifying the major drivers of RWA differences as regards credit risk. The same approach could also be used to compare the risk weight of a single institution with some benchmark (e.g. another institution or a set of institutions).

Chart 3 provided a preliminary picture of the effects of the combined use of the IRB and SA approaches on the average risk weight for credit risk. As formula (2) shows, the average risk weight can be expressed as a weighted average of the average IRB risk weight and the average SA risk weight, here denoted by RW^{SA} and RW^{IRB} (remember that q is the share of exposures under the SA approach).

$$RW^{credit} = q \cdot RW^{SA} + (1 - q) \cdot RW^{IRB} \quad (3)$$

A numerical example should clarify our approach (Table 1).

Table 1: A numerical example

Bank	RW	RW^{IRB}	RW^{SA}	Q
1	28.0%	20.0%	60.0%	20.0%
2	45.0%	30.0%	60.0%	50.0%
Average	38.5%	25.0%	60.0%	38.5%

Bank 1 has an average risk weight of 28%, Bank 2 of 45%. The difference ($\Delta RW = RW_2 - RW_1$) is thus 17 percentage points. Our aim is to determine the portion of this difference that depends on the different extent of the IRB approach.

In section 4.4 we saw that to be meaningful the comparison of average risk weights should apply to banks with the more or less the same SA share. Now we simply assign the same SA share to all banks: in terms of Chart 3 we are putting the banks on the same x-level. A straightforward choice for the x-level is the average of the sample (in this case, the two banks). Employing equation (3) with $q = 38.5\%$ for both banks, we can calculate the average risk weight they would have if they had the same SA share. For bank 1 we obtain 35.4% and for bank 2, 41.6%. The difference is now 6.2 percentage points. This means that the remainder of the initial difference ($17 - 6.2 = 10.9$ points) is generated solely by the difference in SA shares. The 6.2-point difference that still remains requires further analysis.

In this example we compared the average risk weights between two banks, but when there are n banks we could calculate $n(n-1)/2$ differences. A simpler way is to compare each bank with a common benchmark, calculating n differences $\Delta RW_i = RW_i - RW_B$, where RW_i is the overall average risk weight for bank i and RW_B stands for the benchmark.

Referring to equation (3) it is simple to write ΔRW_i as:

$$\Delta RW_i = RW_i^{SA} q_i + RW_i^{IRB} (1 - q_i) - (RW_B^{SA} q_B + RW_B^{IRB} (1 - q_B))$$

By adding $\pm (RW_i^{SA} q_B + RW_i^{IRB} (1 - q_B)) = 0$ and simplifying the resulting expression, we readily derive the following⁶:

$$\Delta RW_i = q_B \cdot \Delta RW_i^{SA} + (1 - q_B) \Delta RW_i^{IRB} + (RW_i^{SA} - RW_i^{IRB}) \Delta q_i \quad (4)$$

⁶ See Appendix 1 for some general remarks on possible decompositions

$$\text{In (4), } \Delta RW_i^{SA} = RW_i^{SA} - RW_B^{SA} \ ; \ \Delta RW_i^{IRB} = RW_i^{IRB} - RW_B^{IRB} \ ; \ \Delta q_i = q_i - q_B$$

The difference ΔRW_i is then decomposed into three factors: the “SA risk-weight effect” ($q_B \cdot \Delta RW_i^{SA}$), the “IRB risk-weight effect” ($q_B \cdot \Delta RW_i^{IRB}$) and a “residual effect” $((RW_i^{SA} - RW_i^{IRB})\Delta q_i)$.

Consider again the numerical example with two banks.

$$\Delta RW_1 = 28\% - 38.5\% = -10.5\%$$

$$\Delta RW_2 = 45\% - 38.5\% = 6.5\%$$

It is worth noting that $\Delta RW_2 - \Delta RW_1 = RW_2 - RW_1 = 17$ percentage points . Now applying the suggested decomposition for ΔRW_i we have the following figures:

Table 2: A numerical example, decomposition of ΔRW_i

Bank	ΔRW_i	$q_B \Delta RW_i^{SA}$	$(1 - q_B) \Delta RW_i^{IRB}$	$(RW_i^{SA} - RW_i^{IRB}) \Delta q_i$
1	-10.5%	0.0%	-3.1%	-7.4%
2	6.5%	0.0%	3.1%	3.5%
2-1	17.0%	0.0%	6.2%	10.9%

It should be clear from Table 2 that we were able to isolate the portion of the difference that depends only on the different share of SA in the “residual effect”, which we call the “roll-out effect”.

