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Banking regulation: coherence between stress test exercise and RWA-based capital requirements

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Anno Accademico 2016-2017

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Introduction

The banking sector has always been affected by the regulatory framework. The 2007-2008 worldwide financial crisis led to several structural changes in the regulation. In particular, the increasing role of the banking authorities was caused by the new sources of risk identified in the financial markets. The response of the competent authorities to the systemic risk, that has become one of the greatest concern in the banking sector, determined the direction of the regulation and the scope of the supervisory activities. Basel Agreements reached after the crisis clearly embodied the financial stability as a primary objective. In European and US banking sectors a whole new set of operations have been implemented in order to ensure a constant supervisory activity over the main financial institutions.

Such a new regulatory scenario witnessed the constitution of two important instruments for the risk assessment, whose role and effect on the financial markets raised a huge debate: the RWA[1] calculation made with IRB[2] model approaches and the stress test exercise outcome. From the point of view of capital requirements calculation, the IRB Approaches acquired a central role in the risk management and compliance department of many large banks. The model building activity started to require a higher level of sophistication, in order to guarantee the accuracy in the risk parameters estimation. The methodology of IRB Approaches was intended to improve the accuracy of the estimates and to provide a tailored measure of risk for each sophisticated bank. The level of capital raised for regulatory purpose on top of the IRB calculation was expected to be sufficient to cover the single bank against the occurrence of severe economic scenarios. In this sense, the supervisory authority wanted to increase the scope of its activity, therefore the regulators developed an instrument aimed to assess the level of systemic risk inside the banking sector; this behaviour of the regulators took place both in EU and US banking sectors and led to the implementation of the stress test exercise. Such a regulatory tool allowed to test each single bank's resilience against a generated adverse scenario, defined by a set of stressed economic and financial variables. The result of the stress test exercise became the object of the attention of the supervisory entities. The outcome of the whole sample of banks tested in any exercise was assumed to represent the status of the banking sector, then it became a useful instrument in the hands of the supervisor, aimed to calibrate the intervention on financial markets. After a few years from the stress test introduction, the authority started to publish the results of the stress test exercise on individual basis. These informations provoked a huge turmoil in the market, since the performance of the single bank was taken into account while pricing securities (the stress test exercise performance began to be treated as a rating grade assigned by an external rating agency) issued by the bank.

The level of capital requirement determined through internal models implementation and the outcome of the stress test suddenly became two of the principal topics debated in the regulatory field. In fact, many large banks involved in the stress test had really negative outcomes, with huge amount of losses and a consequent significant capital depletion. The same banks were sufficiently capitalized according to the risk assessment provided by RWA-based methodologies (whether

[1]Risk-Weighted Assets.
[2]Internal Ratings Based.

exploiting internal models or not), nonetheless they suffered the adverse scenario in an unexpected way. The discrepancy between the riskiness implied by these two different regulatory tools is at the center of the analysis that is run in this paper. After the presentation of the main features of the actual banking regulatory field, a brief description of these two instruments will follow. The main characteristics, advantages and drawbacks will be presented in order to provide a solid foundation for a quantitative empirical analysis aimed to investigate the relationship between the conclusions provided by each risk assessment method. The data set will be focused mainly on the 2014 and 2016 EU-wide stress test exercise samples of banks. By collecting data for a selected set of financial indicators, it will be possible to verify the relationship between the risk assessed with RWA techniques (in particular with IRB Approach), and the outcome of the stress test exercise with the adverse scenario. Furthermore, the analysis will try to infer the effect of the internal models implementation on the level of RWA.

At the end of the analysis, the possibility to take some conclusions on this regulatory issue will arise, allowing to furtherly discuss the role of each instrument. The evidence of the empirical analysis will clearly go in the direction of a conceptual and practical divergence between the risk assessments of the two instruments. The recognition of such an empirical evidence will be intended to increase the level of transparency about the scope of application and the limits of each tool, and it will allow to disentangle what these regulatory instruments can assess and what they cannot, outlining the importance of each one for the supervisory and regulatory activity.

Chapter 1 Risk regulation in the banking sector

The actual banking sector is subjected to a regulatory framework that is a direct response to the latest financial crisis. The regulators and the supervisory authorities adjusted their structure to pursue new objectives dictated by the new necessities of the financial markets. The severe lessons learnt during the 2007-2008 crisis led to a focus on the risk identification process and forced the development of a new capital requirements framework for the banks. During the following years, a common trend was observed: banks were increasing the level of capitalization (measured by different indicators) in order to demonstrate the capacity to absorb high amount of losses. Such a tendency was fostered, if not explicitly forced, by the regulators. In fact, the fear of a new systemic collapse of the financial system was still perceived and the regulators thought that the undercapitalization[3] of many banks was one of the main cause of the 2007-2008 mayhem.

All these elements led to a risk regulation for the banking sector that is disciplined mostly by the latest Basel Agreements (Basel III documents) at international level and that is assisted by the supervisory and monitoring authorities both at national and supra-national level. The following chapter will present the main banking authorities in EU and US systems, in order to give a portrait of the different activities implied by the banking regulation. Such a brief summary will be useful to contextualize the presentation of IRB Approaches and the stress test exercise in the next chapters.

1.1 Banking authorities and entities (EU and US)

In this Paragraph, the main task and objectives of the relevant authorities for the banking sector in EU and US are enlisted, in order to have a clear vision of the supervisory and regulatory activities.

In US the banking sector regulation was deeply reformed since the enactment of the Dodd-Frank Act in 2010. Many institutions were eliminated right after the crisis and their tasks were distributed among old and newly constituted institutions.

FED

U.S. banking system has at its center the Federal Reserve System (FED), the U.S. central bank. FED structure is made of a group of twelve Regional Banks (each one relative to a specific Federal District[4]) distributed in twelve large U.S. cities and a Board of Governor in Washington D.C.. It is a private entity independent of the U.S. Government and carry out several tasks:

- Monetary policy setting, in order to achieve price stability and full employment and to lower long-term interest rates.
- Supervisory and regulation tasks on the financial markets in order to promote their stability and to guarantee customers' rights.
- Maintaining financial stability to reduce systemic risk.

[3]It may be defined better as an "underestimated" required capitalization, with respect of the riskiness of the bank's assets.

[4]Each regional bank is a private entity with his own Board of Governor, and their stocks could be owned only by U.S. banks.

- Treasury services for deposit-taking institutions.

FDIC (Federal Deposit Insurance Corporation)

Founded in 1933 through the Glass-Steagall Act, FDIC is an agency independent of both U.S. government and Federal Reserve System. It provides insurance for deposit taking institution in order to guarantee banks solvability against deposit holders' withdrawals. FDIC is not financed by public funds, but through insured banks' dues paid periodically. Moreover, FDIC has a 100 billion line of credit with United States Department of Treasury[5].

FDIC has two separate tasks: to provide insurance for deposit-taking institutions and to monitor solvability of State banks not under FED vigilance. FDIC demands several requirements that a banks needs to fulfill in order to be insured. Moreover there are also rules to set the coverage threshold for each bank account[6]; now this threshold is 250,000 dollars for each depositor. Such an insurance aims to increase confidence in deposit-taking institutions and, by doing so, to ensure banks short-term solvability.

OCC (Office of the Comptroller of the Currency)

Founded with the National Currency Act in 1863, Office of the Comptroller of the currency is a federal agency that has a vigilance role on national banks and their subsidiaries abroad. Among its objectives there are:

- Fostering competition within banking sector.
- Increasing efficiency and effectiveness of bank vigilance activity.
- Inquiring for illegal behaviors inside banks.
- Ensuring easy access to bank services for all citizens.

Even though OCC is a bureau within United States Department of Treasury, it is an independent entity whose role has acquired importance after 2007-2008 financial crisis, especially on risk management matter.

All the above institutions are very important for the U.S. banking system. The difference between State banks and national banks is really marked because volumes of trades and types of transactions varies a lot; therefore there is a wide set of vigilance authorities with capability in handling different regulatory framework.

European banking environment is quite different from U.S. system. Such a difference arises because of the different political structure and historical background. In EU, the principal authority is the European Central Bank that cooperates with central banks of each Member State. The main supervisory authority is the European Banking Authority.

[5]Executive government department whose tasks are printing money, collecting federal taxes and U.S. debt instruments management.

[6]It depends on the number of accounts and the type of entity holding them.

ECB (European central bank)

It was founded on 1st June 1998 to decide monetary policy for the States inside the European system of the single-currency (Eurozone). ECB and the central banks of the Member States of European Union[7] belongs to the ESCB (European System of Central Banks).

ECB tasks are:

- Monetary policy setting.
- Holding Member States central banks reserves.
- Promoting correct functioning of payment systems.
- Operating currency exchange transactions.

Main economic objective of the ECB is price stability, that is achieved by setting the medium-term inflation rate below a 2% threshold: central banks of the single State of Eurozone are allowed to set objectives which focus their attention on other macro-economic variable (employment, GDP growth etc.), but such objectives cannot go against the ECB inflation rate target.

EBA (European Banking Authority)

EBA plays the role of vigilance and supervision authority for the European banking sector since 2011. It cooperates with all the competent national vigilance authorities of the Eurozone countries. It belongs to the ESFS (European System of Financial Supervisors), together with EIOPA (European Insurance and Occupational Pensions Authority) and ESMA (European Securities and Markets Authority).

EBA's tasks are:

- Improvement of financial market functioning.
- Integrity, transparency and efficiency of financial markets.
- Providing customer's protection.
- International coordination of banking sector national authorities.

Among EBA's activities there is the vigilance over risk requirements compliance by the banks. One of the instrument used to verify banks requirements fulfillment is the stress test exercise: it will be analyzed in the following chapters, together with the IRB Approaches.

A collection of the main features of both these regulatory tools is contained in the next two chapters. They will provide a description of the two elements of the comparison, required to discuss the topic and to evaluate the results of the empirical analysis.

[7] 28 Member States up to 2017.

Chapter 2 IRB Approach and IFRS 9 introduction

2.1 RWA internal model approaches in Basel II

The internal model approaches for the capital requirements calculation represent one of the main topic discussed within banking regulation. The introduction of this instrument was aimed to compensate the limits of external estimates of the parameters required by the RWA-based framework. Prescribed for the first time in BIS 98, the RWA-based framework was upgraded in every Basel Accord, going from an initial application for market risk purpose, up to the definition of a complex framework for the Credit risk capital. Since the first setting, the internal model based approach was intended to fulfill a specific regulatory objective: to allow most sophisticated banks to create and use their own models for the estimation of specific parameters relative to the capital requirements calculation. Such an allowance implied a huge leeway for the banks, since each large financial institution recognized the possibility to influence the level of its capital requirement. The greatest change was implied by Basel II rules: the IRB Approaches were prescribed for the Credit risk capital requirements calculation, leading to a bigger set of parameters that could be estimated internally instead of being set at regulatory level.

In the following paragraphs some features of the RWA-based internal models framework (chosen for analysis purpose) prescribed in Basel II, will be shown and discussed, in order to properly explain the regulatory framework and the methodology through which they are intended to achieve the regulatory objectives.

IRB Approach in Basel II

The IRB Approach, as specified in Basel II, relies on 3 key elements:

1. Risk components[8]: risk parameters estimated by the banks or set by the regulator.
2. Risk weight functions: they transform the risk components into risk-weighted assets and therefore capital requirements
3. Minimum Requirements; they represent the minimum standards the bank has to fulfill in order to get the regulatory approval for IRB Approach implementation.

The IRB Approaches are divided into Foundation IRB Approach and Advanced IRB Approach. The difference between the two, as a general rule, is that in the Foundation Approach only the PD estimate is left to the bank, while in the Advanced Approach also LGD, EAD and M can be estimated by the bank[9]. Basel II document gives the definition of all the types of exposure that can be subjected to these kinds of approach. The adoption of IRB Approach by a bank follows several rules and it depends on the fulfillment of a set of minimum requirements. In general, if a

[8]They are listed in Paragraph 2.1.1.

[9]Actually, there is an exception to such a rule, for a specific asset category called SL (special lending); it is made of five sub-classes of assets that need to fulfill specific requirements.

bank adopts an IRB Approach for a particular asset class, it has to extent it to all the exposures inside that asset class. One type of exposure that requires a special treatment, in this sense, is the equity exposure[10]: if equity exposures represents the largest part of the investments of the bank, the supervisors may require banks to apply an IRB Approach even if the bank do not adopt it for any other asset class. The methodology required for each type of exposures is summarized in the following paragraphs.

2.1.1 IRB Approach across different types of exposures

Corporate, Sovereign and Bank Exposures IRB methodology

Risk components for these types of exposures are PD, LGD, EAD ad Effective Maturity.

PD: it is taken as the greater between the internal estimate of the bank for a single exposure and 0,03%[11].

LGD: in the Foundation Approach, it is set at 45% for all senior claims, while any subordinated claims will receive a 75% value. In the Advanced Approach, banks provide their own estimates of the parameter.

EAD: is defined as the sum of the amount by which bank's regulatory capital would be reduced if the position was written-off fully, plus any specific provisions. This amount is also multiplied by CCF (credit conversion factors). Both EAD and CCF follow a Foundation and an Advanced Approach.

M: the general rue for banks applying the Foundation is that the effective maturity of this kind of exposures is 2.5 years, except for repo-style transactions that have a 6 months maturity. In the Advanced Approach, banks are required to estimate effective maturity for each instrument, having 1 year as lower bound and 5 year as upper bound. Effective Maturity has to be computed as follows:

$$M = \frac{\sum_{t=1}^{M} t * CF_t}{\sum_{t=1}^{M} CFt} \tag{2.1}$$

The risk weight functions provided by the regulators are shown, in order to illustrate the rationale behind the calculation of capital requirements in case of Corporate, Sovereign and Banks Exposures. The first function provides the relationship between PD and the correlation parameter R, which is actually the copula correlation[12] between each pair of obligors of the bank:

[10]It a particular asset class that receives a specific treatment in the document, requiring a methodology that is quite different from other asset classes.
[11]It is a value decided by the regulators.
[12]The copula correlation is the correlation between the two normal distributed random variables used in a copula mapping process. Marginal distribution of two random variables (PD within 1 year of a single obligor of the bank) are mapped into two normally distributed random variables that are assumed to have a joint bivariate normal distribution with a correlation parameter.

$$R = 0.12 * \frac{(1-e^{(-50*PD)})}{(1-e^{(-50)})} + 0.24 * [1 - \frac{(1-e^{(-50*PD)})}{(1-e^{(-50)})}] \quad (2.2)$$

The MA (Maturity Adjustment) depends on the definition of a parameter *b*, named Maturity Adjustment:

$$b = (0.11852 - 0.05478 * \ln(PD))^2 \quad (2.3)$$

By the way, the proper Maturity Adjustment formula depending on Maturity (M) is the following:

$$MA = \frac{(1+(M-2.5)*b)}{(1-1.5*b)} \quad (2.4)$$

This formula allows to take into account credit risk arising from creditworthiness change or default of the counterparty, for exposure that last longer than a year[13].

The Capital Requirement (K) associated to these types of exposure depends on the following function[14]:

$$K = \left[LGD * N\left(\frac{N^{-1}(PD)}{\sqrt{1-R}} + \sqrt{\frac{R}{1-R}} * N^{-1}(0.999) \right) - PD * LGD \right] * \frac{(1+(M-2.5)*b)}{(1-1.5*b)} \quad (2.5)$$

Such a function strongly depends on the correlation parameter, that is assumed to be the same between each pair of obligors. Furthermore, R itself depends on PD, outlining an inverse relationship: if R increases, PD decreases and vice versa. The rationale behind it is that if a hypothetical single obligor is observed while its creditworthiness declines, its correlation with all the other obligors should decrease because its distressed situation makes his PD more idiosyncratic and less affected by overall market conditions[15]. Moreover, this function depends on LGD, that in the Foundation Approach is set at 45% for senior claims, and 75% for subordinated claims. Here the rules on the adjustments for collateral are recalled[16], in particular the Comprehensive Approach: banks has to estimate haircuts on both the exposure and the collateral item associated to it, to forecast value changes and to assess the ultimate LGD for the instrument. In this sense, the type of instrument and its level of collateralization affect formula 2.5. On top of that, the RWA is calculated with the following formula:

$$RWA = K * 12.5 * EAD \quad (2.6)$$

[13]If M=1 the MA is 1, so it is ineffective.

[14]N (x) denotes the cumulative distribution function for a standard normal random variable (i.e. the probability that a normal random variable with mean 0 and variance equal to 1 is less than or equal to x). N^{-1} denotes the inverse cumulative distribution function for a standard normal random variable (i.e. the value of x such that N(x) = z.

[15]This type of reasoning could theoretically conflict with another empirical evidence (previously quoted in the text): in distressed market conditions correlation among the assets increases. In this case, it's important to notice that the point of view is different: obligors on a side and assets on the other.

[16]One of the main novelty of Basel II was the new rules regarding the adjustments for collateral: the regulation prescribed a simple approach and a comprehensive approach.

The other types of exposures[17] require different treatments (precisely defined by the regulators) that take into account all the peculiarities. The relative capital charge is directly applied through the above formula or has to take it as a reference, given a series of add-on factors required by the risk weighting procedure.

2.1.2 Minimum Requirements for IRB Approach

All these types of exposures share the use of internal estimate of the bank for all their specific IRB Approaches. As previously mentioned, regulatory approval is necessary for the implementation of such IRB methodologies, then Basel II text enlisted a series of Minimum Requirements that have to be fulfilled. These requirements are aimed to pursue regulators' objectives and they concern 12 separate sections:

- composition of minimum requirements
- compliance with minimum requirements
- rating system design
- risk rating system operations
- corporate governance and oversight
- use of internal ratings
- risk quantification
- validation of internal estimates
- supervisory LGD and EAD estimates
- requirements for recognition of leasing
- calculation of capital charges for equity exposures
- disclosure requirements

These requirements should be considered the rules for the IRB construction by a bank, but in general, they provide more guidelines principles than prohibitions or specific technical recommendations. In particular, for the purpose of this analysis, it is useful to discuss the main regulatory statements about the internal rating models of the banks, both in terms of objectives and methodology.

Rating System design

Basel II first defines the rating system as "*all of the methods, processes, controls and data collection and IT system that support the assessment of credit risk, the assignment of internal risk ratings and the quantification of default and loss estimates*"[18]; after such a definition, the regulators outlined an important *caveat* with regard of one of the most important functions of the rating system. If a bank uses multiple rating systems (in order to increase the specialization for a given

[17]E.g. retail exposures and equity exposures.
[18]"International Convergence of Capital Measurements and Capital Standards. A Revised Framework", paragraph 394.

set of operations), it is not allowed to allocate borrowers to unsuitable rating system only for lowering regulatory capital purpose.

Each type of exposures has its own risk dimension and risk drivers, according to Basel II text. Corporate, sovereign and banks exposure, for example require two different risk dimensions: risk of borrower default and transaction specific factors. The definition of default is set by the regulator, while the assignment of borrower's grade follows this principle: different exposure to the same borrower cannot be assigned to different borrower's grades[19]. Such a statement could lead banks to treat all the exposures to a single borrower regardless of the product's characteristics. Then the second risk dimension helps to define the rules of the assets' treatment. Transaction specific factors are very important for the rating system design, since they forces the risk manager to consider collateral, seniority, product type, cash flows timing etc.

Banks are required to respect some criteria in the making of their rating system: these criteria involves the rating structure intended to guarantee a meaningful distribution of exposures across all the borrower's grades. Such a provision is intended to avoid the concentration of instrument of the same riskiness inside a single portfolio. Another important aspect of the rating procedure is the time horizon. Even though the PD estimation is done over a year, banks are expected to take longer period of time into considerations for the rating grade assignment. In this sense, the regulators recognize the difficulties in forecasting future events that might influence borrower's creditworthiness, so they recommend a conservative approach for projected information.