The algebraic formulation of the roll-out effect poses some problems of interpretation. In principle the average risk weight under the SA approach should be higher than under the IRB approach, so $RW_i^{SA} - RW_i^{IRB}$ should be positive for every bank; consequently a larger share of assets under SA will be reflected in a positive roll-out effect. However, for some banks the SA approach risk weight is smaller than the IRB share, so the third term is also influenced by the difference (sign and size) in average risk weights under the SA and IRB approaches.

5.2 The portfolio mix effect

The second step is to quantify the role of the business model in explaining the differences in average risk weights, decomposing the SA-weight effect and IRB-weight effect into two parts: one depending on the portfolio share, the other on all other factors.

Suppose that the SA provides for only two asset classes, say Corporate (Cor) and Other (Oth). The average risk weight under the SA will be given by:

$$RW^{SA} = q^{Cor} RW^{Cor} + (1 - q^{Cor}) RW^{Oth}$$

Employing the same approach used for isolating the roll-out effect we can decompose the quantity ΔRW_i^{SA} as follows:

$$\Delta RW_i^{SA} = q_B^{Cor} \cdot (RW_i^{Cor} - RW_B^{Cor}) + (1 - q_B^{Cor}) (RW_i^{Oth} - RW_B^{Oth}) + (RW_i^{Cor} - RW_i^{Oth}) \Delta q_i^{Cor}$$

The last addendum is the ‘‘Portfolio Mix’’ effect, which represents the part of the difference that depends only on the differing relative importance of the asset classes, i.e. on different business models. If we consider more than two asset classes, the SA-weight effect and the IRB-weight effect can be decomposed as follows:

$$\Delta RW_i^{IRB} = \sum_{j=1}^P q_B^j \cdot \Delta RW_i^j + \sum_{j=1}^{P-1} (RW_i^j - RW_i^P) \Delta q_i^j \quad (5)$$

where $j = 1, 2, \dots, P$ are the asset classes.

The first term represents the impact of different risk weights in the single portfolios (ΔRW^{SME} , ΔRW^{Cor} , ΔRW^{Mor} ...), while the last terms can be taken as a single effect and interpreted as the impact of the allocation of exposures among portfolios (‘‘Allocation effect’’).

6. An application to banking data

The methodology proposed is applied to actual banking data, in accordance with availability: Pillar 3 reports only allow using the RWA/EAD ratio, whereas supervisory information for Italian banks allow for the ratio in (1), RWA/EAD supplemented by the RCD effect.

6.1 European banks

We look more carefully at the values of the SA and IRB risk-weight effects for the 24 European banking groups considered in the sample. For this purpose, we set reference values for q , RW^{SA} , RW^{IRB} (as weighted average of the sample), so as to compare each institution with these benchmarks (Table 3).

Table 3: Comparison of ΔRW for large EU banks against a common benchmark (December 2010)

Bank	ΔRW_i	SA risk-weight effect	IRB risk-weight effect	Roll-out effect
Banco Popolare	24.31%	4.18%	0.00%	20.13%
RBS	9.11%	6.76%	6.38%	-4.03%
MPS	7.78%	2.64%	2.87%	2.26%
Credem	7.07%	-5.44%	32.87%	-20.35%
HSBC	6.91%	6.18%	2.28%	-1.55%
Intesa	6.03%	-3.83%	14.06%	-4.20%
UBI	5.92%	-1.60%	0.00%	7.52%
Unicredit	5.59%	0.58%	2.73%	2.28%
BNP	5.12%	9.76%	-2.71%	-1.93%
Santander	5.02%	0.55%	2.18%	2.29%
Lloyds	2.01%	6.67%	-0.52%	-4.13%
Barclays	1.09%	6.17%	0.19%	-5.27%
BBVA	1.04%	-0.97%	0.13%	1.88%
DnB NOR group	-1.13%	1.03%	-2.33%	0.17%
Société Generale	-1.46%	10.16%	-4.72%	-6.89%
Nordea	-4.14%	-3.15%	-0.30%	-0.68%
SEB	-4.78%	-7.83%	1.75%	1.30%
Deutsche	-7.87%	-6.77%	-1.51%	0.40%
Commerzbank	-8.69%	-6.58%	-2.20%	0.09%
Danske	-9.28%	-3.22%	-4.97%	-1.09%
Crédit Agricole	-11.43%	-8.24%	-2.14%	-1.06%
Crédit Suisse	-11.82%	0.60%	-5.00%	-7.42%
DZ bank	-12.77%	-11.68%	3.14%	-4.23%
UBS	-18.71%	-8.72%	-9.69%	-0.29%