One last important part of the rating system regulation regards the use of models: the relative paragraph[20] contains a very clear statement as first requirement:

"***The burden is on the bank to satisfy its supervisor that a model or procedure has good predictive power and that regulatory capital requirements will not be distorted as a result of its use***"

Such a recommendation is really important for the purpose of our analysis, since it clearly shows one of the regulator's objectives with regard of the validation of banks' internal models. In particular, regulatory capital requirements distortion quoted above is expected to have a lowering effect on banks' capital level, but this topic will be discussed properly in Chapter 5, when the conflict of interest of banks using internal models will be quoted.

The correct implementation of models should have in place processes aimed to vet data inputs of the statistical tool, with two requirements on the bank side. The bank has to demonstrate that data inputs are representative of both the borrower's population and the set of financial instruments. Moreover, as any statistical tools-based analysis requires, the rating assignment process and the parameters estimation must be combined with human judgment, that should take into account all available informations not included into the models.

[19]Except for two case; when two exposure to the same borrower are denominated in different currencies and for the presence of some associated guarantees.

[20]"International Convergence of Capital Measurements and Capital Standards. A Revised Framework", paragraph 417.

Risk Rating System Operations

Corporate, sovereign and banks exposures treatment, that includes a rating assignment for the borrower and a rating grade for the facility itself, is separated from the treatment of retail exposures, that are assigned to a pool of instruments with same ratings. Both the two treatment has to be refreshed on an annual basis, taking into account all the significant information that could change borrower's rating grade.

During the rating assignment operations a well-know phenomenon could take place: the override. It is defined as the situation where an (expert) human judgment overrides the outputs of the ratings process, especially when it comes from an internal model application. Banks has to report all the circumstances in which it took place and should have specific guidelines on the matter.

IRB Banks are expected to put in place a stress testing program for the assessment of capital adequacy. Internal models need to be sided by a sound comprehension of how banks' credit exposures could change, therefore internal stress testing procedures become very important for the risk manager of a bank, in order to forecast how the regulatory capital level will change in the future due to possible events. Because of its importance for the risk management and compliance of the bank, the regulators provide a series of guidelines for the scenario constitution. In particular, three examples of scenario are suggested by the text: economic or industry downturns, market-risk events and liquidity conditions.

Use of internal ratings

Regulators specifically addressed some recommendations about this subject, recognizing the reality inside the risk department of IRB banks. Risk rating system and internal estimates are not acceptable when they are used exclusively for IRB qualification purpose, nonetheless regulation allow banks to use different techniques for the same parameters (PD, LGD, EAD) in different situations (e.g. in IRB approaches and in other internal estimation processes), if there is an adequate motivation in the risk compliance documents. Another important requirement regards the constant reporting activity of the informations about the internal ratings. This activity is intended to demonstrate the adequacy to regulatory requirements.

Validation of internal estimates

Requirements referred to the validation of internal models becomes very important for the regulator as far as the complexity of these models rises. Because of that, banks are required to demonstrate the accuracy of their internal estimates to the supervisors in order to guarantee the functioning of their risk rating system. The validation is executed with the evaluation of the parameters, whose estimation is made by the banks (depending on the choice between Foundation and Advanced approach). Actual default rates are compared with estimated PD and even LGD and EAD estimates have to be verified with the use of processes based on historical data. Any quantitative testing and validation method is subject to the demonstration that it does not vary systematically with the economic cycle.

2.2 RWA internal model approaches changes in Basel III

Basel III document implied several changes to the capital requirements framework since it represented the regulatory response to the liability and weaknesses pointed out during the financial crisis. As mentioned earlier in the text, the definition of capital for risk requirements purpose changed and a full new framework concerning the liquidity risk[21] was developed. The strengthening of bank's capital position took place through the introduction of capital buffers (Capital Conservation Buffer and the Countercyclical Buffer). Basel III implementation actually increased both the amount and the quality of capital to be held by the banks, but it pursued the aim of covering all the main risks inside the banking sector. In this post-crisis scenario, where international regulators were re-evaluating their objectives, one type of risk produced a huge concern that led to an upgrade from Basel II framework: that is counterparty credit risk.

2.2.1 Counterparty credit risk

Basel III outlines a reform in counterparty credit risk framework that became effective in January 2013: it introduced the requirement of credit value adjustment (CVA) estimation for additional capital charges calculation. A huge concern spread in the banking sector after the financial crisis about derivatives instruments regulatory treatment, so Basel III text provided a new approach on the counterparty risk.

Regulators distinguishes between two kinds of capital charges for counterparty risk purpose: the default risk capital charge for counterparty credit risk (CCR) and the CVA mark-to-market capital charge. The first one was already included in Basel II framework[22] and it was revised to properly define the internal method implementation. It is computed on OTC derivatives with both Standardized and IRB Approaches, by multiplying the outstanding EAD[23] for the appropriate risk weight. The other capital charge embodies the main novelty in the regulation, since it represents a change in the perspective of the counterparty risk. The mark-to-market counterparty risk losses treatment demonstrates the new perception of the regulators on derivative products. These type of instruments could be seriously affected by changes in the value of the underlying asset due to market movements, so a new type of capital charge was established in order to secure banks' derivative portfolios on the market risk side. The CVA capital charges for market risk reflected the new attention of the regulators to both the derivative instruments peculiarities and the wrong-

[21]Basel III document introduced two new liquidity ratios; the Net Stable Funding Ratio and the Liquidity Coverage Ratio. They are set by the regulators to be higher than 100%.

[22]It is quoted in this section because it is now useful for a comparison with the CVA capital charge for mark-to-market losses in the new counterparty risk framework.

[23]For the estimation of this parameter, Basel III introduced a "stress calibration", that is intended to better reflect the features of OTC derivatives instruments.

way risk[24] issue. The CVA capital charges relies on the estimation of CVA, that is the expected loss in a transaction due to the possibility of a default by the counterparty; such amount influences the value of the financial product and any change of CVA inversely affects reported profits. Banks are required to calculate CVA for each of their derivatives counterparties. Moreover, two factors are recognized as source of CVA risk: changes in market variables and changes in credit spreads. The regulation groups these two causes of losses for the banks under the definition of mark-to-market losses, then credit spreads is considered a component of market risk in this framework.

This type of risk, due to all its features, requires a high degree of sophistication in the structure of the internal models used by the banks.

2.3 TRIM: Targeted Review of Internal Models

Basel II introduced internal models for capital requirements assessment. Regulators gave autonomy to the banks for the estimation of their risk parameters needed for capital charges calculation. Regulators initially wanted to allow banks to develop new models for risk assessment, in order to improve the accuracy of all the processes involved, but most sophisticated banks started to take advantage of IRB models regulatory approval.

Models complexity rapidly increased, making banks more difficult to monitor and letting them to exploit several techniques to manipulate the level of capital requirements. Although 2007-2008 financial crisis was mainly driven by irresponsible market behaviors, many people blamed the lack of regulation on some important financial issues. In particular, Basel II implementation coincided with the beginning of the crisis and the entire new IRB framework was prematurely tested in a severe financial environment leading to negative results. Because of that, the debate about IRB took place by comparing the advantages and the drawbacks of the freedom accorded to banks. As a response, the ECB announced for 2017-2018 the TRIM project: it consists of a two-year[25] project made of missions executed by ECB staff cooperating with national supervisors, external auditors and consultants. In February 2017 published the "Guide for Targeted Review of Internal models", in order to show to all the financial institutions how such TRIM project will take place and, most importantly, the principles that it will follow.

2.4 IFRS 9 Accounting principle

Financial crisis aftermath led many countries around the world to recognize the necessity of changes in the financial regulation. Apart from the Basel III finalization, a significant change was also required from the accounting point of view. During G20 summit in April 2009, financial authorities and regulators were asked to reform the framework about the recognition of losses on credit exposures. In particular, G20 members demanded for some measures to reduce the pro-

[24]It is defined as the risk arising from a negative correlation between the level of credit exposure and the credit quality of the counterparty in a transaction.
[25]There is the possibility that it will be extended for a third year (2019).

cyclicality of loss absorption capacity[26]. The current IAS 39 accounting principle on the subject started to be discussed by highlighting all its drawbacks arisen during the crisis. IASB[27] answered with a new accounting principle called IFRS 9 to be implemented starting from 1st January 2018.

2.4.1 Incurred loss vs expected loss

IFRS 9 represents a huge step away from IAS 39 and implies several changes that will potentially produce a huge impact on financial markets. There is an underlying change of perspective on the credit losses recognition: the transition from an *incurred loss* principle to an *expected loss* principle. Basically, IAS 39 prescribed to report losses on credit (giving the possibility to provide adequate capital reserves to absorb them afterwards) only after the occurrence of a so-called *trigger event*: such event had to be enough severe (bankruptcy, rating downgrade etc.) to justify the recognition of an *incurred loss* on a given credit exposure. IFRS 9 embodies a new methodology that is conceptually different from IAS 39: each credit requires a long-term vision of the life of the credit itself, that relies on a collection of data and relevant information. Such a method is used to report (right from the beginning) all the expected losses over the credit lifetime. Moreover, losses are continuously adjusted any time a new event or information could change the Credit risk profile of the counterparty. The process involves the estimation of several probability distribution in order to project future events and to constantly record changes in losses expectation.

2.4.2 Staging process

The process through which credit exposures has to be initially recorded, according to IFRS 9, is called "staging": it involves the classification of all credits into three different stages. The criterion used in the staging process is the likelihood of change in Credit risk of the exposure through all its expected life. The variables considered in this process are the following:

- Probability of default variation during the life of the exposure.
- Expected life of the exposure.
- Forward looking informations that could significantly change the Credit risk.

These elements, together with several parameters estimation, contribute to define the 3 stages above mentioned. Credits could move from one stage to another when certain events take place, so each credit exposures is individually monitored to keep track of any relevant information that could affect the fulfillment of future payments. A description of each stage is outlined:

Stage 1: the first stage collects all the credits with their own expected loss estimation over a one-year period. Credits classified in this stage did not show meaningful signs of a future creditworthiness deterioration.

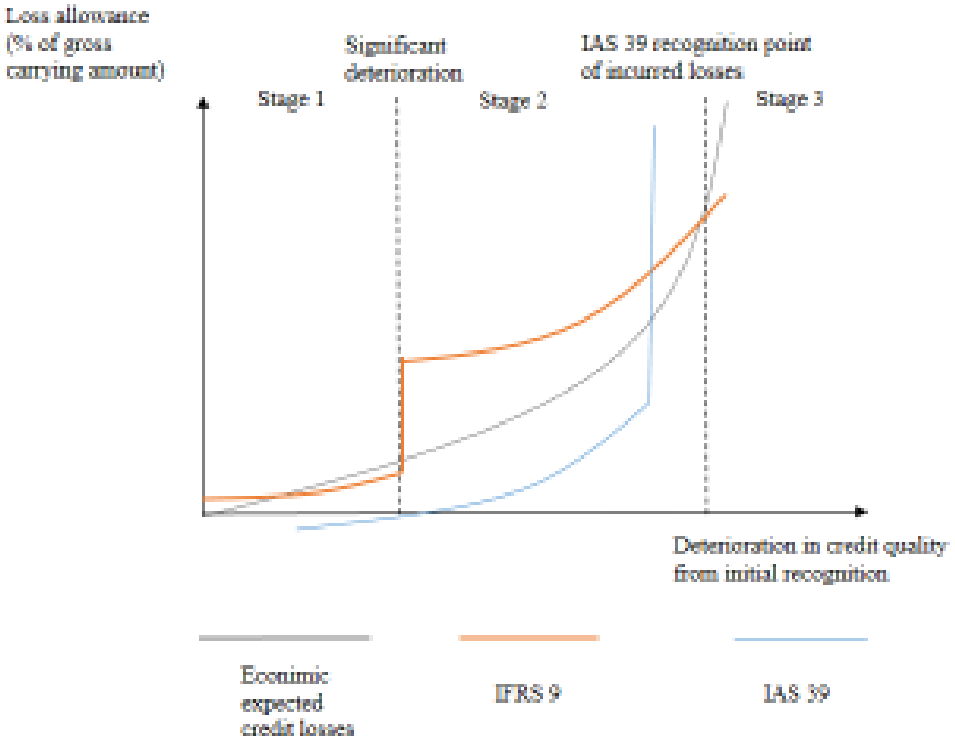
Stage 2: any credit experiencing an increase in its riskiness from the moment of initial recognition is classified in this stage, where a lifetime[28] expected loss is estimated.

[26]"Declaration on strengthening the financial system", London summit, 2 April 2009.
[27]International Accounting System Board.
[28]Until the maturity of the instrument.

Stage 3: when the credit risk deterioration has been recognized as severe[29] enough to compromise future payments, the credit exposure is classified inside this stage.

Each stage requires its own calculation methodology for the loss recognition; a key difference from the previous accounting standard is that IFRS 9 relies on both past and present data, together with projections, all inside a system that continuously keeps track of Credit risk changes. What was previously named *trigger event*, that usually forced to recognize (incurred) losses, is now substituted by a set of events and info that could imply a stage transition and a series of projections adjustment under the new accounting system. The following graph will outline the difference between the IFRS9 and IAS 39 from the point of view of losses accounting approach:

Figure 1 IFRS 9 vs IAS 39 loss recognition



Source: "Il principio contabile IFRS 9 in banca: la prospettiva del Risk Manager" AIFIRM, December 2016, (IASB snapshot)[30]

The graph clearly shows how IFRS 9 line stands above the IAS 39 line, recognizing losses at an early stage of the credit quality deterioration. By applying IFRS 9 banks are forced to be more cautious about credit quality treatment and to anticipate the losses instead of letting them to

[29]Especially for specific events occurred after the first reporting of the instrument.
[30]The economic expected credit losses are taken from the 2009 IASB ED (Exposure Draft).

occur. Such a process implies a higher degree of complexity and an operative burden for the banks, that is required to monitor credit quality of each counterparty for all the instrument's lifetime.

2.4.3 PD point in time (PIT) and through the cycle (TTC)

IFRS 9 implementation will be implemented in a regulatory scenario where most of Basel III rules will be effective, then financial institutions started to think how much the IRB approaches will compatible with it. In this sense, the *expected loss* accounting approach is conceptually close to IRB methodology since it involves many of the same parameters to be estimated. In particular, PD parameter has a central role in IFRS 9 because of the necessities of the staging process. Given that Stage 1 and Stage 2 credits require an expected loss estimation over a long period of time, PD calculation should take into account lots of factors not strictly related to the counterparty. From this point of view the PD estimation could be approximately divided into two different categories:

- **PIT** (point in time) probability of default: this measure is sensitive to short-term variations of macroeconomic variables, augmenting the parameter during recessions and reducing it during the expansions. Counterparty's credit quality (assumed to be positive correlated with the economic cycle) immediately react according to the phase of the economic cycle.
- **TTC** (through the cycle) probability of default: this measure does not include parameters changes due to the economic cycle factor. It is usually a more stable and less volatile measure of the PD, that captures medium-term and long-term components affecting the creditworthiness.

Actual PD estimation techniques used by banks are often hybrid versions, where elements of each one are mixed together in order to obtain a balanced calibration of the IRB models. Although it could seems a reasonable and effective trial to improve the accuracy of PD, the union of these two approach is quite difficult and most of the times it mitigates the advantages of each one. Because of that, a long debate is taking place (among financial institutions) in order to asses which one is more suitable for the upcoming IFRS 9. It is useful to remind what happened during the financial crisis, when most of the IRB models were calibrated on TTC estimates: those models had not enough sensitivity to capture the evolution of credit quality of the counterparty in short periods of time[31]. In a regulatory scenario where counterparty credit risk and counterparty risk are recognizable as market risk[32] in some cases, the "*pitness*"[33] of the model will become an essential characteristic. Since IFRS 9 require the use of both available and projected information, PIT methods are adequate to provide the right degree of reactiveness to economic variables changes that have a quick effect on credit quality.

[31]Even daily news and events could produce huge impact on large financial institutions creditworthiness in distressed financial markets.
[32]See Paragraph 2.2.1.
[33]PD estimation model sensitivity to the economic cycle.

2.4.4 Forward-looking scenarios

Projected information constitutes the foundation of the expected loss estimation required by credits belonging to each stages. In order to do so, a forward-looking approach is recommended by IFRS 9. The forward-looking approach is used to generate scenarios in which banks calculate their losses. The overarching principle for the scenario generation is that scenarios should be comprehensive of the main factors that really influence bank's activity, considering the composition of its portfolio. If, for example, a bank has large portion of its portfolio invested in MBS, one of the scenarios used by the bank should include a downgrade movement of a suitable real estate price index. The use of scenarios and the prescriptions about data and informations input, represent a linkage between IFRS 9 and the stress-test exercise techniques executed by banks themselves or for regulatory purpose.

IFRS 9 establishes a scenarios generation methodology that is quite different from the stress-test exercise conducted by the authority. While the authorities[34] usually provides a unique central scenario (and in some case a worst-case scenario, considered severe and plausible), IFRS 9 requires the generation of a set of different scenarios, representing a "range of outcomes", each one associated with a given probability to happen. The expected loss is calculated on the mean of losses recorded across all the scenarios weighted for their probability. The estimation of EL parameter is intended to be driven by a set of non-distorted[35] scenarios. In order to create these suitable scenarios, banks must use a forward-looking approach: internal data[36] should be used as input for the projections of selected economic variables together with wide consensus provisions[37].

All the process put in place by the banks to develop scenarios adds complexity to the accounting operations, and IFRS 9 specifies that each phase of that process have to be disclosed and justified. In particular, all the outcomes of operations made for IFRS 9 accounting purpose have to follow methods coherent with similar operations put in place for other purposes. Moreover, such methods have to be periodically back-tested.

As shown in this paragraph IFRS 9 have points in common with both IRB approaches and the stress-test mechanism, then it is important to notice that IFRS 9 goes in the same direction of both these regulatory tools. It enhances the role of internally managed processes for parameters estimation and increases the necessity to project information and to forecast future changes in economic variables.

[34]E.g. EBA for the EU wide stress test exercise. It provided principles on scenarios generation for stress-testing purpose.
[35]In the sense that they must not reflect neither a best-case scenario nor a worst-case scenario.
[36]If they are not sufficient or accurate, banks are allowed to use external data.
[37]IFRS 9 recommend it even though in 2007 the wide consensus prevision on MBS (Mortgage-Backed Securities) market clearly misinterpreted markets signals.

Chapter 3 Stress test exercise for regulatory purpose

3.1 Stress test mechanism: first introduction

In the last decade, a new regulatory tool provoked a huge turmoil in financial markets: the stress test exercise put in place by banking sector authorities for regulatory purpose. It is a simulation exercise large banks are periodically submitted to. The results of this procedure are evaluated by the regulators, in order to assess the solidity of the banking system.

Stress test exercise began its life as a statistical tool run by banks for their own internal capital assessment. It was recommended by 1996 Amendment[38] for banks allowed to use internal estimates for capital requirements: sophisticated banks, at that time, was expected to develop a stress test exercise program in order to self-evaluate their models accuracy and effectiveness. If banks "passed"[39] the stress test, they reasonably assumed that their RWA estimation (needed for the fulfillment of capital requirements), made also with IRB methodologies, was run properly enough to secure them from possible economic downturn scenarios. In this sense, it was in bank's best interest to generate severe and plausible scenarios to be tested over, but after a few years, stress test exercise became a tool used by the regulators.

After 2007-2008 financial crisis, several national regulators conducted stress test exercises; their aim was to assess banking system vulnerability to adverse market movements. In late 2012, U.S. regulators started to require large national banks to undergo stress tests exercise twice a year; one had to be conducted internally by the bank, while the other one had to be conducted by the authority. In Europe, CEBS[40], assisted by national authorities, conducted a series of stress test, starting from year 2009. The impact of these exercises on financial markets was deep, since all market players interpreted stress test results as a sort of indicator of banking system solidity. Each bank submitted to the tests was evaluated through its performance under the regulatory scenarios, leading to a huge concern for bank's management. Portfolio composition and the choice of instruments used for capital adequacy began to be influenced by the features of the stress test; the occurrence of a stress test failure actually became a driver of the assets selection process.

Stress test represented a useful but controversial tool for the assessment of banking system capacity to face adverse scenarios. In fact, the evaluation of a bank based solely on stress test result could be misleading, since regulatory scenarios are intended to be severe an plausible but they do not represent the only possible worst-case scenario in the financial markets; nonetheless stress test exercise provide a wide set of informations for the banks tested and for the retail investors.