Source: Pillar 3 reports.

The situation is significantly differentiated among banks. The low risk weight of, say, Crédit Agricole (11.4 percentage points less than the benchmark) is mostly to be attributed to lower risk weight in the SA portfolio (-8.2 percentage points), while the low risk weight of Crédit Suisse (11.8 percentage points less than the benchmark) is driven to a large extent by more extensive use of the IRB approach (-7.4 percentage points attributed to the roll-out effect). To understand the reasons for the low credit risk weight at Dz Bank (-12.8 percentage points with respect to the benchmark) we must deepen the analysis of the SA approach (-11.7 percentage points). For UBS, significantly low risk weights are evident for both IRB and SA portfolios.

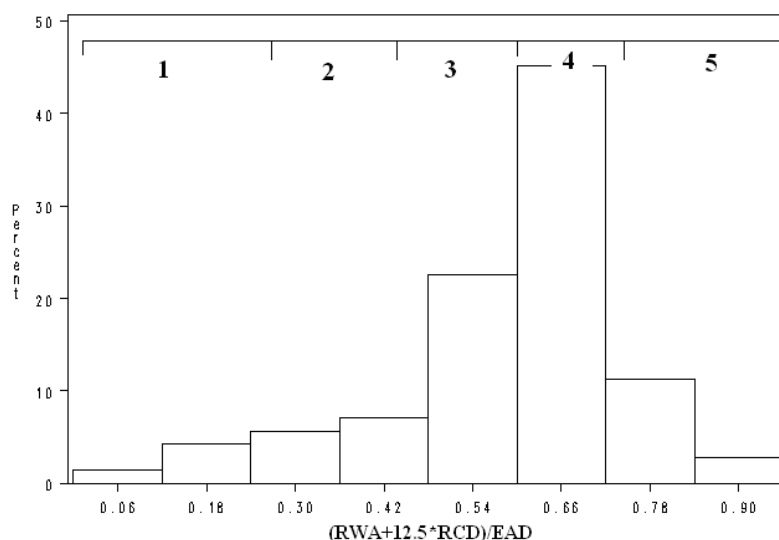
It might be surprising that the SA approach accounts for a significant part of the observed average risk weight dispersion but, as we show in the next section, different compositions of the portfolio in terms of asset classes can justify different average risk weights at a portfolio level. At the same time the portfolio mix could hide at aggregate level huge dispersion in average risk weight at asset classes level. For this reasons it appears of crucial importance to control for the portfolio mix effect in explaining the differences in average risk weights.

6.2 Italian banks

As regards Italian banks, the methodology is applied to the ratio $(RWA + RCD * 12.5 / EAD)$, given the high degree of detail of supervisory reporting data. The data refer to the end of 2011. At this reference date, the banking groups adopting the IRB approaches were five, whereas the remaining groups adopted the Standardised Approach.

The average ratio is 51.5%, the share of SA is 66% and the average risk weights are 55.9% and 43% under the SA and IRB approaches respectively. Chart 4 shows considerable dispersion at bank level: the 71 Italian banking groups are divided into five homogeneous clusters and the decomposition is applied to the average value for each, considered as if they were five composite banks (Table 4).

Chart 4: $(RWA+12.5 \cdot RCD) / EAD$ all Italian groups, December 2011



Source: Supervisory reporting template

Table 4: Statistics by cluster, December 2011

Cluster	Number of groups	$(RWA+12,5 \cdot RCD) / EAD$		
		avg	min	max
1	7	15.1%	9.1%	27.6%
2	10	45.5%	33.1%	50.7%
3	28	61.5%	52.0%	65.4%
4	24	69.3%	66.2%	75.7%
5	2	90.8%	86.3%	91.7%

Source: Supervisory reporting template

The average risk weight of the clusters ranges from 15% to 91% (76 percentage points). Controlling for the fact that some institutions adopt the IRB approach (roll-out effect), the range of variation decreases to 56 points (18.5% to 74.5%). More interestingly, a large part of the observed difference depends on the Standardised approach (Table 5).

Table 5: ΔRW decomposition, December 2011

cluster	ΔRW	SA risk-weight effect	IRB risk-weight effect	Roll-out Effect
1	-36.3%	-20.6%	-12.3%	-3.5%
2	-6.0%	-6.1%	0.4%	-0.4%
3	10.0%	3.4%	14.2%	-7.6%
4	17.8%	8.9%	0.0%	9.0%
5	39.3%	23.1%	0.0%	16.3%

Source: Supervisory reporting template

As regards the banks using the Standardised approach only, we have already observed that, perhaps unexpectedly, the average SA risk weight plays an important role in explaining the observed differences in RW^{credit} . Dispersion across institutions in terms of average risk weight under SA can be largely explained by two factors: the different shares of the different portfolios (composition effect) and the effect of external ratings and/or credit risk mitigation.

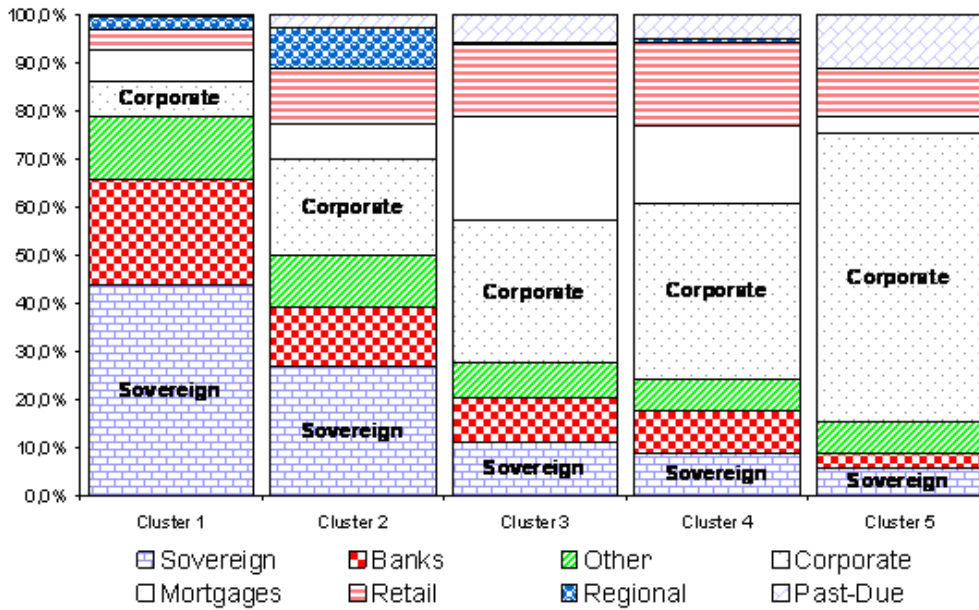
Table 6 yields two main findings: i) the banks' risk weights at portfolio level are similar; and ii) the difference in aggregate RW is largely explained by the different shares of the Corporate (with its high risk weights) and Sovereign portfolios. The clusters with lower average risk weights have the highest shares of EAD allocated to the Sovereign portfolio, while those with the higher average risk weights are more involved with Corporate counterparties (Chart 5); in particular, the high value of the indicator for cluster 5 is due to the high share of Past-due items and the low share of Mortgages.