[38]Basel document that introduced the market risk capital charge framework in the banking regulation.
[39]This terminology is actually improper, since only stress test with a declared threshold limit value can lead to a test failure by the bank.
[40]Committee of European Banking Supervisors.

3.1.1 Definition of stress test exercise

Stress test exercise is a statistical analysis executed through a simulation in which, over a short period of time (usually the following 3 years) several key economic variables are assumed to experience a downturn movement. The set of variables and parameters whose behavior is simulated, constitute the scenario. A stress test exercise typically want to evaluate banks under the occurrence of an adverse scenario, but regulators usually[41] provide also a baseline scenario that is intended to represent normal market conditions.

The stress test exercise is conducted by simulating the performance of the bank's portfolio (considered at the beginning of the period) throughout the development of the scenarios. This procedure is thought to generate value losses on the financial products owned by the bank and to force bank to be likely to default on its transactions. Scenarios' adverse conditions should put bank in financial distress until the point where losses are recognized and accounted[42].How much these losses reduce the capital of the bank is the key result of the stress test exercise: a specific threshold in term of capital disruption was usually established by regulators to determine which bank passed the test.

The evolution of the stress test exercise through the years implied an increased complexity of the scenario generation process, where several variables were projected in order to re-create adverse market conditions for all the financial institutions submitted to the test. Both the choice of the variables and the magnitude of the shocks were important for the constitution of the scenarios.

3.1.2 Variables involved

In the stress test exercise a given set of variables is involved; most of them are macroeconomic variables and interest rates on debt instruments. To make an example, the latest EU-wide stress test exercise (that had a huge aftermath on financial markets[43]) took place in 2016 and involved 51 banks, requiring two different scenarios: a baseline and an adverse scenario.

The adverse scenario was intended to test solvency of banks against a set of risks: such risks were considered threats to the financial stability, so the authority chose to convert them into coherent economic variables shocks. In order to outline of the relationship between the source of risk and the relative shocks of the economic variables and parameters in the scenario, the following table is shown:

[41]2014 and 2016 EBA stress test exercises had both baseline and adverse scenarios.
[42]The IFRS 9 accounting principle will represent a huge change in losses recognition process.
[43]The outcome of the 2016 EU wide stress test conducted by EBA is discussed in Chapter 6.

Table 1 Main financial stability risks and assumed financial and economic shocks (2016 stress test exercise)

Source of risk	Financial and economic shocks
An abrupt reversal of compressed global risk premia, amplified by low secondary market liquidity	- Rising long-term interest rates and risk premia in the United States and other non-EU advanced economies - Global equity price shock - Increase in the VIX volatility index and spillover to emerging market economies - Foreign demand shocks in the EU via weaker world trade - Exchange rate shocks - Oil and commodity price shocks
Weak profitability prospects for banks and insurers in a low nominal growth environment, amid incomplete balance sheet adjustments	- Investment and consumption demand shocks in EU countries - Residential and commercial property price shocks in EU countries
Rising of debt sustainability concerns in the public and non-financial private sectors, amid low nominal growth	- Country-specific shocks to sovereign credit spreads - Shocks to corporate credit spreads
Prospective stress in a rapidly growing shadow banking[44] sector, amplified by spillover and liquidity risk	- EU-wide uniform shock to interbank money market rates - Shocks to EU financial asset prices - Shocks to financing conditions in EU countries (via shocks to household nominal wealth and user cost of capital)

Source:" Adverse macro-financial scenario for the EBA 2016 EU-wide bank stress testing exercise" ESRB, 29th January 2016

The magnitude of each shocks is assumed to be representative of the adverse conditions of the market. To decide how much each variable had to change during the stress test projected period, several quantitative studies were conducted by the authority. The objective was to generate a scenario with adverse economic conditions, such that it was possible to re-create some specific past periods of recession.

For example FED, that requires a stress test exercise every year called CCAR (Comprehensive Capital Analysis and Review) since 2009, chose scenarios similar to those in 1973-75, 1981-1982 and 2007-2009. The stress test is made for all banks with consolidated assets of more than 50 billion dollars (G-SIBs[45] and D-SIB[46]) . The scenarios chosen by the FED involves projections on about 25 variables, including macroeconomic variables like gross domestic product growth (GDP), unemployment rate, stock market indexes and house price indexes.

[44]The set of all those financial intermediaries that provide banking services without properly being banks.
[45]Global Systemically Important Banks.
[46]Domestic Systemically important Banks.

3.2 SREP (Supervisory Review and Evaluation Process) in Pillar 2 framework.

In Europe, baking sectors authorities started to increase the monitoring process over single financial institutions. The 2007-2009 financial crisis forced the regulators to assess the financial health of the largest banks on a regular basis, in order to reduce the risk for the overall financial stability. The monitoring activity took the form of a complex process that was introduced inside Pillar 2 of the Basel II document: the SREP.

Pillar 2 is about Supervisory Review[47] process; it divides the tasks assigned to the regulators from all the operations that have to be executed by the banks for compliance purpose. From the bank's point of view, a rigorous stress test program and several back-testing procedures are recommended for the validation of internal models, while on the regulators side the SREP is prescribed. It began as a supervisory operation run by single national authorities, but after the financial crisis, all methods and procedures were unified. SREP activities are actually managed by ECB on European scale.

SREP involves the analysis of individual banks over their internal models implementation and their capital requirements fulfillment. In particular, regulators wants to be sure that IMM[48] banks are not taking advantage of their leeway in the capital requirements calculation. Since Equity capital (especially Common Equity Tier 1 Capital, the one with the highest quality) is a high-cost funding source for the banks, the authorization for internal models implementation could be exploited to reduce capital requirements burden.

SREP operations are managed by ECB but the outcome of other competent authorities' activities is considered. In fact, the 2016 EU wide stress test exercise results were integrated inside SREP, in order to properly assess how such large banks would react in a hostile environment, given their capitalization and risk exposure. The outcome of the stress test results allowed to define the specific recommendations of the authority to each single bank regarding the required level of capitalization.

[47]Second Pillar of Basel II document; the other two were the Minimum Capital Requirements and the Market Discipline.
[48]Internal Models Method.

Chapter 4 European banking sector trends

4.1 Post-crisis banking sector analysis

In the period after the financial turmoil due to the crisis, banking sector experienced several changes. The regulation and the macro-economic scenario contributed to transform the environment in which large internationally active banks run their businesses. Because of that, many movements of a set of important economic and regulatory variable took place, determining sound trends observable in the European banking sector.

The main concern of banking regulation after the crisis was the solidity of the financial institutions: many indicators could give a measure of the capital solidity of a bank, like the Leverage ratio does. It provides the proportion between the banks' own source of funding and the debt instruments. The RWA of a bank for capital requirement purposes instead, incorporates the riskiness estimated through risk-weighting processes in the value of the assets, leading to a different measure of bank's capitalization: that is the CET 1 Ratio. Furthermore, the RWA are taken into account to evaluate the riskiness of the overall exposure of a bank while calculating the RWA intensity. These three measure evolved in the post-crisis period, outlining some definite trends in the European banking sector.

4.2 Leverage ratio

The first banking indicator to analyze is the so-called Leverage ratio, defined as follows:

$$\text{Leverage ratio} = \frac{\text{Equity}}{\text{Equity+Total Debt}} \tag{4.1}$$

If the asset side is considered:

$$\text{Leverage Ratio} = \frac{\text{Equity}}{\text{Total Assets}} \tag{4.2}$$

This ratio represents the portion of the Total assets of the bank financed through Equity (banks own financing source). The inverse of this ratio[49] measures the proportion between the Total Assets and the bank's Equity: it is commonly called financial leverage. Banks highly leveraged theoretically are able to achieve better performances because, given the same return on a given portfolio of assets, debt costs (interests) are less than the Equity costs on average as a financing sources. Banking regulation has always monitored the level of financial leverage of the banks and in recent years Basel Committee established a minimum level of Leverage ratio to be maintained by the banks in the European banking system[50]. The Basel Leverage ratio is calculated

[49]Total Assets/Equity.

[50]Basel Committee set a 3% minimum Leverage ratio for the banks, to be applied in a period of observation that begins on 1st January 2013 and ended on 1st January 2017.

with a set of specific rules[51], that allows to determine the ratio between a measure of the bank's Equity and a measure of the Total Assets of the banks.

The Leverage ratio depends on two variables, the Equity and the sum of Equity and Total Debt (assume to be equal to the Total Assets amount) of the banks, respectively the numerator and the denominator of the ratio. The evolution of the Leverage ratio within the banking sector in the post-crisis period is a result of the movement of these Equity and Total Assets variables individually. Data collected for large sets of banks for these two variables outlines the trends in the sector and allows to identify the drivers of the leverage ratio.

First, the Total Assets amount is reported for a given set of banks from the 2011 up to the 2016; Total Assets value are observed in 2011 and in 2016. The difference between these values leads to the Δ Total Assets in 2011-2016 period and to the % change of the Total Assets, defined as the ratio between Δ Total Assets and the initial Total Assets amount (2011).

[51]Basel Committee provided the rules to determine the numerator (Core capital) and the denominator (Total Assets of the banks plus out-of- balance sheets exposures) in "Basel III leverage ratio framework and disclosure requirements" Basel Committee on Banking Supervision 1st January 2014.

Table 2 Total Assets variation (2011-2016) in a set of 78 EU large banks

*Thousands dollars amounts	Total Assets		2011-2016 period	
	2011	2016	Δ Total Assets	Δ Total Assets/Total Assets 2011
Aareal Bank AG	$ 54.103.130,00	$ 50.289.005,00	$ -3.814.125,00	-7,05%
Abanca Corporacion Bancaria SA	$ 93.465.878,00	$ 47.580.398,00	$ -45.885.480,00	-49,09%
ABLV Bank AS	$ 3.273.943,00	$ 4.188.280,00	$ 914.337,00	27,93%
ABN AMRO Group N.V.	$ 523.617.997,00	$ 415.823.491,00	$ -107.794.506,00	-20,59%
Alior Bank Spólka Akcyjna	$ 4.530.819,00	$ 14.645.884,00	$ 10.115.065,00	223,25%
Allied Irish Banks plc	$ 176.812.714,00	$ 100.795.154,00	$ -76.017.560,00	-42,99%
Alpha Bank AE	$ 76.531.649,00	$ 68.381.858,00	$ -8.149.791,00	-10,65%
Banca Carige SpA	$ 58.044.428,00	$ 27.523.610,00	$ -30.520.818,00	-52,58%
Banca Monte dei Paschi di Siena SpA	$ 311.444.255,00	$ 161.465.427,00	$ -149.978.828,00	-48,16%
Banca Piccolo Credito Valtellinese-Credito Valtellinese Soc Coop	$ 36.761.624,00	$ 26.847.358,00	$ -9.914.266,00	-26,97%
Banca Popolare di Milano SCaRL	$ 67.193.550,00	$ 53.897.230,00	$ -13.296.320,00	-19,79%
Banca Popolare di Sondrio Societa Cooperativa per Azioni	$ 37.889.159,00	$ 39.208.648,00	$ 1.319.489,00	3,48%
Banca Popolare di Vicenza Societa per azioni	$ 54.186.860,00	$ 36.286.594,00	$ -17.900.266,00	-33,03%
Banco BPI SA	$ 55.580.656,00	$ 40.355.853,00	$ -15.224.803,00	-27,39%
Banco Comercial Português, SA-Millennium bcp	$ 120.956.448,00	$ 75.120.240,00	$ -45.836.208,00	-37,89%
Banco de Sabadell SA	$ 129.955.915,00	$ 224.004.394,00	$ 94.048.479,00	72,37%
Banco Popolare - Società Cooperativa-Banco Popolare	$ 173.546.417,00	$ 123.762.943,00	$ -49.783.474,00	-28,69%
Banco Popular Espanol SA	$ 169.404.753,00	$ 155.928.515,00	$ -13.476.238,00	-7,96%
Bank Handlowy w Warszawie S.A.	$ 12.371.451,00	$ 10.817.581,00	$ -1.553.870,00	-12,56%
Bank Nederlandse Gemeenten NV, BNG	$ 176.565.580,00	$ 162.331.406,00	$ -14.234.174,00	-8,06%
Bank Ochrony Srodowiska SA	$ 4.575.735,00	$ 4.983.966,00	$ 408.231,00	8,92%
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	$ 48.487.857,00	$ 23.371.437,00	$ -25.116.420,00	-51,80%
Bank of Ireland-Governor and Company of the Bank of Ireland	$ 200.399.216,00	$ 129.790.283,00	$ -70.608.933,00	-35,23%
Bank of Valletta Plc	$ 8.942.861,00	$ 11.967.774,00	$ 3.024.913,00	33,82%
Banque et Caisse d'Epargne de l'Etat Luxembourg	$ 51.421.414,00	$ 45.820.279,00	$ -5.601.135,00	-10,89%
Barclays Plc	$ 2.417.369.127,00	$ 1.492.387.524,00	$ -924.981.603,00	-38,26%
Belfius Banque SA/NV-Belfius Bank SA/NV	$ 300.843.426,00	$ 186.281.535,00	$ -114.561.891,00	-38,08%
BPCE Group	$ 1.472.969.170,00	$ 1.302.066.529,00	$ -170.902.641,00	-11,60%
BPER Banca S.P.A.	$ 78.265.327,00	$ 68.471.206,00	$ -9.794.121,00	-12,51%
Caisse de Refinancement de l'Habitat SA-CRH	$ 64.144.849,00	$ 41.770.065,00	$ -22.374.784,00	-34,88%
Commerzbank AG	$ 856.255.075,00	$ 506.442.363,00	$ -349.812.712,00	-40,85%
Cooperatieve Rabobank U.A.	$ 946.701.266,00	$ 698.439.306,00	$ -248.261.960,00	-26,22%
Credito Emiliano SpA-CREDEM	$ 40.236.804,00	$ 41.709.719,00	$ 1.472.915,00	3,66%
Danske Bank A/S	$ 596.004.443,00	$ 493.941.428,00	$ -102.063.015,00	-17,12%
De Volksbank N.V.	$ 105.157.832,00	$ 64.891.452,00	$ -40.266.380,00	-38,29%
DekaBank Deutsche Girozentrale AG	$ 173.043.066,00	$ 90.604.852,00	$ -82.438.214,00	-47,64%
Deutsche Apotheker- und Aerztebank eG	$ 50.254.741,00	$ 40.692.042,00	$ -9.562.699,00	-19,03%
Deutsche Bank AG	$ 2.800.132.642,00	$ 1.676.594.597,00	$ -1.123.538.045,00	-40,12%
DNB Bank ASA	$ 314.682.467,00	$ 272.421.344,00	$ -42.261.123,00	-13,43%
DZ Bank AG-Deutsche Zentral-Genossenschaftsbank	$ 525.227.608,00	$ 537.008.101,00	$ 11.780.493,00	2,24%
Erste Group Bank AG	$ 271.727.173,00	$ 219.492.162,00	$ -52.235.011,00	-19,22%
Eurobank Ergasias SA	$ 99.399.978,00	$ 69.984.864,00	$ -29.415.114,00	-29,59%
Getin Noble Bank SA	$ 15.667.488,00	$ 15.915.858,00	$ 248.370,00	1,59%
Hellenic Bank Public Company Limited	$ 10.712.166,00	$ 7.418.339,00	$ -3.293.827,00	-30,75%
HSBC Holdings Plc	$ 2.555.579.000,00	$ 2.374.986.000,00	$ -180.593.000,00	-7,07%
HSH Nordbank AG	$ 175.848.759,00	$ 88.929.150,00	$ -86.919.609,00	-49,43%
IKB Deutsche Industriebank AG	$ 42.196.543,00	$ 20.514.747,00	$ -21.681.796,00	-51,38%
ING Groep NV	$ 1.655.192.973,00	$ 890.799.913,00	$ -764.393.060,00	-46,18%
Intesa Sanpaolo	$ 827.087.984,00	$ 764.327.937,00	$ -62.760.047,00	-7,59%
Jyske Bank A/S (Group)	$ 47.030.773,00	$ 83.187.247,00	$ 36.156.474,00	76,88%
KBC Groep NV/ KBC Groupe SA-KBC Group	$ 369.255.739,00	$ 290.088.330,00	$ -79.167.409,00	-21,44%
Landesbank Hessen-Thueringen Girozentrale - HELABA	$ 212.180.174,00	$ 174.099.378,00	$ -38.080.796,00	-17,95%
Landeskreditbank Baden-Wuerttemberg - Förderbank-L-Bank	$ 87.974.760,00	$ 79.136.968,00	$ -8.837.792,00	-10,05%
Liberbank SA	$ 65.790.610,00	$ 40.397.791,00	$ -25.392.819,00	-38,60%
Lloyds Banking Group Plc	$ 1.500.561.190,00	$ 1.006.048.894,00	$ -494.512.296,00	-32,96%
Münchener Hypothekenbank eG	$ 48.324.956,00	$ 40.592.331,00	$ -7.732.625,00	-16,00%
National Bank of Greece SA	$ 138.100.437,00	$ 82.779.530,00	$ -55.320.907,00	-40,06%
Nederlandse Waterschapsbank NV	$ 87.591.847,00	$ 99.521.801,00	$ 11.929.954,00	13,62%
Nova Kreditna Banka Maribor d.d.	$ 7.525.577,00	$ 5.084.399,00	$ -2.441.178,00	-32,44%
NRW.BANK	$ 197.379.252,00	$ 149.751.436,00	$ -47.627.816,00	-24,13%
Nykredit Realkredit A/S	$ 242.429.869,00	$ 198.588.652,00	$ -43.841.217,00	-18,08%
OTP Bank Plc	$ 42.382.114,00	$ 38.502.042,00	$ -3.880.072,00	-9,15%
Permanent TSB Plc	$ 93.208.667,00	$ 24.880.977,00	$ -68.327.690,00	-73,31%
Piraeus Bank SA	$ 63.856.946,00	$ 85.909.716,00	$ 22.052.770,00	34,53%
Powszechna Kasa Oszczednosci Bank Polski SA - PKO BP SA	$ 55.816.714,00	$ 68.330.270,00	$ 12.513.556,00	22,42%
Raiffeisen Zentralbank Oesterreich AG - RZB	$ 194.197.639,00	$ 142.141.780,00	$ -52.055.859,00	-26,81%
Raiffeisenlandesbank Niederösterreich-Wien AG	$ 41.537.729,00	$ 26.779.184,00	$ -14.758.545,00	-35,53%
Raiffeisenlandesbank Oberösterreich AG	$ 49.589.584,00	$ 41.515.866,00	$ -8.073.718,00	-16,28%
RCI Banque SA	$ 35.071.157,00	$ 45.663.614,00	$ 10.592.457,00	30,20%
Royal Bank of Scotland Group Plc (The)	$ 2.329.767.099,00	$ 982.506.558,00	$ -1.347.260.541,00	-57,83%
Skandinaviska Enskilda Banken AB	$ 342.549.915,00	$ 289.184.297,00	$ -53.365.618,00	-15,58%
Société Générale SA	$ 1.528.577.105,00	$ 1.457.020.289,00	$ -71.556.816,00	-4,68%
Svenska Handelsbanken AB	$ 356.340.440,00	$ 289.949.454,00	$ -66.390.986,00	-18,63%
Swedbank AB	$ 269.620.489,00	$ 237.713.022,00	$ -31.907.467,00	-11,83%
Sydbank A/S	$ 26.705.828,00	$ 20.798.265,00	$ -5.907.563,00	-22,12%
UniCredit SpA	$ 1.199.145.979,00	$ 906.033.529,00	$ -293.112.450,00	-24,44%
Unione di Banche Italiane Scpa-UBI Banca	$ 167.952.983,00	$ 118.463.891,00	$ -49.489.092,00	-29,47%
Veneto Banca scpa	$ 49.127.596,00	$ 29.597.289,00	$ -19.530.307,00	-39,75%

Source: Orbis Bank Focus database 2017

Table 2 shows that 64 banks out of a 78 banks sample[52] actually decreased the amount of their Total Assets during the chosen period. This phenomenon is deeply affected by the aftermath of the financial crisis. The majority of the entities belonging to the EU banking sector recorded significant losses due to the adverse conditions of the distressed financial markets, and contracted the volume of their businesses. The amount of Total Assets reduction experienced during the selected period is about 8.035.389.446 dollars and the average Total Assets percentage change (defined in Table 2 as Δ Total Assets/ Total Assets 2011) for banks recording a decrease was about -15,81%[53]. The decrease of the level of Total Assets in the above 78 banks sample lets to identify a sound trend in the chosen period. A similar historical data analysis for the Equity value is needed in order to verify the movement of the denominator variable of the Leverage ratio.