Table 6 RW^{SA} , Italian Banks, December 2011

Cluster	SA risk weight effect	Allocation effect	Sovereign	Banks	Regional	Corporate	Mortgages	Retail	Past-Due	Other
1	-20.6%	-17.5%	-0.3%	0.6%	0.1%	0.4%	-0.5%	-1.0%	-0.3%	-2.2%
2	-6.1%	-6.6%	0.1%	-0.1%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%
3	3.4%	4.7%	-0.3%	-0.1%	0.3%	-0.3%	-0.1%	0.0%	0.0%	-0.7%
4	8.9%	7.6%	-0.2%	0.3%	0.3%	0.2%	-0.2%	0.0%	0.0%	0.9%
5	23.1%	20.7%	-0.3%	-0.4%	0.3%	0.7%	-0.5%	0.0%	0.2%	2.4%

Source: Supervisory reporting template

Chart 5: SA Asset classes EAD distribution, December 2011



Source: supervisory reporting template

Summing up, the observed range of variation of the average risk weight for the Standardised approach (44 percentage points) is mostly influenced by the allocation effect, which accounts for 38 percentage points.

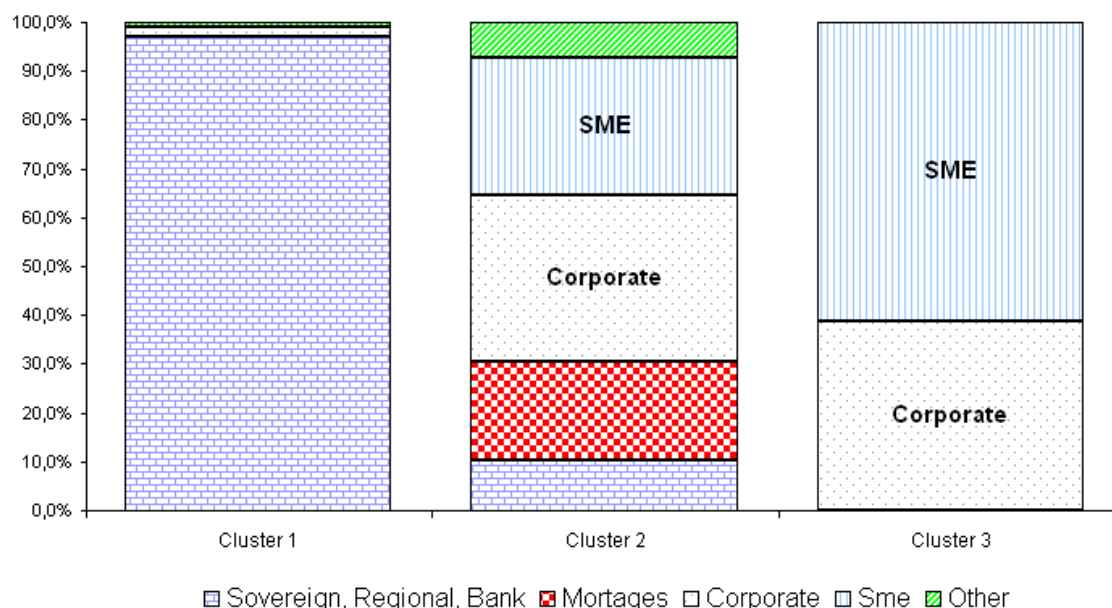
Turning to IRB, Table 7 shows that the risk weight effect explains 26 percentage points of the observed difference in the indicator, a large part of which depends on the allocation effect (i.e. different portfolio mix). The IRB banks in cluster 1 have more than 90% of their exposures in the asset classes with lower risk weights (Sovereign, Regional and Bank). The banks in cluster 3 allocate all their IRB exposure to Corporate and SME, which can largely explain the higher RW^{IRB} (Chart 6).

Table 7: $RWA^{irb} + RCD / EAD^{irb}$ and portfolio EAD share, December 2011

Cluster	IRB risk-weight effect	Allocation effect	Banks	Corporate	SME
1	-12.3%	-9.4%	-0.7%	-2.4%	
2	0.4%	0.2%	0.1%	0.0%	-0.1%
3	14.2%	5.9%		5.0%	3.2%

Source: Supervisory reporting template

Chart 6: IRB Asset classes EAD distribution, December 2011



Source: Supervisory reporting template

All in all, the empirical exercise confirms our intuition that a large part of the RWA difference, at least for credit risk, can be explained by factors other than the actual risk profile of banks’ assets and, possibly, different supervisory approaches. For example, the low IRB risk weight for Cluster 1 (36.3 percentage points below the benchmark) depends mostly on business models: asset allocation under SA accounts for 17.5 percentage points and under IRB for 9.4 percentage points. Taking into account also the roll-out effect, we can infer that 30 percentage points of the observed difference depend on simple factors that we can classify as intended consequences of the regulation. More generally, controlling for the roll-out and portfolio-mix effects, the dispersion of the average risk weight decreases from 76 to 8 percentage points.