The Equity amount represents banks' own source of financing and comprehends all the different types of regulatory capital instruments held to absorb losses. In Table 3 data from a smaller set of European banks (31) are collected in order to assess the variation of the amount of Equity during the chosen period.

[52]The banks are among those submitted to the 2014 and 2016 EU wide stress test exercises.
[53]An equally-weighted mean across the whole sample is calculated.

Table 3 Equity variation (2011-2016) in a set of 31 EU large banks

*Thousand dollars amounts	Equity		2011-2016 Period	
	2011	2016	Δ Equity	Δ Equity/Equity 2011
ABN AMRO Group N.V.	$ 14.776.337,00	$ 19.961.492,00	$ 5.185.155,00	35,09%
Allied Irish Banks plc	$ 18.713.674,00	$ 13.859.307,00	$ -4.854.367,00	-25,94%
Banca Monte dei Paschi di Siena SpA	$ 14.209.268,00	$ 6.809.776,00	$ -7.399.492,00	-52,08%
Banco de Sabadell SA	$ 7.678.188,00	$ 13.790.765,00	$ 6.112.577,00	79,61%
Banco Popolare - Società Cooperativa-Banco Popolare	$ 12.192.817,00	$ 8.058.435,00	$ -4.134.382,00	-33,91%
Banco Popular Espanol SA	$ 10.853.522,00	$ 11.687.453,00	$ 833.931,00	7,68%
Bank of Ireland-Governor and Company of the Bank of Ireland	$ 13.265.062,00	$ 9.910.649,00	$ -3.354.413,00	-25,29%
Barclays Plc	$ 100.799.537,00	$ 87.793.218,00	$ -13.006.319,00	-12,90%
BPCE Group	$ 59.029.007,00	$ 71.579.717,00	$ 12.550.710,00	21,26%
Commerzbank AG	$ 32.092.599,00	$ 31.243.525,00	$ -849.074,00	-2,65%
Cooperatieve Rabobank U.A.	$ 58.226.789,00	$ 42.716.350,00	$ -15.510.439,00	-26,64%
Danske Bank A/S	$ 21.904.589,00	$ 23.623.951,00	$ 1.719.362,00	7,85%
Deutsche Bank AG	$ 70.724.568,00	$ 68.325.710,00	$ -2.398.858,00	-3,39%
DNB Bank ASA	$ 17.413.021,00	$ 22.050.812,00	$ 4.637.791,00	26,63%
Erste Group Bank AG	$ 19.641.400,00	$ 17.500.165,00	$ -2.141.235,00	-10,90%
HSBC Holdings Plc	$ 166.093.000,00	$ 182.578.000,00	$ 16.485.000,00	9,93%
ING Groep NV	$ 65.264.311,00	$ 53.125.588,00	$ -12.138.723,00	-18,60%
Intesa Sanpaolo	$ 61.794.071,00	$ 51.987.160,00	$ -9.806.911,00	-15,87%
Jyske Bank A/S (Group)	$ 2.409.844,00	$ 4.610.084,00	$ 2.200.240,00	91,30%
KBC Groep NV/ KBC Groupe SA-KBC Group	$ 21.701.289,00	$ 18.296.014,00	$ -3.405.275,00	-15,69%
Lloyds Banking Group Plc	$ 72.038.984,00	$ 60.052.210,00	$ -11.986.774,00	-16,64%
Nykredit Realkredit A/S	$ 9.626.323,00	$ 10.060.685,00	$ 434.362,00	4,51%
OTP Bank Plc	$ 5.892.928,00	$ 4.837.240,00	$ -1.055.688,00	-17,91%
Powszechna Kasa Oszczednosci Bank Polski SA - PKO BP SA	$ 6.678.172,00	$ 7.792.836,00	$ 1.114.664,00	16,69%
Royal Bank of Scotland Group Plc (The)	$ 117.585.545,00	$ 60.776.797,00	$ -56.808.748,00	-48,31%
Skandinaviska Enskilda Banken AB	$ 14.916.300,00	$ 15.556.487,00	$ 640.187,00	4,29%
Société Générale SA	$ 66.133.811,00	$ 69.260.697,00	$ 3.126.886,00	4,73%
Svenska Handelsbanken AB	$ 13.723.595,00	$ 15.049.436,00	$ 1.325.841,00	9,66%
Swedbank AB	$ 14.247.572,00	$ 14.312.749,00	$ 65.177,00	0,46%
UniCredit SpA	$ 70.902.580,00	$ 45.524.791,00	$ -25.377.789,00	-35,79%
Unione di Banche Italiane Scpa-UBI Banca	$ 12.729.319,00	$ 9.551.838,00	$ -3.177.481,00	-24,96%

Source: Orbis Bank Focus database 2017

The Equity amount increased for 14 out of 31 banks in the sample, while it decreased for 17 of them. The proportion between banks that increased the amount of their Equity and the banks that decreased such amount is near 50%, so it is not possible to recognize any sound decrease or increase trend. Nonetheless, the amount of the Equity variation is quite different in the sample. The sum of all the Equity loss for the banks experiencing a decrease in the Equity is about 177.405.968 dollars, while the total Equity increase recorded by the other banks was just 56.431.883 dollars. The difference between these two values gives the loss of Equity in the overall sample of banks that is 120.974.085 dollars. Because of that, it is clear that the Equity decrease recorded by 17 banks in the sample was much higher in absolute value compared to the Equity increase made by the other 14 banks of the sample. This actual change in the overall Equity amount of the whole sample outlines a reduction in the level of capitalization of the banks inside the sample.

The historical data collection for these two variables allow to observe the trend during the selected period for one of the most important banking indicator: the Leverage ratio. As previously mentioned, the Leverage ratio is intended as the ratio between the values reported in Table 3 and

Table 2 (i.e. Equity and Total Assets). The following table reports the value of such a ratio between 2011 and 2016 for the same sample of banks used in Table 3.

Table 4 Leverage ratio variation (2011-2016) in a set of 31 EU large banks

	Leverage ratio		2011-2016 period	
	2011	2016	Δ Leverage ratio	Δ Leverage ratio/Leverage ratio 2011
ABN AMRO Group N.V.	2,82%	4,80%	1,98%	70,11%
Allied Irish Banks plc	10,58%	13,75%	3,17%	29,91%
Banca Monte dei Paschi di Siena SpA	4,56%	4,22%	-0,34%	-7,56%
Banco de Sabadell SA	5,91%	6,16%	0,25%	4,20%
Banco Popolare - Società Cooperativa-Banco Popolare	7,03%	6,51%	-0,51%	-7,32%
Banco Popular Espanol SA	6,41%	7,50%	1,09%	16,99%
Bank of Ireland-Governor and Company of the Bank of Ireland	6,62%	7,64%	1,02%	15,36%
Barclays Plc	4,17%	5,88%	1,71%	41,08%
BPCE Group	4,01%	5,50%	1,49%	37,18%
Commerzbank AG	3,75%	6,17%	2,42%	64,60%
Cooperatieve Rabobank U.A.	6,15%	6,12%	-0,03%	-0,56%
Danske Bank A/S	3,68%	4,78%	1,11%	30,13%
Deutsche Bank AG	2,53%	4,08%	1,55%	61,35%
DNB Bank ASA	5,53%	8,09%	2,56%	46,28%
Erste Group Bank AG	7,23%	7,97%	0,74%	10,30%
HSBC Holdings Plc	6,50%	7,69%	1,19%	18,28%
ING Groep NV	3,94%	5,96%	2,02%	51,25%
Intesa Sanpaolo	7,47%	6,80%	-0,67%	-8,96%
Jyske Bank A/S (Group)	5,12%	5,54%	0,42%	8,15%
KBC Groep NV/ KBC Groupe SA-KBC Group	5,88%	6,31%	0,43%	7,32%
Lloyds Banking Group Plc	4,80%	5,97%	1,17%	24,34%
Nykredit Realkredit A/S	3,97%	5,07%	1,10%	27,58%
OTP Bank Plc	13,90%	12,56%	-1,34%	-9,64%
Powszechna Kasa Oszczednosci Bank Polski SA - PKO BP SA	11,96%	11,40%	-0,56%	-4,68%
Royal Bank of Scotland Group Plc (The)	5,05%	6,19%	1,14%	22,56%
Skandinaviska Enskilda Banken AB	4,35%	5,38%	1,02%	23,54%
Société Générale SA	4,33%	4,75%	0,43%	9,87%
Svenska Handelsbanken AB	3,85%	5,19%	1,34%	34,77%
Swedbank AB	5,28%	6,02%	0,74%	13,94%
UniCredit SpA	5,91%	5,02%	-0,89%	-15,02%
Unione di Banche Italiane Scpa-UBI Banca	7,58%	8,06%	0,48%	6,39%

Source: Orbis Bank Focus database 2017

In Table 4 it's possible to observe that the majority of banks actually increased their Leverage ratio in the reference period. Indeed 24 out of 31 banks ended with an higher leverage ratio in 2016 compared to the 2011. This fact implies that the financial leverage of the majority of the banks decreased during that period. On top of the results outlined in Table 3 and Table 2, it's possible to disentangle the trend for the Leverage ratio. When a ratio increases between two different moments, movements in one of the two variable or both are expected. In this case, the amount of Total Assets decreased for most of the banks of the sample, while almost half of the banks increased their Equity. Therefore, a possible explanation of Leverage ratio variation in the sample relies on the following reasoning.

Given that the Leverage ratio mostly raised up

$$\text{Leverage ratio} \uparrow = \frac{\text{Equity}}{\text{Total Assets}} \tag{4.3}$$

and the amount of Total Assets mostly decreased, the focus is on the movement of the Equity amount.

For banks increasing the Equity amount, the change in the Leverage ratio is explained by movements of both the numerator and the denominator in opposite directions as follows:

$$\text{Leverage ratio} \uparrow = \frac{\text{Equity} \uparrow}{\text{Total Assets} \downarrow} \tag{4.4}$$

If a bank recorded an Equity amount decrease together with a Leverage ratio increase as shown below

$$\text{Leverage ratio} \uparrow = \frac{\text{Equity} \downarrow}{\text{Total Assets} \downarrow} \tag{4.5}$$

the Total Assets decrease had an higher impact compared to the Equity decrease.

The overall increase in the Leverage ratio for the majority of the banks of this sample, represents a good proxy of the trend spread in the whole EU banking sector in the chosen period. This phenomenon is a result of many drivers; one of them is the regulatory setting of a minimum Leverage ratio (Basel Committee) that forced all the banks under the 3% threshold to adequate. Furthermore, the adverse conditions of the financial markets in the reference period contributed to reduce the level of Equity as a result of heavy losses. At the same time, stress testing procedure and the supervisory recommendations led many banks to raise capital or to collect funds through capital instrument issuing. European banks' Equity level was actually submitted to the impact of the losses absorption due to negative performance and the regulatory recommendations toward a higher capitalization: such opposite drivers led to different variation of the Equity capital of each individual banks. Because of that, the main driver of the increase in the Leverage ratio could be identified in the overall reduction of the Total Assets of the banks: such a reduction of the amount of assets held by the banks is a direct consequence of the economic scenario, that witnessed a world-wide recession started in 2009.

4.3 CET 1 Ratio

The analysis on the Leverage ratio is free from the risk-weighting procedure, and it's considered an important measure of the solidity of the banks because it allows to balance any measure calibrated on RWA. Measure based on RWA comes from regulatory framework implied by the Basel Agreements that is intended to define banks Capital requirements. In particular, the principal indicator used to evaluate stress test exercise outcomes is the CET 1 Ratio that is defined as follows:

$$\text{CET 1 Ratio} = \frac{\text{CET 1 Capital}^{54}}{\text{RWA}} \tag{4.6}$$

An explanation of the movement of the CET 1 Ratio in the European banking sector implies a further data collection referred to the numerator and the denominator variable.

First, data on the level of CET 1 Capital for a given set of banks are reported in the following table. Once again, the set of banks is a subset of 2016 EU wide stress test exercise sample, so it is assumed to be representative of the European banking sector.

Table 5 CET 1 Capital variation (2011-2016) in a set of 29 EU large banks

	CET 1 Capital		2011-2016 period	
*Thousands dollars amounts	2011	2016	Δ CET 1 Capital	Δ CET 1 Capital/CET 1 Capital
ABN AMRO Group N.V.	$ 16.309.608,00	$ 18.721.871,00	$ 2.412.263,00	14,79%
Allied Irish Banks plc	$ 19.597.408,00	$ 8.763.788,00	$ -10.833.620,00	-55,28%
Banca Monte dei Paschi di Siena SpA	$ 15.072.298,00	$ 5.643.018,00	$ -9.429.280,00	-62,56%
Banco de Sabadell SA	$ 7.222.575,00	$ 10.891.341,00	$ 3.668.766,00	50,80%
Banco Popolare - Società Cooperativa-Banco Popolare	$ 9.716.280,00	$ 5.351.201,00	$ -4.365.079,00	-44,93%
Banco Popular Espanol SA	$ 11.454.480,00	$ 8.230.561,00	$ -3.223.919,00	-28,15%
Bank Nederlandse Gemeenten NV, BNG	$ 3.145.471,00	$ 3.479.584,00	$ 334.113,00	10,62%
Bank of Ireland-Governor and Company of the Bank of Ireland	$ 12.431.790,00	$ 6.555.448,00	$ -5.876.342,00	-47,27%
Barclays Plc	$ 66.584.343,00	$ 55.609.958,00	$ -10.974.385,00	-16,48%
Belfius Banque SA/NV-Belfius Bank SA/NV	$ 8.715.710,00	$ 8.187.195,00	$ -528.515,00	-6,06%
Cooperatieve Rabobank U.A.	$ 36.648.421,00	$ 31.220.335,00	$ -5.428.086,00	-14,81%
Danske Bank A/S	$ 18.592.663,00	$ 18.814.372,00	$ 221.709,00	1,19%
Deutsche Bank AG	$ 46.985.387,00	$ 44.566.295,00	$ -2.419.092,00	-5,15%
DNB Bank ASA	$ 15.889.315,00	$ 18.954.524,00	$ 3.065.209,00	19,29%
Erste Group Bank AG	$ 13.820.145,00	$ 13.973.150,00	$ 153.005,00	1,11%
HSBC Holdings Plc	$ 122.496.000,00	$ 115.984.000,00	$ -6.512.000,00	-5,32%
Intesa Sanpaolo	$ 48.255.997,00	$ 37.869.598,00	$ -10.386.399,00	-21,52%
Jyske Bank A/S (Group)	$ 2.282.964,00	$ 4.267.100,00	$ 1.984.136,00	86,91%
KBC Groep NV/ KBC Groupe SA-KBC Group	$ 20.085.208,00	$ 14.637.233,00	$ -5.447.975,00	-27,12%
Lloyds Banking Group Plc	$ 58.737.886,00	$ 36.025.175,00	$ -22.712.711,00	-38,67%
Nykredit Realkredit A/S	$ 10.353.488,00	$ 9.338.561,00	$ -1.014.927,00	-9,80%
OTP Bank Plc	$ 4.145.392,00	$ 3.103.027,00	$ -1.042.365,00	-25,15%
Royal Bank of Scotland Group Plc (The)	$ 71.647.821,00	$ 37.672.413,00	$ -33.975.408,00	-47,42%
Skandinaviska Enskilda Banken AB	$ 13.516.414,00	$ 12.625.962,00	$ -890.452,00	-6,59%
Société Générale SA	$ 51.990.192,00	$ 43.151.693,00	$ -8.838.499,00	-17,00%
Svenska Handelsbanken AB	$ 11.525.473,00	$ 12.716.559,00	$ 1.191.086,00	10,33%
Swedbank AB	$ 11.223.195,00	$ 10.889.077,00	$ -334.118,00	-2,98%
UniCredit SpA	$ 55.530.329,00	$ 33.243.366,00	$ -22.286.963,00	-40,13%
Unione di Banche Italiane Scpa-UBI Banca	$ 10.708.675,00	$ 7.198.747,00	$ -3.509.928,00	-32,78%

Source: Orbis Bank Focus database 2017

Table 5 clearly shows that the level of CET 1 Capital decreased for 21 out of 29 banks of the sample; the high-quality portion of bank's Equity was deeply affected by losses in the post-crisis period, therefore the numerator of the CET 1 Ratio had a downturn movement in the reference period.

The other variable observed is the denominator of the CET 1 Ratio: the amount of RWA. The decomposition of this variable with regard of the type of risk and regulatory approach (in case of Credit risk) is left for a further analysis in a following chapter. In this section, the amount of

[54]Common Equity Tier 1 Capital. This is the highest quality Tier 1 Capital according to the Basel III rules referred to the definition of capital.

RWA is recorded for a sample of banks, in order to assess if the level of risk-weighted exposure has grown in the reference period. Table 5 collects data referred to this variable.