7. A simple proposal for improving banks’ disclosure

Our analysis relies on a methodology that requires relatively little information, at least for credit risk. However, the insufficient level of granularity and the heterogeneous implementation of Pillar 3 reports prevent its application at international level.

The discussion on banking disclosure in the wake of the financial crisis has been intense indeed. From the theoretical standpoint, some authors highlight the importance of the way in which information is acquired and processed by investors. Freixas and Laux (2012) distinguish disclosure from transparency, arguing that disclosure is the provision of information by firms and issuers, while transparency exists only when the information disclosed effectively reaches the market and is adequately interpreted. Consequently, the analysis of transparency has to consider not only the incentives and skills of market participants in disclosing information, but also the ability of the information receivers to invest in processing the information. That is, failure at either end of the line of communication will invalidate the entire information process.

In the light of the experience of the financial crisis, both authorities and market participants have asserted that disclosure to the market of material risk factors has been insufficient, notwithstanding the Pillar 3 framework formally introduced by Basel 2. This is relevant for a range of items, starting with capital. In December 2011 the Basel Committee published for consultation new disclosure requirements on the composition of regulatory capital, after observing that “during the financial crisis, many market participants and supervisors have attempted to undertake detailed assessments of the capital positions of banks and comparisons of their capital positions on a cross jurisdictional basis. The level of detail of the disclosure and the lack of consistency in the way that it was reported typically made this task difficult and often made it impossible to do with any accuracy” (BCBS, 2011).

The issue is obviously relevant also for RWA, where limited and inconsistent disclosure of assumptions and methodologies makes it hard to compare banks’ riskiness; therefore, many observers argue that providing more granular and more easily comparable information on RWA would enable financial institutions to reduce investors’ uncertainty and, in the medium term, foster market discipline (Le Leslé and Avramova, 2012). Our suggested framework confirms this intuition. On the one hand, the Pillar 3 templates do not contain all the elements needed to carry out our proposed decomposition; and on the other, also some basic items are not disclosed uniformly across banks and jurisdictions. For example, one cannot always extract the EAD at portfolio level from Pillar 3, while data on provisions and expected losses are very limited.

For these reasons, we propose – as a complement to the suggested methodology – a relatively simple data template (Table 9) in which the main innovation consists in more granular data on EAD and provisions.

Table 8 – A proposal for a new Pillar 3 template

APPROACH	ASSET CLASS	EAD	RWA	EL	Provisions	average PD	average LGD	average Maturity	average CCF
IRB	Corporate								
	of which: defaulted					1			
	SME treated as corporate								
	of which: defaulted					1			
...									
SA	Corporate								
	of which: 0% weighted								
	of which: 20% weighted								
	...								
	Bank								
	of which: 0% weighted								
	of which: 20% weighted								
..									

8. Concluding remarks

Risk-weighted assets are central to the Basel capital framework; their role as the denominator of the solvency ratio is confirmed under Basel 3. They are currently under intense scrutiny from the supervisory community and the market itself, in the light of the post-crisis debate on the effectiveness of financial regulation in capturing banking risks and properly differentiating the prudential metrics according to different business models.

RWA are, by nature, complex. This reflects the evolution of finance as well as of regulation, which – since Basel 1 – has progressively strengthened the linkage between capital and risk. Thus the comparison of RWA across institutions is objectively more difficult, but given its substantial information content analysis and comparison of RWA across institutions are still crucial to understand the dynamics of banks' strategies and risk profiles.

The literature is scanty to date, owing to the relatively recent implementation of Basel 2 and the consequent lack of a lengthy time series. More recently, a number of

reports have highlighted the divergences in banks' RWA and sought to identify the main factors in them. However, the proper identification of the possible causes of RWA divergences is only the first step in the analysis; it must be followed by a more focused investigation of the contribution of each factor. This paper examines the way RWA for credit risk can be effectively analysed, focussing on the static dimension; further developments of the proposed framework might well be explored in the future.