Table 6 RWA variation (2011-2016) in a set of 65 EU large banks

*Thousands dollars amounts	RWA		2011-2016 period	
	2011	2016	Δ RWA	Δ RWA/RWA 2011
Aareal Bank AG	$ 19.813.489,00	$ 15.326.615,00	$ -4.486.874,00	-22,65%
ABN AMRO Group N.V.	$ 153.050.243,00	$ 109.853.035,00	$ -43.197.208,00	-28,22%
Alior Bank Spólka Akcyjna	$ 2.869.111,00	$ 11.129.232,00	$ 8.260.121,00	287,90%
Allied Irish Banks plc	$ 109.048.589,00	$ 57.169.115,00	$ -51.879.474,00	-47,57%
Alpha Bank AE	$ 58.342.597,00	$ 53.269.267,00	$ -5.073.330,00	-8,70%
Banca Carige SpA	$ 29.930.588,00	$ 17.950.031,00	$ -11.980.557,00	-40,03%
Banca Monte dei Paschi di Siena SpA-Gruppo Monte dei Paschi	$ 136.104.075,00	$ 69.066.377,00	$ -67.037.698,00	-49,25%
Banca Piccolo Credito Valtellinese	$ 27.518.113,00	$ 15.325.605,00	$ -12.192.508,00	-44,31%
Banca Popolare di Milano SCaRL	$ 59.282.029,00	$ 37.276.236,00	$ -22.005.793,00	-37,12%
Banca Popolare di Sondrio Societa Cooperativa per Azioni	$ 30.486.416,00	$ 24.463.228,00	$ -6.023.188,00	-19,76%
Banca Popolare di Vicenza Societa per azioni	$ 36.722.513,00	$ 22.639.341,00	$ -14.083.172,00	-38,35%
Banco BPI SA	$ 33.687.719,00	$ 25.427.135,00	$ -8.260.584,00	-24,52%
Banco Comercial Português, SA-Millennium bcp	$ 71.753.219,00	$ 41.278.336,00	$ -30.474.883,00	-42,47%
Banco de Sabadell SA	$ 72.674.744,00	$ 90.726.369,00	$ 18.051.625,00	24,84%
Banco Popolare - Società Cooperativa-Banco Popolare	$ 116.495.291,00	$ 41.254.432,00	$ -75.240.859,00	-64,59%
Banco Popular Espanol SA	$ 114.097.678,00	$ 67.854.772,00	$ -46.242.906,00	-40,53%
Bank Handlowy w Warszawie S.A.	$ 7.793.747,00	$ 6.579.816,00	$ -1.213.931,00	-15,58%
Bank Nederlandse Gemeenten NV, BNG	$ 15.070.052,00	$ 12.994.945,00	$ -2.075.107,00	-13,77%
Bank Ochrony Srodowiska SA	$ 2.864.202,00	$ 3.502.258,00	$ 638.056,00	22,28%
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	$ 32.075.633,00	$ 19.885.833,00	$ -12.189.800,00	-38,00%
Bank of Ireland-Governor and Company of the Bank of Ireland	$ 86.820.683,00	$ 53.548.282,00	$ -33.272.401,00	-38,32%
Bank of Valletta Plc	$ 4.653.378,00	$ 5.132.485,00	$ 479.107,00	10,30%
Barclays Plc	$ 604.523.562,00	$ 449.821.375,00	$ -154.702.187,00	-25,59%
Belfius Banque SA/NV-Belfius Bank SA/NV	$ 68.607.748,00	$ 49.258.095,00	$ -19.349.653,00	-28,20%
BPCE Group	$ 532.610.601,00	$ 412.133.086,00	$ -120.477.515,00	-22,62%
BPER Banca S.P.A.	$ 60.947.861,00	$ 34.356.530,00	$ -26.591.331,00	-43,63%
Commerzbank AG	$ 306.128.951,00	$ 200.834.518,00	$ -105.294.433,00	-34,40%
Cooperatieve Rabobank U.A.	$ 289.332.837,00	$ 222.653.334,00	$ -66.679.503,00	-23,05%
Credito Emiliano SpA-CREDEM	$ 21.720.730,00	$ 14.152.049,00	$ -7.568.681,00	-34,85%
Danske Bank A/S	$ 157.682.232,00	$ 115.592.251,00	$ -42.089.981,00	-26,69%
De Volksbank N.V.	$ 26.568.940,00	$ 11.409.579,00	$ -15.159.361,00	-57,06%
DekaBank Deutsche Girozentrale AG	$ 32.527.349,00	$ 25.101.284,00	$ -7.426.065,00	-22,83%
Deutsche Bank AG	$ 493.294.159,00	$ 375.507.327,00	$ -117.786.832,00	-23,88%
DNB Bank ASA	$ 170.494.155,00	$ 120.752.552,00	$ -49.741.603,00	-29,17%
DZ Bank AG-Deutsche Zentral-Genossenschaftsbank	$ 128.904.777,00	$ 124.871.853,00	$ -4.032.924,00	-3,13%
Erste Group Bank AG	$ 147.529.172,00	$ 107.316.871,00	$ -40.212.301,00	-27,26%
Eurobank Ergasias SA	$ 56.474.849,00	$ 40.594.447,00	$ -15.880.402,00	-28,12%
Hellenic Bank Public Company Limited	$ 6.987.917,00	$ 3.946.029,00	$ -3.041.888,00	-43,53%
HSBC Holdings Plc	$ 1.209.514.000,00	$ 857.200.000,00	$ -352.314.000,00	-29,13%
HSH Nordbank AG	$ 59.390.005,00	$ 30.147.261,00	$ -29.242.744,00	-49,24%
IKB Deutsche Industriebank AG	$ 23.107.214,00	$ 13.826.671,00	$ -9.280.543,00	-40,16%
Intesa Sanpaolo	$ 420.784.009,00	$ 299.277.974,00	$ -121.506.035,00	-28,88%
Jyske Bank A/S (Group)	$ 18.907.861,00	$ 25.833.003,00	$ 6.925.142,00	36,63%
KBC Groep NV/ KBC Groupe SA-KBC Group	$ 163.462.255,00	$ 91.578.103,00	$ -71.884.152,00	-43,98%
Landesbank Hessen-Thueringen Girozentrale - HELABA	$ 74.124.290,00	$ 55.708.133,00	$ -18.416.157,00	-24,84%
Landeskreditbank Baden-Wuerttemberg	$ 25.845.780,00	$ 19.813.918,00	$ -6.031.862,00	-23,34%
Lloyds Banking Group Plc	$ 544.754.427,00	$ 265.149.912,00	$ -279.604.515,00	-51,33%
Münchener Hypothekenbank eG	$ 11.122.687,00	$ 5.771.725,00	$ -5.350.962,00	-48,11%
National Bank of Greece SA	$ 83.130.480,00	$ 43.349.864,00	$ -39.780.616,00	-47,85%
Nederlandse Waterschapsbank NV	$ 1.701.478,00	$ 3.140.164,00	$ 1.438.686,00	84,56%
Nykredit Realkredit A/S	$ 60.595.066,00	$ 49.533.237,00	$ -11.061.829,00	-18,26%
OTP Bank Plc	$ 34.628.349,00	$ 22.916.893,00	$ -11.711.456,00	-33,82%
Permanent TSB Plc	$ 19.936.410,00	$ 11.166.082,00	$ -8.770.328,00	-43,99%
Piraeus Bank SA	$ 44.927.195,00	$ 56.147.803,00	$ 11.220.608,00	24,98%
Raiffeisen Zentralbank Oesterreich AG - RZB	$ 129.106.852,00	$ 71.737.071,00	$ -57.369.781,00	-44,44%
Raiffeisenlandesbank Niederösterreich-Wien AG	$ 17.528.462,00	$ 13.993.155,00	$ -3.535.307,00	-20,17%
Raiffeisenlandesbank Oberösterreich AG	$ 36.099.790,00	$ 24.535.196,00	$ -11.564.594,00	-32,04%
Royal Bank of Scotland Group Plc (The)	$ 678.737.909,00	$ 280.731.625,00	$ -398.006.284,00	-58,64%
Skandinaviska Enskilda Banken AB	$ 120.158.401,00	$ 67.308.047,00	$ -52.850.354,00	-43,98%
Svenska Handelsbanken AB	$ 73.800.690,00	$ 50.626.447,00	$ -23.174.243,00	-31,40%
Swedbank AB	$ 109.871.512,00	$ 43.492.197,00	$ -66.379.315,00	-60,42%
Sydbank A/S	$ 12.297.933,00	$ 9.018.688,00	$ -3.279.245,00	-26,67%
UniCredit SpA	$ 595.704.837,00	$ 408.079.999,00	$ -187.624.838,00	-31,50%
Unione di Banche Italiane Scpa-UBI Banca	$ 117.758.105,00	$ 62.701.943,00	$ -55.056.162,00	-46,75%
Veneto Banca scpa	$ 33.615.250,00	$ 20.103.465,00	$ -13.511.785,00	-40,20%

Source: Orbis Bank Focus database 2017

The overall RWA variation in the sample was negative, and in particular the amount of RWA decreased for 58 out of 65 banks. This movement of the variable is a direct consequence of the reduction in the Total Assets experienced in the banking sector (see Table 2). RWA calculation is calibrated on the amount of the Assets and it assigns risk weighting following rules outlined in the regulatory approaches. Therefore, the downward movement trend of Total Assets variable identified in Table 1 implied a reduction of the RWA in the reference period too. If Total Assets decreases, RWA calculated on them are expected to decrease as well ceteris paribus[55].

The overall reduction of the Total Assets of the banks is not the only driver of the RWA decrease. The regulatory monitoring activity focuses on many RWA indicators, and the stress test exercise evaluate the impact of the adverse scenario simulation through the change of the CET 1 Ratio. Because of that, most of the large European banks were concerned about their RWA amount. A reduction of RWA amount, given a quantity of CET 1 Capital, allows to increase the CET 1 Ratio. From this point of view, banks had a clear incentive to lower the RWA amount before a stress test exercise in order to start the exercise with a higher initial CET 1 Ratio. Another key element that explains the trend of RWA amount regards the Capital Requirements: the implementation of Basel III raised the amount and the quality of capital that banks are required to hold proportionally to their RWA. Because of that, given a fixed RWA amount, banks would have forced to issue more capital and specifically to widen the portion of Tier 1 Capital. Capital raising processes implies costs for the banks, furthermore Equity Capital is a more expensive financing source for the bank compared to the debt[56]. An easier way to increase the CET 1 Ratio without issuing more Equity capital, is to reduce the RWA. To achieve such a goal, a single bank could reduce the Total Assets or choose low risk assets (with low risk-weights). Low risk assets are assumed to have lower returns and such a portfolio constraint affect negatively the performance of the bank. Because of that, a RWA reduction has both positive and negative aftermaths.

In this section of the analysis, the decreasing trends of CET 1 Capital and RWA observed in Table 5 and Table 6 needs to be compared with the trend of the CET 1 Ratio. For this purpose, Table 6 collects data from a set of 28 EU large banks.

[55]A change in the portfolio composition of the bank could lead to an increase of the RWA even if Total Assets are lower. Banks may choose riskier assets in order to achieve higher returns; by doing so, chosen assets could require the utilization of higher risk weights (regulations prescribes many situations in which risk weights are far more than 100%) up to the point where the actual RWA can increase.

[56]Shareholders typically requires higher return on their investments, compared to debt holders.

Table 7 CET 1 Ratio variation (2011-2016) in a set of 28 EU large banks

	CET 1 Ratio		2011-2016 period	
	2011	2016	Δ CET 1 Ratio	Δ CET 1 Ratio/CET 1 Ratio 2011
ABN AMRO Group N.V.	10,66%	17,04%	6,39%	59,93%
Allied Irish Banks plc	17,97%	15,33%	-2,64%	-14,70%
Banca Monte dei Paschi di Siena SpA	11,07%	8,17%	-2,90%	-26,22%
Banco de Sabadell SA	9,94%	12,00%	2,07%	20,79%
Banco Popolare - Società Cooperativa-Banco Popolare	8,34%	12,97%	4,63%	55,52%
Banco Popular Espanol SA	10,04%	12,13%	2,09%	20,82%
Bank Nederlandse Gemeenten NV, BNG	20,87%	26,78%	5,90%	28,29%
Bank of Ireland-Governor and Company of the Bank of Ireland	14,32%	12,24%	-2,08%	-14,50%
Barclays Plc	11,01%	12,36%	1,35%	12,24%
Belfius Banque SA/NV-Belfius Bank SA/NV	12,70%	16,62%	3,92%	30,84%
Cooperatieve Rabobank U.A.	12,67%	14,02%	1,36%	10,70%
Danske Bank A/S	11,79%	16,28%	4,49%	38,04%
Deutsche Bank AG	9,52%	11,87%	2,34%	24,60%
DNB Bank ASA	9,32%	15,70%	6,38%	68,43%
Erste Group Bank AG	9,37%	13,02%	3,65%	38,99%
HSBC Holdings Plc	10,13%	13,53%	3,40%	33,60%
Intesa Sanpaolo	11,47%	12,65%	1,19%	10,34%
Jyske Bank A/S (Group)	12,07%	16,52%	4,44%	36,80%
KBC Groep NV/ KBC Groupe SA-KBC Group	12,29%	15,98%	3,70%	30,08%
Lloyds Banking Group Plc	10,78%	13,59%	2,80%	26,01%
Nykredit Realkredit A/S	17,09%	18,85%	1,77%	10,34%
OTP Bank Plc	11,97%	13,54%	1,57%	13,11%
Royal Bank of Scotland Group Plc (The)	10,56%	13,42%	2,86%	27,13%
Skandinaviska Enskilda Banken AB	11,25%	18,76%	7,51%	66,76%
Svenska Handelsbanken AB	15,62%	25,12%	9,50%	60,84%
Swedbank AB	10,21%	25,04%	14,82%	145,10%
UniCredit SpA	9,32%	8,15%	-1,18%	-12,61%
Unione di Banche Italiane Scpa-UBI Banca	9,09%	11,48%	2,39%	26,25%

Source: Orbis Bank Focus database 2017

Table 7 shows that 24 out of 28 banks increased their CET 1 Ratio in the period; the movement of such a ratio is then decomposed taking into account the trends of the numerator and the denominator variables:

$$\text{CET 1 Ratio } \uparrow = \frac{\text{CET 1 Capital}}{\text{RWA}} \tag{4.7}$$

Given that CET 1 Capital and RWA decreased,

$$\text{CET 1 Ratio } \uparrow = \frac{\text{CET 1 Capital}\downarrow}{\text{RWA}\downarrow} \tag{4.8}$$

If the CET 1 ratio increases but both numerator and denominator decrease, the change of the RWA variable had a greater impact compared to the CET 1 Capital change.

In the end, data collected above showed how two very important indicators of the banking sector, i.e. Leverage ratio and CET 1 Ratio increased during the period after the worldwide financial crisis. These phenomena are a response of the changes in the regulatory framework and need to be contextualized in a period in which several stress test exercise were conducted by the

authority in order to assess banking sector resilience. All data showing the movements of the variables involved, helped to disentangle the overall evolution of the banking sector, but the RWA variable is also used to calculate another important indicator: the RWA intensity. This indicator combines the risk-weighted amount of the assets and the actual exposure of the bank, in order to provide a riskiness measure of the bank's total exposure.

4.4 RWA intensity

The overall decrease of the RWA in the banking sector has been outlined in Table 6, (Table 6 shows data for 65 banks[57]). At the same time, the amount of Total Assets decreased too (Table 2). The proportion between the RWA amount and the Total Assets amount is measured by the RWA intensity, therefore a data collection for this variable allows to assess how the riskiness measure based on the risk-weighted procedure is changed in the post-crisis period. The following analysis, indeed, regards the RWA intensity and collects data for a wide set of European large banks.

The ratio between the level of RWA and the Total Assets of the banks is called RWA intensity and it is defined as follows:

$$\text{RWA intensity} = \frac{\text{RWA}}{\text{Total Assets}} \tag{4.9}$$

It represents the portion of RWA over the Total Assets. The results previously shown with regard of the movement of the Total Assets and RWA, are summarized as follows:

RWA $\downarrow$ and Total Assets $\downarrow$ then

$$\text{RWA intensity} = \frac{\text{RWA}\downarrow}{\text{Total Assets}\downarrow} \tag{4.10}$$

The actual change in the ratio depends on the magnitude of the two variables changes. In this case, the movement of the variables are assumed to represent the trend observed in the sample considered previously and leads to conclusions referred to the European banking sector. Nonetheless, the movements of the variables and the RWA intensity indicator may differ significantly on individual basis.

In order to verify how the RWA intensity changed in the reference period, a data collection similar to the previous ones is presented in Table 8:

[57]Banks from 2014 and 2016 EU wide stress test exercises samples were included.

Table 8 RWA intensity variation (2011-2016) in a set of 65 banks

	RWA intensity		2011-2016 period	
	2011	2016	Δ RWA intensity	Δ RWA intensity/RWA 2011
Aareal Bank AG	36,62%	30,48%	-6,14%	-16,78%
ABN AMRO Group N.V.	29,23%	26,42%	-2,81%	-9,62%
Alior Bank Spólka Akcyjna	63,32%	75,99%	12,66%	20,00%
Allied Irish Banks plc	61,67%	56,72%	-4,96%	-8,04%
Alpha Bank AE	76,23%	77,90%	1,67%	2,19%
Banca Carige SpA	51,56%	65,22%	13,65%	26,48%
Banca Monte dei Paschi di Siena SpA-Gruppo Monte dei Paschi di Siena	43,70%	42,77%	-0,93%	-2,12%
Banca Piccolo Credito Valtellinese-Credito Valtellinese Soc Coop	74,86%	57,08%	-17,77%	-23,74%
Banca Popolare di Milano SCaRL	88,23%	69,16%	-19,06%	-21,61%
Banca Popolare di Sondrio Societa Cooperativa per Azioni	80,46%	62,39%	-18,07%	-22,46%
Banca Popolare di Vicenza Societa per azioni	67,77%	62,39%	-5,38%	-7,94%
Banco BPI SA	60,61%	63,01%	2,40%	3,95%
Banco Comercial Português, SA-Millennium bcp	59,32%	54,95%	-4,37%	-7,37%
Banco de Sabadell SA	55,92%	40,50%	-15,42%	-27,57%
Banco Popolare - Società Cooperativa-Banco Popolare	67,13%	33,33%	-33,79%	-50,34%
Banco Popular Espanol SA	67,35%	43,52%	-23,84%	-35,39%
Bank Handlowy w Warszawie S.A.	63,00%	60,83%	-2,17%	-3,45%
Bank Nederlandse Gemeenten NV, BNG	8,54%	8,01%	-0,53%	-6,21%
Bank Ochrony Srodowiska SA - BOS SA-Bank Ochrony Srodowiska Capital Gr	62,60%	70,27%	7,68%	12,26%
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	66,15%	85,09%	18,93%	28,62%
Bank of Ireland-Governor and Company of the Bank of Ireland	43,32%	41,26%	-2,07%	-4,77%
Bank of Valletta Plc	52,03%	42,89%	-9,15%	-17,58%
Barclays Plc	25,01%	30,14%	5,13%	20,53%
Belfius Banque SA/NV-Belfius Bank SA/NV	22,81%	26,44%	3,64%	15,95%
BPCE Group	36,16%	31,65%	-4,51%	-12,46%
BPER Banca S.P.A.	77,87%	50,18%	-27,70%	-35,57%
Commerzbank AG	35,75%	39,66%	3,90%	10,92%
Cooperatieve Rabobank U.A.	30,56%	31,88%	1,32%	4,31%
Credito Emiliano SpA-CREDEM	53,98%	33,93%	-20,05%	-37,15%
Danske Bank A/S	26,46%	23,40%	-3,05%	-11,55%
De Volksbank N.V.	25,27%	17,58%	-7,68%	-30,41%
DekaBank Deutsche Girozentrale AG	18,80%	27,70%	8,91%	47,38%
Deutsche Bank AG	17,62%	22,40%	4,78%	27,13%
DNB Bank ASA	54,18%	44,33%	-9,85%	-18,19%
DZ Bank AG-Deutsche Zentral-Genossenschaftsbank	24,54%	23,25%	-1,29%	-5,25%
Erste Group Bank AG	54,29%	48,89%	-5,40%	-9,95%
Eurobank Ergasias SA	56,82%	58,00%	1,19%	2,09%
Hellenic Bank Public Company Limited	65,23%	53,19%	-12,04%	-18,46%
HSBC Holdings Plc	47,33%	36,09%	-11,24%	-23,74%
HSH Nordbank AG	33,77%	33,90%	0,13%	0,38%
IKB Deutsche Industriebank AG	54,76%	67,40%	12,64%	23,08%
Intesa Sanpaolo	50,88%	39,16%	-11,72%	-23,04%
Jyske Bank A/S (Group)	40,20%	31,05%	-9,15%	-22,76%
KBC Groep NV/ KBC Groupe SA-KBC Group	44,27%	31,57%	-12,70%	-28,69%
Landesbank Hessen-Thueringen Girozentrale - HELABA	34,93%	32,00%	-2,94%	-8,41%
Landeskreditbank Baden-Wuerttemberg - Förderbank-L-Bank	29,38%	25,04%	-4,34%	-14,78%
Lloyds Banking Group Plc	36,30%	26,36%	-9,95%	-27,40%
Münchener Hypothekenbank eG	23,02%	14,22%	-8,80%	-38,22%
National Bank of Greece SA	60,20%	52,37%	-7,83%	-13,00%
Nederlandse Waterschapsbank NV	1,94%	3,16%	1,21%	62,43%
Nykredit Realkredit A/S	24,99%	24,94%	-0,05%	-0,21%
OTP Bank Plc	81,71%	59,52%	-22,18%	-27,15%
Permanent TSB Plc	21,39%	44,88%	23,49%	109,82%
Piraeus Bank SA	70,36%	65,36%	-5,00%	-7,11%
Raiffeisen Zentralbank Oesterreich AG - RZB	66,48%	50,47%	-16,01%	-24,09%
Raiffeisenlandesbank Niederösterreich-Wien AG	42,20%	52,25%	10,05%	23,83%
Raiffeisenlandesbank Oberösterreich AG	72,80%	59,10%	-13,70%	-18,82%
Royal Bank of Scotland Group Plc (The)	29,13%	28,57%	-0,56%	-1,92%
Skandinaviska Enskilda Banken AB	35,08%	23,28%	-11,80%	-33,65%
Svenska Handelsbanken AB	20,71%	17,46%	-3,25%	-15,69%
Swedbank AB	40,75%	18,30%	-22,45%	-55,10%
Sydbank A/S	46,05%	43,36%	-2,69%	-5,83%
UniCredit SpA	49,68%	45,04%	-4,64%	-9,33%
Unione di Banche Italiane Scpa-UBI Banca	70,11%	52,93%	-17,18%	-24,51%
Veneto Banca scpa	68,42%	67,92%	-0,50%	-0,73%

Source: Orbis Bank Focus database 2017

The data collection of the RWA intensity in this set of 65 banks showed that 47 out of 65 banks decreased their RWA intensity in the reference period. The movement of this indicator, given the observed changes of the numerator and the denominator variables, could be synthetized as follows:

$$\text{RWA intensity} \downarrow = \frac{\text{RWA}\downarrow}{\text{Total Assets}\downarrow} \tag{4.11}$$

Both RWA and Total Assets decreased, so the movement of the ratio implies that RWA decrease had a greater impact compared to what Total Assets. Once again, the significant reduction of RWA drives a trend of an important indicator of the banking sector, like it did for the CET 1 Ratio[58].

RWA intensity has become more important from its first introduction, because it represents the portion of risk-weighted exposure of the banks over their total exposure. If the risk-weighting procedure evaluates risk of the assets with the maximum possible accuracy, banks with high RWA intensity are assumed to have the most risky portfolios of assets. In this sense, banks with high RWA intensity are considered riskier than those with low RWA intensity. Because of that, a deeper analysis on the RWA and the RWA intensity is required.

[58]See Paragraph 4.3.

Chapter 5 RWA intensity and internal models

RWA have become a key variable of the new banking regulatory framework; given the overall trend for the European banking sector observed in the previous Paragraphs, it's important to disentangle the RWA and to inquire any relationship between this variable and other relevant variables for the individual bank. The following analysis is aimed to decompose the RWA of the single banks, in order to search a link between the level of RWA of the banks, the type of risk and the effect of regulatory approach application on it. The next step will involve a collection of stress test results for EU large banks coupled with different RWA indicators in order to outline some empirical evidence that supports the thesis of this work. The RWA decomposition will differentiate the amount of RWA held with regard of different type of risk, credit, market, counterparty and operational risk.

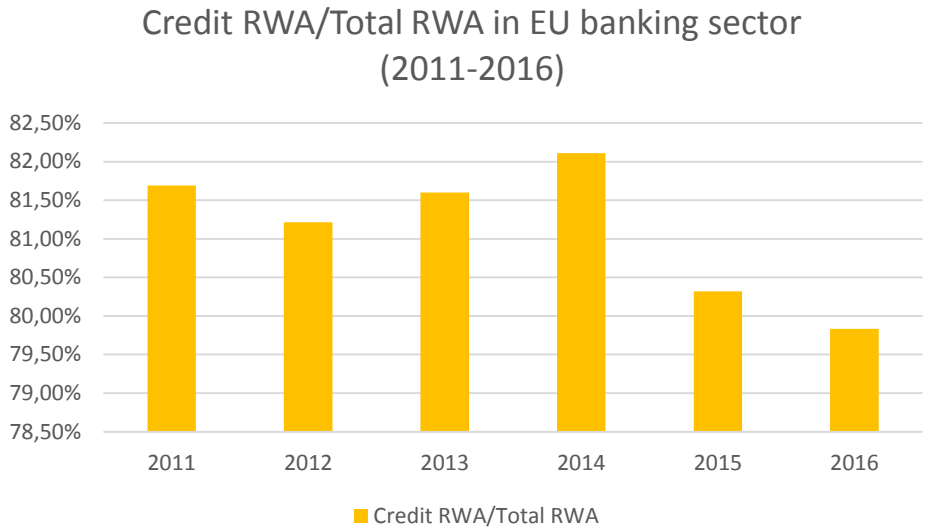
The first utilization of RWA data is a sound representation of RWA across the banking sector. RWA are classified by the regulation with regard of the type of risk. Credit risk, market risk, counterparty risk and operational risk are the most important ones. Credit risk represents the major component of the RWA asset of a bank, indeed it was the first type of risk deeply regulated since the First Basel Agreement. The regulation with regard of Credit risk involves three distinct regulatory approach, depending on the scope of application of banks' internal models for the risk parameters estimation.

The RWA intensity is a variable that helps to identify the level of risk chosen by a bank with regard of its portfolio of asset. Given the variety of approach prescribed for the Credit risk RWA calculation, a data collection for both RWA intensity and the Credit risk RWA portion over the Total RWA is required. The set of banks chosen for the analysis comprehends large European banks, tested in the two previous EU wide stress test exercise.

5.1 RWA intensity and Credit risk RWA

The major component of the risk-weighted exposure for the banks is the one associated with Credit risk. The portion of Credit Risk RWA has been predominant among all the RWA categories in the post-crisis period; because of that, in the last two EU wide stress test exercises most of the losses were due to Credit risk. In order to understand role of this type of risk in the EU Banking sector a few reference data will be reported. The following table will show the average level of Credit risk portion over the Total RWA in a sample of large EU banks during the 2011-2016 period.

Figure 2 Credit RWA/Total RWA in EU banking sector 2011-2016



Source: Orbis Bank Focus database 2017

The level of Credit RWA/Total RWA was about 80% on average for all the reference period, making it the main component of the portfolio of assets of the European banks.

In order to evaluate how much this type of risk could impact banks' performance in adverse market conditions, it's sufficient to observe the outcome data of the stress test exercises; the amount of losses recorded in the adverse scenario projections due to credit risk outlines the weight of the credit risk exposures for the performance of the European banks.

The stress test exercise conducted by EBA went through a significant evolution and it has developed a framework that reports individual results of each bank submitted to the stress test. EBA evaluates results at the aggregate level in order to assess the resilience of the banking sector, but it implement a valuation methodology oriented to the single bank. Banks performing poorly in the stress test simulation goes under the scope of the supervisory activity, therefore they are expected to follow specific provisions; in particular, they are usually forced to take measures aimed to restore bank's robustness against adverse scenario occurrence.

The Credit risk has been one of the key driver of losses in the stress test exercise. Here, the following table offer an overview of Credit risk impact in the two latest stress test exercises (2014[59] and 2016).

[59]For the 2014 results the measure assumed for the credit risk losses are the "impairments on financial assets other than instruments designated at fair value account".

Table 9 2014 and 2016 EU wide stress test exercise results on aggregate level: overall outcome and credit risk losses

Adverse Scenario full period outcome 2014 and 2016 EU wide stress tests

2014 EU wide stress test exercise	initial CET 1 Ratio (2013)	Final CET 1 Ratio (2016)	Δ CET 1 Ratio (2013-2016)	Δ CET 1 Ratio due to credit risk losses (2013-2016)
Total	**11,12%**	**8,42%**	**-2,70%**	**-4,40%**

2016 EU wide stress test exercise	initial CET 1 Ratio (2015)	Final CET 1 Ratio (2018)	Δ CET 1 Ratio (2015-2018)	Δ CET 1 Ratio due to credit risk losses (2015-2018)
Total	**13,19%**	**9,36%**	**-3,83%**	**-3,71%**

Source: EBA templates, 2014 and 2016 EU wide stress test results (2017)

Table 9 shows the outcome of the "Total[60]" sample of banks submitted to the last two stress test exercises. The effect of the adverse scenario on the main variables of the banks (CET 1 Capital, Risk exposure, CET 1 Ratio) was divided into the changes of the amount of different banks' items. In particular, Table 9 reports the impact on the CET 1 Ratio (at the aggregate level) of the credit risk exposure. Several other categories of the stress test outcome generated a positive change of the CET 1 Ratio (e.g. impairments on market risk exposures and the operating profit during the projected years) in the simulation. Because of that, it was possible that credit risk losses had an impact that was actually greater than the overall impact on the CET 1 Ratio in absolute value[61]; indeed in the 2014 stress test exercise the change of CET 1 Ratio due to credit risk losses was about -4,40%, while the overall change was just about -2,70%. On top of this data, the Credit risk exposure can be recognized as one of the main sources of losses in case of adverse economic scenarios.

The importance of Credit risk exposure over the total RWA of the banks is not recognizable only at quantitative level; the complex Basel III capital requirements framework for Credit risk exposures allows banks to use validated internal models. The internal model originated estimates imply the possibility to calibrate the model in a way such that it is theoretically possible to lower the level of capital requirements: the cost of raising capital (and mostly the cost of capital) generates an incentive for the bank to develop internal model in order to exploit such a possibility.

In this section, the empirical analysis focuses on a set of indicators that helps to identify a relationship between the RWA intensity of the banks and the application of internal models for credit risk exposures. The first indicators to analyze are the RWA intensity and the level of Credit risk RWA.

RWA intensity represents the ratio between the amount of RWA and the Total Assets, so it gives the measure of the riskiness of the overall exposures of the bank. The Credit risk RWA is a type of exposure on which regulation allows to apply IRB Approach and the assets affected by this type of risk represents the majority of banks' total exposures[62]. The historical data for all the banks

[60]The entire sample of banks is treated as a single bank: effects of the stress test simulation on that are reported. EBA takes this measure as a reference for the assessment of the EU banking sector as a whole.
[61]Many banks of the sample experienced CET 1 Ratio change due to credit risk losses higher than the overall CET 1 Ratio change.
[62]See Figure 2.

submitted to the last two stress test exercises are observed in order to identify a relationship between the level of riskiness implied by the risk weighting procedure and the weight of the credit risk exposure.

The analysis intended to identify the relationship between these two variables is motivated by the following questions: the level of RWA intensity of the banks is linked to the amount of Credit risk RWA over the Total RWA? Does the credit risk exposure, that is able to benefit from the application of three different regulatory approaches (Standardized, Foundation and Advanced), contribute to lower the overall RWA intensity of the banks? Does internal models application for the credit risk exposure imply a lower level of RWA intensity? Once again, the following analysis exploits data for the samples of banks submitted to the last two stress test exercises referred to the 2011-2016 period.

The first two variables compared are the

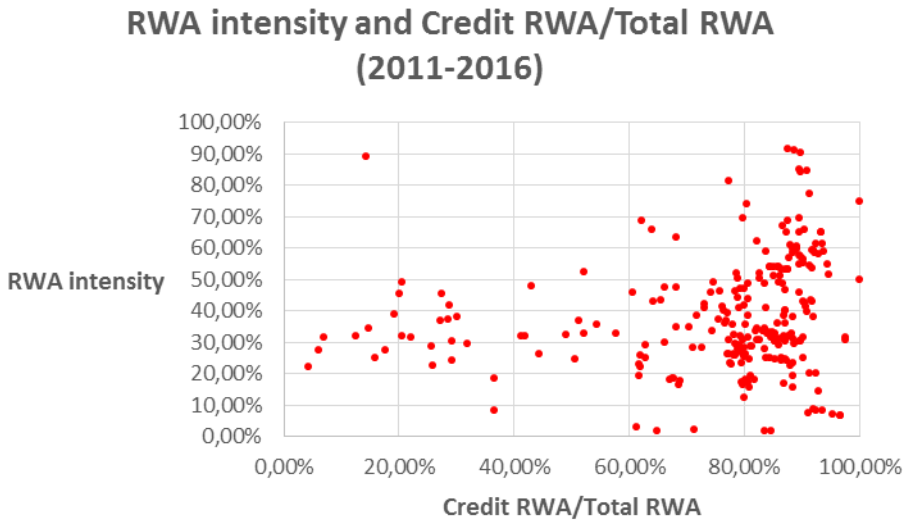
$$\text{RWA intensity} = \frac{\text{RWA}}{\text{Total Assets}} \tag{5.1}$$

And the

$$\frac{\text{Credit risk RWA}}{\text{Total RWA}} \tag{5.2}$$

The scatter plot graph in Figure 3 shows the overall position of each bank of the stress tests samples in a single year between 2011 and 2016. The set of points on Cartesian plane summarizes the EU banking sector in the post crisis period: each point represents a bank in the sample in one year within the reference period.

Figure 3 RWA intensity and Credit RWA/Total RWA (2011-2016) for banks in 2014 and 2016 stress tests sample



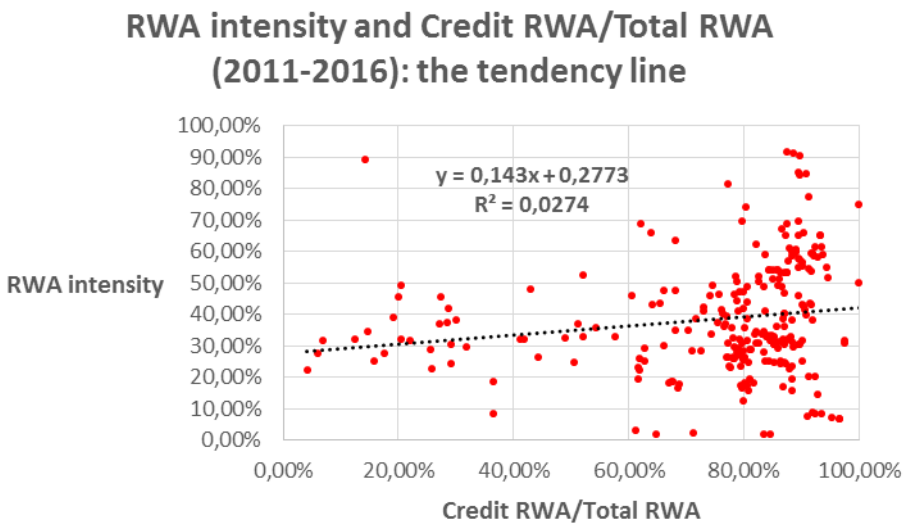
Source: Orbis Bank Focus database 2017

The above scatter plot graph shows that the majority of points lie in the lower right area of the first quadrant of the Cartesian plane. This graphical representation outlines another feature of the European banking sector in the post-crisis period: most of the European banks in the years between 2011 and 2016 had a high portion of Credit risk RWA over the Total RWA associated with a relatively low RWA intensity. The relationship between these two variables inside the set of data is analyzed through a liner regression. The RWA intensity is assumed to be a function of the Credit risk RWA/Total RWA as follows:

$$\text{RWA intensity} = \text{f}\left(\frac{\text{Credit risk RWA}}{\text{Total RWA}}\right) \tag{5.3}$$

The linear regression[63] is run over the same set of data of the previous table; the tendency line and the correspondent linear model are shown below:

Figure 4 RWA intensity and Credit RWA/Total RWA (2011-2016) for banks in 2014 and 2016 stress tests sample: tendency line



Source: Orbis Bank Focus database 2017

The linear regression is run taking the RWA intensity as the explained variable y, while the Credit risk RWA/Total RWA is taken as the explanatory variable x. The linear model is based on the following equation:

$$y = \alpha + \beta * x + \mu \tag{5.4}$$

[63]With a OLS (ordinary least squares) method.

Where y represents the RWA intensity, x is the Credit risk RWA/Total RWA, α is the intercept, β is the coefficient of the explanatory variable and μ is the stochastic error.

In this regression the estimated linear model was:

$$y = 0{,}143 * x + 0{,}2773 \tag{5.5}$$

The tendency line on the graph shows a positive coefficient of the variable x; according to the linear model, the RWA intensity grows with the portion of Credit risk RWA over the total RWA. Apart from that, the very low R^2 (meaning low fitness of the data to the linear model) suggests that the linear model is not fully reliable to assess the relationship between these two variables. Another element that influences the results are the portions of RWA affected by risks different from the Credit risk; indeed, they were near 20% on average in the reference period[64]. The dispersion of points, highly concentrated in the right zone of Cartesian plane, suggests that many banks with a high portion of Credit risk exposures benefited from it with a lower RWA intensity. This empirical evidence requires an integration with further analysis, in particular one focused on the internal models usage for the Credit risk exposures. In order to verify if internal models estimates justify the level of RWA intensity of the banks, data from the 2014 and 2016 stress test exercises are collected.

5.2 Credit risk exposure and internal models implementation

If only the Credit risk exposures and the correspondent RWA are considered, it's possible to derive an indicator of riskiness of this type of assets. The risk exposure amount (risk-weighted) is divided by the amount of exposure values (as it is done for the ratio between the RWA and the Total Assets) obtaining a new measure intuitively called Credit risk RWA intensity[65]:

$$\text{Credit risk RWA intensity} = \frac{\text{Risk Exposure amounts for credit risk}}{\text{Exposure values for credit risk}} \tag{5.6}$$

The data set provided by EBA in the stress test exercise results allows to assess how the Credit risk RWA intensity defined above is correlated to the regulatory approach applied to calculate the Credit risk RWA: to provide an answer to such a question, data disclosed in the last two stress test exercise are observed. The amount of RWA calculated through the three different regulatory approaches are collected in order to distinguish between a regulatory parameters-based estimation (i.e. Standardized Approach) and the IRB Approaches (Foundation and Advanced Approach). In particular, the sum of the exposure values treated with Foundation and Advanced Approach is calculated, then the ratio between this measure and the total exposure values is computed for each bank. Such a ratio is defined as follows:

[64]In Figure 2, near 80% of the assets were affected by credit risk in the reference period.

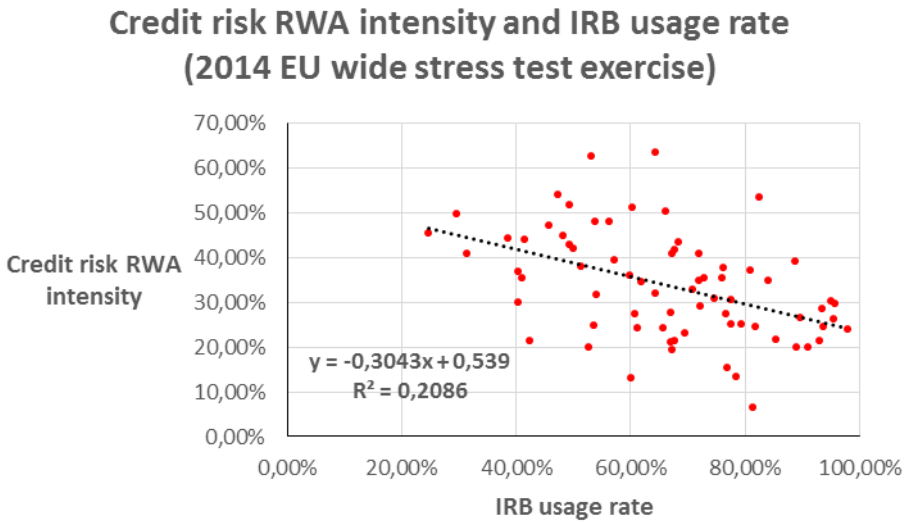
[65]The name was chosen due to the analogy with the RWA intensity: this measure represents the riskiness of the assets affected by credit risk. The ratio between the risk exposure amounts and the exposure values (denominated by EBA in the stress test results), solely referred to credit risk, gives a measure of the riskiness quantified by the risk-weighting mechanism. In this sense, it is a RWA intensity measure referred solely to credit risk exposures.

$$\text{IRB usage rate} = \frac{\text{Exposure under Foundation IRB Approach+Exposures under Advanced IRB Approach}}{\text{Total Exposure values}} \quad (5.7)$$

IRB usage provides a measure of the portion of credit risk exposure computed by banks with IRB Approaches; it can be taken as an indicator of the level of internal models implementation put in place by the large banks submitted to the stress test. In order to evaluate if the use of internal models affects the amount of RWA computed by the banks, both the Credit risk RWA intensity and the IRB usage variables are represented in scatter plot graphs. Moreover, data set is submitted to a liner regression estimation process, taking the Credit risk RWA intensity as the explained variable and the IRB usage rate as the explanatory variable.

Data are referred to the end of the year before the stress test exercise (i.e. 2013 and 2015 in these cases) and the samples do not include banks that applied only the Standardized Approach for the credit risk exposures.