Building on a critical review of most of the recent reports on banks' RWA, we first discuss the desirable properties of appropriate metrics for this type of analysis: consistency, completeness and decomposability. On this basis, we propose a set of indicators to be used according to the available information, starting from the widely-used ratio RWA/total assets ('RWA density') to a more granular metric that compares RWA for credit risk only and the possible difference between expected loss and provisions to a prudential measure of exposure (EAD). Independently of the indicator chosen, we argue that a thorough investigation of the phenomenon must involve the decomposition of the major factors, their identification and measurement. We propose a specific methodology, in which the principal factors considered are individual banks' business mix and the roll-out effect. Empirical analysis of European and Italian banks confirms that a large part of the observed dispersion is due to these factors. This is a significant step forward in the analysis of banks' RWA, mainly because it can direct the attention of the interested parties (supervisors, market analysts, banks) to the areas that most need it.

Ideally, the subsequent steps ahead should include extending the methodology to a broader sample of banks and other dimensions of analysis (e.g. dynamic behaviour of RWA), so as to seek confirmation of the picture drawn here. This is the purpose of our proposal to supplement current Pillar 3 reports. Second, one could perform an in-depth analysis of risk parameters, by comparing either the values assigned to a given counterparty by different institutions (benchmarking) or banks' internal estimates with actual values (backtesting). This is a task that the working groups recently set up in the international supervisory fora might undertake in the next future.

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Annex – Methodology

Here we describe, from an analytical point of view, our methodology for explaining the different risk weights. Let us say we have a function $f(x,y,z)$, evaluated at two different points:

$$\begin{aligned}v_1 &= f(x_1, y_1, z_1) \\v_2 &= f(x_2, y_2, z_2)\end{aligned}$$

One possible way to see how differences in the input values (x, y, z) affect the output (v) is to use the Taylor expansion formula:

$$\begin{aligned}v_2 - v_1 &= \frac{\partial f}{\partial x}(x_1, y_1, z_1) \cdot (x_2 - x_1) + \frac{\partial f}{\partial y}(x_1, y_1, z_1) \cdot (y_2 - y_1) + \\&+ \frac{\partial f}{\partial z}(x_1, y_1, z_1) \cdot (z_2 - z_1) + \text{higher order derivatives...}\end{aligned}$$

or

$$\Delta v = \frac{\partial f}{\partial x}(x_1, y_1, z_1) \cdot \Delta x + \frac{\partial f}{\partial y}(x_1, y_1, z_1) \cdot \Delta y + \frac{\partial f}{\partial z}(x_1, y_1, z_1) \cdot \Delta z + \text{higher order derivatives...}$$

Here the first set of inputs (x_l, y_l, z_l) serves as reference point or benchmark, and accordingly the deviation from the output associated with this benchmark (Δv) is expressed in terms of the changes in the inputs ($\Delta x, \Delta y, \Delta z$) and of the derivatives of f computed at the reference point.

This approach, applied to the formula (2) for RW^{credit} , yields one possible decomposition of the difference of average risk weights between two banks:

$$\Delta RW^{credit} = q_1 \cdot \Delta RW^{SA} + (1 - q_1) \Delta RW^{IRB} + (RW_1^{SA} - RW_1^{IRB}) \Delta q + (\Delta RW^{SA} - \Delta RW^{IRB}) \Delta q$$

Here the first three terms are the first-order derivatives of the expansion and the last term is a second-order term, which is the only one needed to have an exact equation.

Another possible decomposition (a minor simplification of the foregoing, obtained by condensing the last two terms) reads as:

$$\Delta RW^{credit} = q_1 \cdot \Delta RW^{SA} + (1 - q_1) \Delta RW^{IRB} + (RW_2^{SA} - RW_2^{IRB}) \Delta q$$

This decomposition is not unique, but it follows quite naturally from a Taylor expansion of the risk-weight formula and is therefore easy to interpret. The same approach can be adapted to much more highly varied settings in order to explain the differences in outcomes generated by much more complex formulas.