Figure 5 Credit risk RWA intensity and IRB usage (2014 EU wide stress test exercise)



Source: EBA templates, 2014 and 2016 EU wide stress test results (2017)

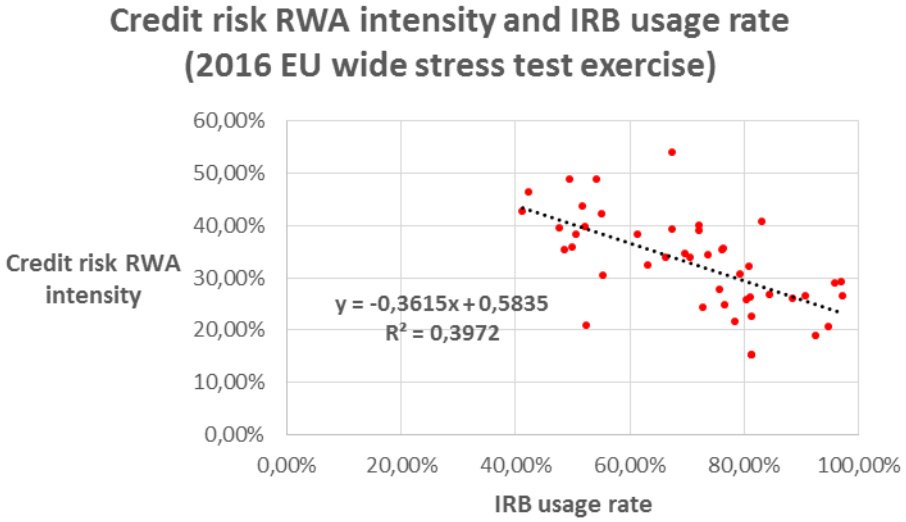
The number of banks involved in the 2014 stress test exercise applying internal models for credit risk exposures are 72 out of 123. The linear regression made with data for these banks outlined a negative coefficient of the explanatory variable (IRB usage rate) in the estimated linear model: in fact, the tendency line of the scatter plot graph is negatively sloped. This means that the y variable decreases as the x variable increases according to the linear model. An inverse relationship between the Credit risk RWA intensity and the IRB Approach usage rate is implied by the model: the intensive use of internal models (high % of IRB Approaches usage rate) generates low level of Credit risk RWA intensity. The estimated linear model has a relatively

high[66] R^2 value (0,2086) implying a good fitness of the data to the model. In fact, most of the points on the graphs lie near the tendency line.

The same analysis is made on the data set referred to the 2016 EU wide stress test exercise.

[66]Compared to the other linear regressions presented in this paper and taking into account the sample size.

Figure 6 Credit risk RWA intensity and IRB usage (2016 EU wide stress test exercise)



Source: EBA templates, 2014 and 2016 EU wide stress test results (2017)

In the 2016 EU wide stress test exercise, the number of banks applying IRB Approaches for credit risk exposures were 45[67] out of 51. Because of the shrinking of the sample of banks tested[68], the data set for the linear regression became smaller; nonetheless the results lead to the same conclusions. The tendency line is negative sloped (actually even more sloped compared to 2014 linear model) meaning that banks with high portion of exposures treated with IRB models tend to have low Credit risk RWA intensity. The R^2 value is 0,3972: it is almost the double of the R^2 for the regression on 2014 data; the estimated linear model on 2016 stress test exercise confirms the empirical evidence highlighted in the previous linear regression, even with a smaller set of data.

The analysis conducted above for the Credit risk exposure, with regard of the Credit risk RWA intensity and the level of implementation of internal models, outlines a specific feature of the actual European banking sector. Banks with high level of internal models implementation have low credit risk RWA intensity; the possibility to lower RWA through the internal models utilization for capital requirement purpose is sustained by the inverse relationship shown in the underlying estimated linear models. Given that the Credit risk exposure represents the largest part of the EU banks portfolio, such an empirical evidence is expected to have a direct impact on the overall RWA intensity level.

[67]It's interesting to notice how the percentage of banks applying IRB Approaches for Credit risk exposures increased a lot between the two stress test exercise: 72 out of 123 (58,54%) in 2014, against 45 out of 51 (88,24%) in 2016. This change is due to the shrinking of the sample , but it is caused also by a trend of the banking sector, where a growing number of banks start to develop internal models for capital requirements purposes.
[68]123 banks in 2014 EU wide stress test exercise and 51 banks in 2016 EU wide stress test exercise.

5.3 Overall RWA intensity and internal models implementation

The level of RWA intensity is dependent from the composition of bank's portfolio among all the different types of risk and the relative regulatory treatment for capital requirements calculation. Given that Credit risk exposure represents the majority of banks' portfolio of assets, the previous results obtained in the linear regression lead to extend the analysis over the overall RWA intensity and the use of internal models for credit risk exposure.

Therefore, the RWA intensity variable is observed for banks submitted to the stress test exercise (2014 and 2016) together with the IRB usage rate, and a linear regression is run on the data set. In this case the RWA intensity is analyzed as a function of the IRB usage rate as follows:

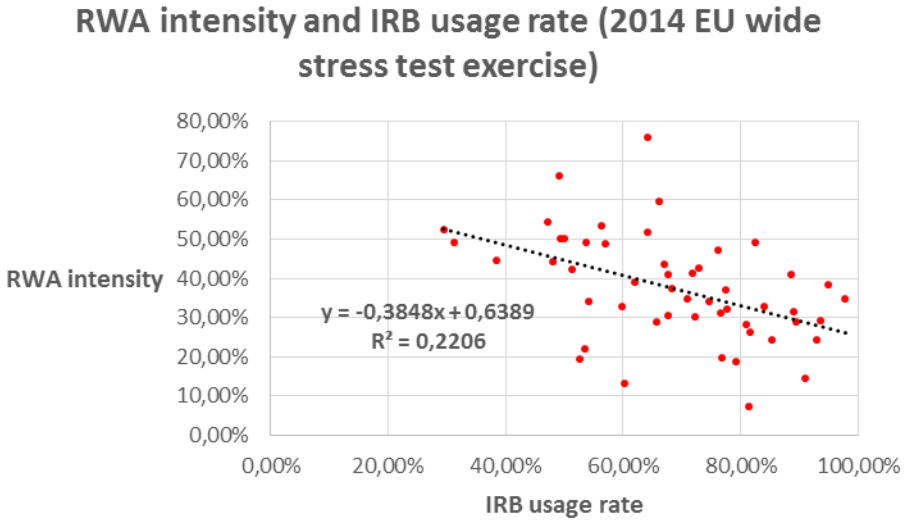
$$\frac{\text{RWA}}{\text{Total Assets}} = \text{f}\left(\frac{\text{Credit exposure F.Approach+Credit exposure Adv.Approach}}{\text{Total Credit expsure}}\right) \qquad (5.8)$$

i.e.

$$\text{RWA intensity} = \text{f(IRB usage rate)} \qquad (5.9)$$

The same type of linear regressions run for the Credit risk intensity and the IRB usage are conducted here, using the overall RWA intensity as the explained variable. The significant portion of Credit risk exposures over the total exposure of the banks generates the reasonable expectation that the above results referred to the Credit risk intensity will be confirmed for the overall RWA intensity. For the 2014 EU wide stress test exercise, data set provides the following scatter plot graph:

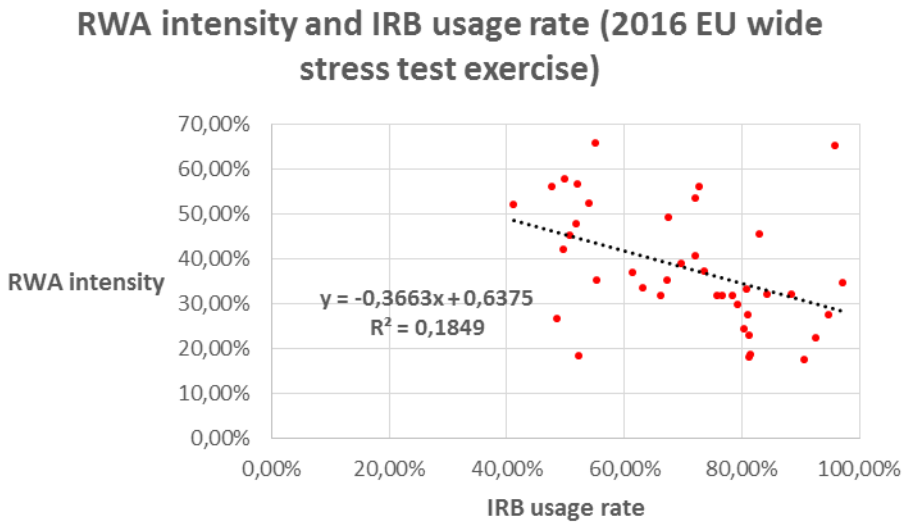
Figure 7 RWA intensity and IRB usage (2014 EU wide stress test exercise)



Source: EBA templates, 2014 EU wide stress test results and Orbis Bank Focus database (2017)

The slope of the tendency line (-0,3838) is negative, therefore the overall RWA intensity increases as the IRB usage rate (the explanatory variable) decreases, according to the estimated linear model. The R^2 is relatively high (0,2206) for such a small set of data (51 banks[69]) and it is close to the R^2 calculated for the linear regression made for the Credit risk RWA intensity in 2014 (0,2086). The same analysis is done for 2016 EU wide stress exercise giving the following scatter plot graph:

Figure 8 RWA intensity and IRB usage rate (2016 EU wide stress test)



Source: EBA templates, 2016 EU wide stress test results and Orbis Bank Focus database (2017)

The 2016 data set comprehends 40 out of the 51 banks submitted to the stress test. The equation of the estimated linear model is similar to the one estimated for the 2014 data set, and the R^2 is 0,1849. The negative coefficient of the explanatory variable x (The IRB usage rate) seems to confirm the relationship between the variables: as far as the IRB usage rate increases, the RWA intensity is small.

If the two data set for 2014 and 2016 respectively are analyzed together, anther empirical evidence can observed: the minimum IRB usage rate reported in the 2014 data set was 29,46%[70], while the minimum IRB usage rate in 2016 data set was 41,21%[71]. Banks with the highest IRB usage rate have values near 100% in both the stress test exercises but the minimum threshold of internal models application raised. This change is a signal of an increasing application of internal models on the assets affected by credit risk, among the European banks with validated internal models.

The results on these two regressions allow to extend the considerations made for the Credit risk RWA intensity to the overall RWA intensity. The use of internal models contribute to lower

[69]Such a reduced sample is obtained from the 123 banks sample of the 2014 stress test sample by subtracting banks not using internal models for credit risk exposure or for which RWA intensity value data were not available.
[70]Credito Emiliano Spa CREDEM.
[71]Raiffeisen Landesbanken Holding GmbH.

the level of RWA intensity; the internal model calibration allows banks to reduce the amount of RWA calculated for capital requirements purposes. As previously mentioned, a lower amount of RWA leads to lower capital requirements for the banks. In this sense, the implementation of internal models appears to be convenient for the banks in terms of cost, therefore such models are not intended to achieve a better accuracy in the risk parameters estimation process. Because of that, internal models approaches allowed by the regulation since the early Basel Accords could generate a distortion in the behaviour of the banks. They might choose to implement them not to achieve a higher accuracy in the risk parameters estimation, but instead to avoid further capital burdens.

All the results obtained in this section helps to identify an important feature of the post-crisis scenario: the overall reduction of the RWA was caused by the effect of the economic recession (indeed a significant reduction in Total Assets was observed in 2011-2016) but the internal models implementation generated a significant contribution for many large banks. In fact, data set suggested that banks benefited from high degree of internal models implementation with low amount of RWA compared to the amount of assets on which they are calculated.

Chapter 6 RWA indicators and stress test results

All the analysis conducted on RWA measures and indicators were aimed to understand the role of the risk-weighting procedure in the regulatory framework; the trends observed on RWA-related variables and the effects produced by different degree of internal models implementation, contributed to assess the role of the RWA-based risk assessment framework developed through Basel Agreements.

This section of the paper is aimed to compare this regulatory tool with another one, that has a different methodology and a different scope of application: the stress test exercise. Chapter 3 outlined the main features of this tool, revealing how important it is for the banking sector supervisory authority. Because of its structure, stress test allows to assess systemic risk and to evaluate banks on individual basis. The stress test results are an important indicator of the level of risk of a bank's portfolio, therefore it can be considered a risk assessment procedure itself. To be more precise, the adverse scenario simulation provides measures of the effect of scenarios with stressed economic and financial variables on a single bank.

Banking regulation has developed a RWA-based framework, where validated internal models (with specific methodologies) are used to estimate risk parameters, but regulators realized very soon that a different tool was needed to evaluate the banking system on aggregate and on individual basis, in order to balance the RWA-based assessment. The stress test exercise was intended also to achieve such a goal: all the banks were submitted to the same adverse scenario simulation. This process provided a transversal risk assessment tool free from the individual differences due to the RWA based measures.

In particular, the risk assessment (whether it is mainly driven by internal models estimates or not) made by the banks following the regulatory framework prescribed for the capital requirements, needed to be balanced by a common risk assessment tool founded on external risk parameters (stressed variables of the stress test scenario).

In order to make a first comparison between the risk assessment provided by the RWA framework and the portfolio riskiness outlined by the stress test outcome, data referred to the stress test outcome will be collected. The comparison will exploit two different measures, originated by RWA framework and the stress test outcome respectively. In the following Paragraph, the measure assumed to synthetize the stress test outcome is presented.

6.1 Measure of the stress test outcome

The CET 1 Ratio has been the most common measure of the stress test outcome; financial markets evaluated the performance of the banks (and of the banking system as a whole) through the change of the CET 1 Ratio between the 31st December of the year before the stress test and the end of the projected period (1-3 years). Such a measure is an indicator of the capital coverage against losses under the adverse scenario, but it depends on the movement of the numerator and denominator variables. In fact, during the stress test simulation both the CET 1 Capital and the RWA changed their amount, so the ratio could have been affected by the discrepancy between the

two, leading to a spurious measure of the adverse scenario occurrence. In this sense, the most sound measure of the impact of the stress test, regards uniquely the level of core capital, indeed the CET 1 Capital.

The difference between the actual figures reported before the stress test (CET 1 Capital initial level) and the CET 1 Capital reported for the end of the projected period is defined as follows:

$$\Delta \text{ CET 1 Capital} = \text{CET 1 Capital final value} - \text{CET 1 Capital initial value} \quad (6.1)$$

This measure alone quantifies how many millions euro of core capital would have been lost in the adverse scenario for each bank, but it does not show how large this loss is, compared to the initial level of core capital. A hypothetical 10 millions euro of CET 1 Capital lost by a bank, in the full period adverse scenario simulation, could represent a dramatic core capital loss only if compared to the CET 1 Capital level observed before the stress test. If the initial level was 100 millions euro (and the final value was 90 millions euro), the CET 1 Capital actually decreased by 10% (10/100=10%), but the same lost is more dramatic if the initial CET 1 Capital was just 50 millions euro. In that case the CET 1 Capital decreased by 20% (10/50=20%). In order to provide a measure more representative of the actual impact on the core capital of each bank, the following indicator is defined:

$$\text{CET 1 Capital depletion} = \frac{\Delta \text{ CET 1 Capital}}{\text{CET 1 Capital initial value}} \quad (6.2)$$

The CET 1 Capital depletions is considered a measure (% value) that represents the portion of initial Capital lost in the adverse scenario simulation, therefore banks experiencing a CET 1 Capital depletion close to 100% are banks that are likely to face bankruptcy in such a scenario, because they might lose all their core capital.

6.2 Stress test outcome and overall RWA intensity

In this Paragraph, the measure of the stress test outcome (CET 1 Capital depletion) and the level of overall RWA intensity[72] are collected for the banks submitted to the last two stress test exercises. Data are transposed into a scatter plot graph to verify if there is a relationship between the two variables. The two measures come from two distinct regulatory tools, respectively designed to assess risk in the banking activity, therefore the aim is to verify if the conclusions toward which they lead are the same. The following analysis is intended to verify the coherence between the results of the stress test exercise and the RWA regulatory framework.

The comparison between the level of RWA intensity and the stress test outcome measure based on the following expectation: if the RWA framework assess the risk properly, the RWA intensity indicator shall give a measure of the overall riskiness of the portfolio of the single bank. Moreover, if the stress test results highlight banks badly expose to the occurrence of the stress test

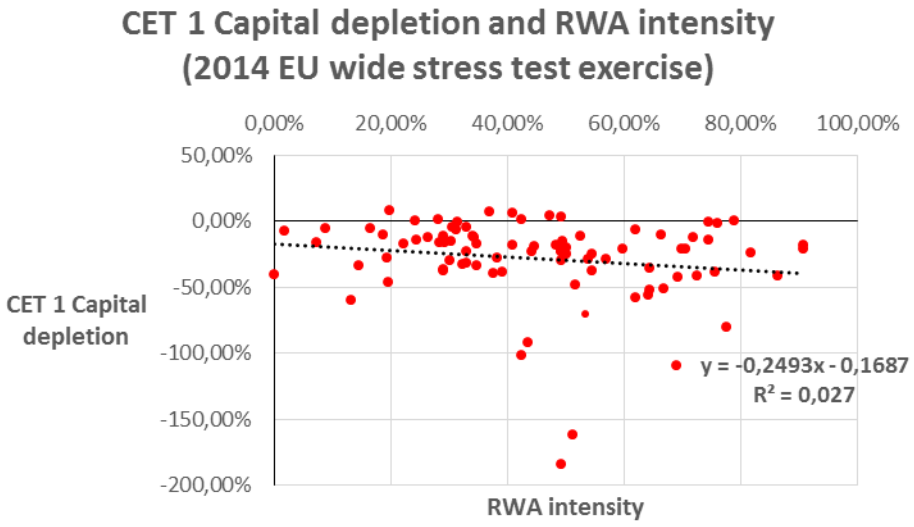
[72]The value observed on 31st December of the last year before the stress test exercise will be reported.

exercise, and the adverse scenario is plausible[73], the losses incurred in the simulation (decomposed into the different types of risk originating them) are reasonably interpreted (by financial markets) as indicators of riskiness of banks exposures. If the risk assessment outlined by each the regulatory tools coincides, the expectation on the data comparison, that is about to be shown, is that banks with the worst stress test outcome should be the ones with the highest RWA intensity. If data set is represented with points on a Cartesian plane, it is possible to build a scatter plot graph with the CET 1 Capital depletion on the y-axis and the RWA intensity on the x-axis.

The scatter plot graphs on the set of banks involved in 2014 and 2016 stress, will show if the empirical evidence matches with the above declared expectation implied by the coherence of the two regulatory tools.

[73]It is important to remind that the adverse scenario established by the authority is just one among many possible others and the probability of its occurrence is difficult to estimate.

Figure 9 CET 1 Capital depletion and RWA intensity (2014 stress test exercise)



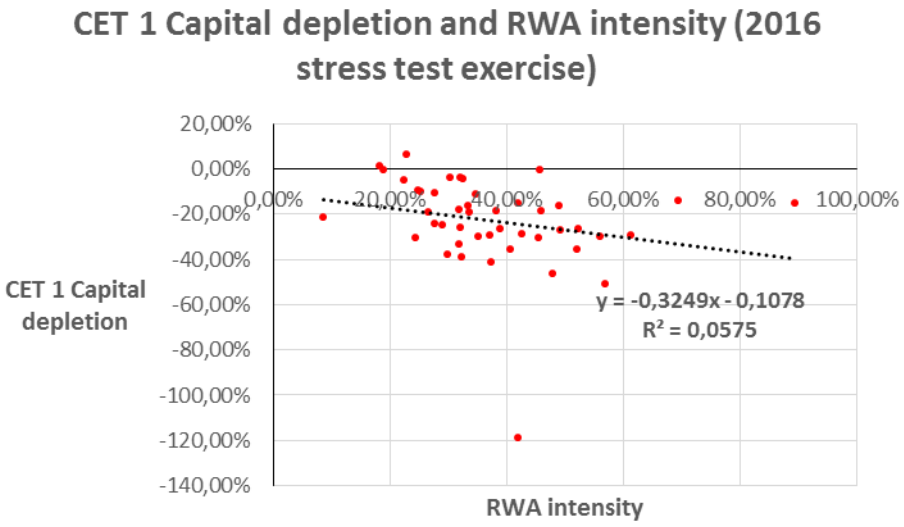
Source: EBA templates, 2014 EU wide stress test results and Orbis Bank Focus database (2017)

The first scatter plot graph regarding banks[74] in the 2014 stress test exercise shows a set of points that do not confirm the expected relationship between the variables. Banks experiencing the worst core capital depletion are not those with the highest RWA intensity; actually banks with a medium RWA intensity (about 50%) are the worst performing (near 100% CET 1 Capital depletion), followed by many others banks spread on the x-axis experiencing a CET 1 Capital depletion close to 50%. Also in this graphical representation, the tendency line is plotted, and the estimated linear model is reported together with the R^2 value. No linear relationship is clearly identified by the regression (R^2=0,027 means a very low fitness of the data to the linear model) and the dispersion of points does not show that high RWA intensity are associated to the worst core capital losses.

The same scatter plot graph based on data referred to the 2016 stress test exercise is shown:

[74]This sample comprehends 88 out of 123 banks submitted to the 2014 stress test exercise.

Figure 10 CET 1 Capital depletion and RWA intensity (2016 stress test exercise)



Source: EBA templates, 2014 EU wide stress test results and Orbis Bank Focus database (2017)

The scatter plot graph for the 2016 stress test outlines a more concentrated set of points, that produces a negatively sloped tendency line: the underlying estimated linear model has a low R^2 (0,0575) and most of the banks are allocated in the area delimited by a range of 20%-50% RWA intensity and a 0%-40% CET 1 Capital depletion. The sample used for this linear regression is almost half of the 2014 sample[75], nonetheless the concentration of points in a specific area of the Cartesian plane does not seem to confirm the expectation. Moreover, there banks whose position (with reference to these coordinates) totally contrasts with the expectation: e.g.[76] Volkswagen Financial Service AG reported a 89,35% RWA intensity (the highest in the sample) but it had a -14,99% CET 1 Capital depletion (way below the average value, that was -23,08%) in the stress test.

On top of these two data set comparisons, the expectation of high RWA intensity banks associated with the largest core capital losses is denied by the empirical analysis. In order to deepen the analysis about the coherence of the results outlined by the two regulatory tools and considering the previous analysis focused on a single type of exposure on which the role of IRB approaches is determinant, a further data comparison referred to the Credit risk exposure is presented.

6.3 Stress test outcome and Credit risk RWA intensity

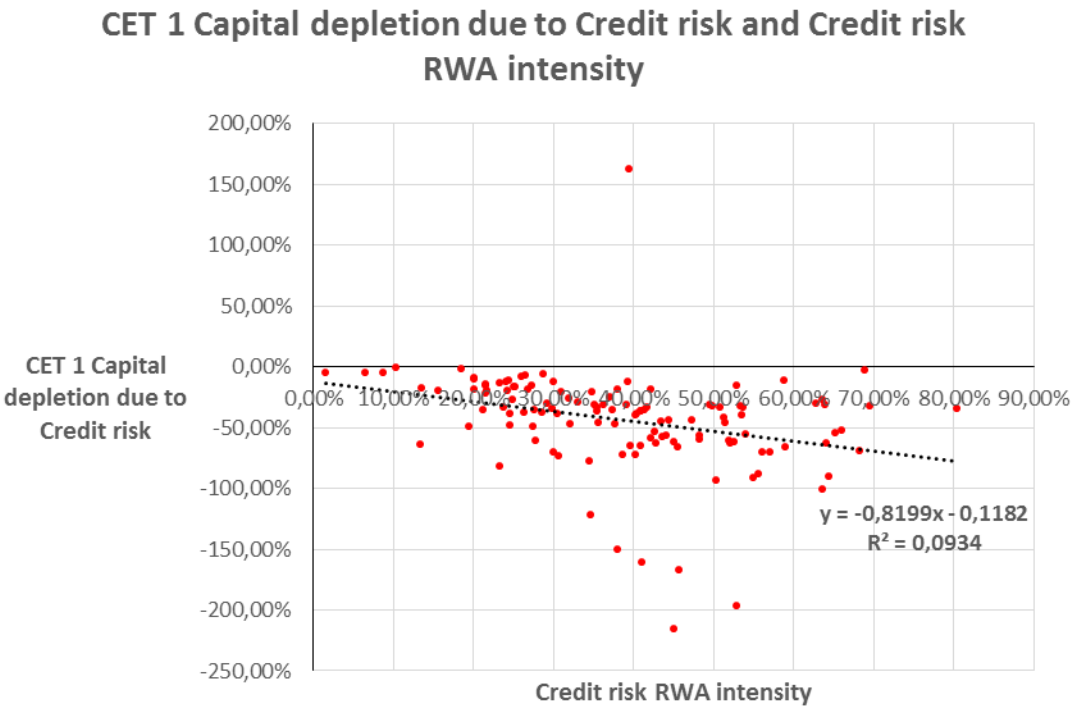
The same rationale of the previous paragraph is followed, then a further analysis is conducted with reference to the Credit risk exposure: in this section only the Credit risk RWA

[75]This sample comprehends 45 out of 51 banks submitted to the 2016 stress test exercise.
[76]The lowest point in the graph represents Banca Monte dei Paschi di Siena s.p.a..

intensity is considered, together with the CET 1 Capital loss due to Credit risk exposure experienced in the stress test exercise. The measures are the same defined in the previous analysis except for the fact that they refer only to Credit risk exposures.

For 2014 stress test exercise, data set on the whole sample provides the following scatter plot graph:

Figure 11 CET 1 Capital depletion due to Credit risk and Credit risk RWA intensity (2014 stress test exercise)



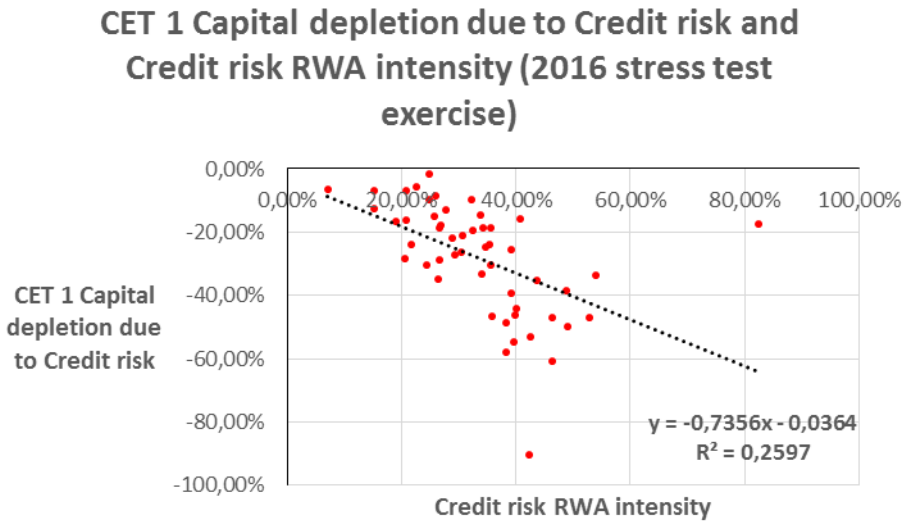
Source: EBA templates, 2014 EU wide stress test results (2017)

Figure 11 do not show the expected distribution of the points on the Cartesian plane: banks that actually had the higher amount of losses due to Credit risk exposures have medium RWA intensity values. If the risk-weighting procedure prescribed for assets affected by Credit risk is assumed to estimate correctly the riskiness of the exposures, the occurrence of the adverse scenario should generate the worst impact in terms of impairments[77] on banks with the highest Credit risk RWA intensity. The 2014 stress test sample does not show such a ranking in the performance of the banks: the top 5 worst performing banks have a Credit risk RWA intensity bounded between 30% and 60%. Moreover, the R^2 is still low (0,0934) even if the sample comprehends 123 banks.

The analysis is extended to the 2016 stress test exercise.

[77]In 2014, the impact generated by credit risk exposures have been presented by the EBA as "Impairment of financial assets other than instruments designated at fair value through P&L (-)" voice.

Figure 12 CET 1 Capital depletion due to Credit risk and Credit risk RWA intensity (2016 stress test exercise)



Source: EBA templates, 2016 EU wide stress test results (2017)

The data set for the 2016 stress test exercise shows a different pattern; the R^2 (0,2597) is really high compare to the 2014 regression meaning that the estimated linear model fits better the behaviour of the variables. In this sense, the empirical evidence outlined by this smaller sample (51 banks) seems to be coherent with the expectations; the measure of the portion of capital lost due to credit risk exposure decreases[78] when the Credit risk RWA intensity grows. Apart from that, further elements require to be considered. The dispersion of points is concentrated in a restricted area of the Cartesian plane; in particular, most of the banks in the sample have Credit risk RWA intensity values near 40% but the range of CET 1 Capital depletion for those banks is large; from 20% up to more than 80%. Moreover the worst performing bank[79] had a -90,38% CET 1 Capital depletion due to Credit risk, but its Credit risk RWA intensity (42,28%) was not among the top ones. If all these observations made on the data set are considered together, a straight confirmation of the expectations about the relationship between a RWA measure and the stress test outcome is not possible. Also for the Credit risk exposure, the level of risk implied by the RWA intensity measure does match the outcome of the stress test exercise. Banks performance under the adverse scenario simulation is not explained by the level of riskiness of their assets embodied in the risk-weighting procedure.

[78]It actually increases in absolute value, since the CET 1 Capital depletion due to credit risk is negative (i.e. the ratio between a negative Δ and the initial CET 1 Capital amount).
[79]Banca Monte dei Paschi di Siena s.p.a..

Conclusions

The overall analysis involved the two regulatory tools outlined in the introduction under many points of view. The main features of each tools and the regulatory context have been explained in the first 3 chapters, in order to have identify their role in the regulation of the banking sector. The risk assessment made on the assets of a bank represented the main concern of the regulators since the first Basel Agreements, but financial markets are actually facing the problem of the coexistence of the RWA-based risk assessment framework for capital requirements purpose, and the stress test program, on which the authority evaluates the measure of intervention on individual basis.

The changes in the European banking sector regulation that took place in the last decade outlines that the weight of the banks own estimates is increasing: in particular, the upcoming IFRS 9[80] principle shows the future evolution of the regulatory framework. Moreover, the regulators are developing a system to control the modelling activity of the banks, as the TRIM[81] process demonstrates. At the same time, the supervisory activity is now implementing a rigorous stress test program intended to evaluate the banking sector resilience and the single banks vulnerability in adverse market conditions. The stress test results go really deep in the analysis of adverse scenario outcome, providing a wide set of information about each single bank. Because of that, the individual performance of the banks are observed and interpreted by market players in order to asses the solidity of a financial institution. The publication of the stress test results generates a huge impact on the market in terms of pricing. Furthermore, it activates a series of regulatory and supervisory mechanisms (Pillar 2 Guidance[82]), then both the financial markets and the single bank are really concerned about the stress test exercise outcome. With regard of the single bank, the results of the stress test exercise have been often interpreted by the market as a rating grade, generating huge turmoil in the financial markets where those banks' securities were negotiated. Banks once considered solid and profitable, experienced financial distress after the publication of the (individual) stress test results.

The empirical research and the analysis conducted in this paper are motivated by a particular debate that is taking place in the banking regulation field. Because of the impact of the stress test exercises results, many market participants started to ask how much reliable they were. In particular, the debate took place because all the large banks experiencing significant losses in the adverse scenario, were theoretically covered against negative economic downturns, since those banks were fulfilling capital requirements. Also, many banks implemented the IRB Approaches after the validation of their internal models. The entire regulatory capital requirements framework, developed to force bank to protect themselves with appropriate capital instruments and capital buffers, started to look ineffective against the occurrence of the regulatory simulated stressed scenarios. How was it possible that IMM banks, with a full capital requirements compliance, could

[80]See Paragraph 2.4.
[81]See Paragraph 2.3.
[82]See Paragraph 3.2.

experiences huge losses in a stressed scenario? And if so, how to reconcile the IRB approach risk assessment with the outcome of a stress test exercise?

These type of questions became the core of a debate in the regulatory field promoted by several scholars and important financial regulation experts. One of them is here quoted in order to underline some elements sustaining the discrepancy between the RWA-based risk assessment and the stress test exercise results.

Larry D. Wall, Research Center Executive Director of the Center for Financial Innovation and Stability (CenFIS) in the research department of the Federal Reserve Bank of Atlanta, in 2013 shared his opinion on this issue in a few working papers[83]. He distinguished the features of these two different approaches outlining the discrepancies. On top of that, he sustained that these two capital adequacy measures have incompatible characteristics, so they cannot provide an undisputable representation of the bank's appropriate capital requirement level. IRB models and stress test exercise follows methodologies founded on different assumptions and they are oriented in different directions. The stress tests exploit future projections on a single scenario simulation, while the IRB approaches rely on estimates founded[84] on a historical distribution that imply the ranking of multi-scenarios outcomes. The use of historical simulation techniques require a backward looking approach that is conceptually opposite to the adverse scenario projections. In a brief article published right after his working papers he states:

"***Basel III casts a dim light over a wide range of possible scenarios. Basel III's use of historical loss distribution data allows it to estimate a lower bound on once-in-1,000-year losses across a wide variety of scenarios. However, Basel III cannot say anything about what may happen in any particular scenario. In contrast, each individual stress test casts a very bright light, but only on one particular scenario. Scenarios similar to the one being tested are likely to produce similar results, but that outcome is not guaranteed. Still, there is no reason to expect that any given scenario will be predictive of the results of a very different stress scenario***"

Source: Federal Reserve Bank of Atlanta "Basel III and Stress Tests" article, Note from the Vault, Larry D. Wall, December 2013

Even though the two instruments provide informations and results potentially conflicting, Larry D. Wall remark their importance. In particular, he suggests that the two tools could be complementary, in the sense that stress test exercise results could actually add incremental value to Basel Capital Adequacy framework. It depends on the design and structure of the stress test scenario, that should be intended to reveal sensitivity to all those risks (e.g. interest rate risk) not fully captured in Basel Capital Requirements.

The analysis conducted in the previous chapters provided a representation of trends in the banking sector with regard of the two main indicators of capital solidity: Leverage ratio and CET

[83]"The adoption of stress testing: why the Basel Capital Measure were not enough" and "Measuring Supervisory Capital Adequacy Stress tests in a Basel World", Federal Reserve Bank of Atlanta Working Paper series, December 2013.

[84]Most of the banks estimates probability distributions (needed for risk parameters estimates) through historical simulation techniques.

1 Ratio. Both these measures increased in the 2011-2016 reference, but these movements were mainly driven by the decrease of the RWA amounts. The RWA amount is the numerator of the RWA intensity, an indicator that quantifies the portion of RWA over the Total Assets, therefore it gives a measure of the riskiness of the overall exposure of the banks according to the actual capital requirement framework. Given that the RWA amounts were decreasing in the sector, a series of empirical analysis helped to verify that the RWA intensity level was influenced by the Credit risk exposures and in particular by the portion of assets calculated with IRB approaches. The empirical evidence suggested that internal models implementation contributed to lower the amount of RWA and therefore the level of capital requirements.

The next step of the empirical analysis required a collection of stress test outcome data. A new measure called CET 1 Capital depletion was defined and preferred to the CET 1 Ratio change outlined by EBA reports; such a measure allowed to quantify the loss of core capital (compared to the initial value) in the adverse scenario for any single bank. The CET 1 Capital depletion was evaluated together with the relative RWA intensity measure for the banks in the stress test sample. The comparison between these two sets of data was intended to verify if the there was a coherence between the RWA-based risk assessment (deeply influenced by the internal models implementation) and the stress test exercise results. The graphical representation and the linear model estimation made on the data showed results that seem to confirm the discrepancy in risk assessment provided by the two different regulatory tools.

All these analysis led to underline the distance in terms of riskiness evaluation provided by two of the most important instruments of the actual banking regulation. The reasons for such a discrepancy supposedly lie in the methodological and conceptual differences of the tools, but it depends also on the role of internal models implementation in the risk assessment. One direct consequence of the increasing level of internal models implementation in the banking sector is the model risk. Stress test results compared with the RWA-based risk measures outlined many undercapitalized banks, therefore a potential threat to the financial market stability was recognized in the model building activity of the banks. Banking regulation is about to face the problem of the assessment of this type of risk in the next few years, and several reforms will be required in order to adjust the actual regulatory framework.

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Appendix 1

Figure 2 Credit RWA/Total RWA in EU banking sector 2011-2016: data set

Orbis bank focus database (2017)

	2011
	Credit RWA/Total RWA
ABN AMRO Group N.V.	85,90%
Allied Irish Banks plc	92,39%
Banco Comercial Português, SA-Millennium bcp	91,80%
Bank Nederlandse Gemeenten NV, BNG	93,51%
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	90,32%
Bank of Ireland-Governor and Company of the Bank of Ireland	91,65%
Barclays Plc	62,72%
Belfius Banque SA/NV-Belfius Bank SA/NV	87,98%
BPCE Group	87,02%
Commerzbank AG	80,21%
Cooperatieve Rabobank U.A.	89,48%
Danske Bank A/S	78,19%
De Volksbank N.V.	84,27%
DekaBank Deutsche Girozentrale AG	67,58%
Deutsche Bank AG	68,84%
DNB Bank ASA	84,99%
Erste Group Bank AG	85,63%
Hellenic Bank Public Company Limited	89,45%
HSBC Holdings Plc	79,22%
HSH Nordbank AG	83,22%
Jyske Bank A/S (Group)	76,34%
Lloyds Banking Group Plc	85,78%
Nederlandse Waterschapsbank NV	84,56%
Nordea Bank Danmark Group-Nordea Bank Danmark A/S	87,69%
OTP Bank Plc	77,19%
Royal Bank of Scotland Group Plc (The)	62,69%
Skandinaviska Enskilda Banken AB	68,15%
Société Générale SA	78,25%
Sydbank A/S	74,02%
AVERAGE	**81,69%**

	2012
	Credit RWA/Total RWA
ABN AMRO Group N.V.	82,63%
Allied Irish Banks plc	92,88%
Banco Comercial Português, SA-Millennium bcp	92,00%
Banco Santander (Mexico) SA	62,12%
Bank Nederlandse Gemeenten NV, BNG	92,40%
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	89,52%
Bank of Ireland-Governor and Company of the Bank of Ireland	91,86%
Barclays Plc	61,84%
Belfius Banque SA/NV-Belfius Bank SA/NV	88,27%
BPCE Group	84,87%
Caixa Geral de Depositos	92,15%
Commerzbank AG	83,88%
Cooperatieve Rabobank U.A.	88,58%
Danske Bank A/S	77,38%
De Volksbank N.V.	90,19%
DekaBank Deutsche Girozentrale AG	66,97%
Deutsche Bank AG	68,63%
DNB Bank ASA	83,47%
Erste Group Bank AG	85,86%
Hellenic Bank Public Company Limited	88,97%
HSBC Holdings Plc	79,93%
HSH Nordbank AG	87,05%
Jyske Bank A/S (Group)	76,16%
Lloyds Banking Group Plc	83,18%
Nordea Bank Danmark Group-Nordea Bank Danmark A/S	84,10%
OTP Bank Plc	80,24%
Royal Bank of Scotland Group Plc (The)	70,32%
Skandinaviska Enskilda Banken AB	54,32%
Société Générale SA	78,41%
Swedbank AB	83,71%
Sydbank A/S	75,74%
AVERAGE	**81,21%**

	2013
	Credit RWA/Total RWA
Aareal Bank AG	89,63%
ABN AMRO Group N.V.	79,07%
Allied Irish Banks plc	94,49%
Banco Comercial Português, SA-Millennium bcp	91,80%
Banco Popular Espanol SA	91,25%
Banco Santander (Mexico) SA	63,82%
Bank Nederlandse Gemeenten NV, BNG	91,99%
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	91,24%
Bank of Ireland-Governor and Company of the Bank of Ireland	90,69%
Barclays Plc	57,71%
Belfius Banque SA/NV-Belfius Bank SA/NV	81,04%
BPCE Group	85,33%
Commerzbank AG	83,43%
Cooperatieve Rabobank U.A.	90,04%
Danske Bank A/S	80,22%
De Volksbank N.V.	88,28%
DekaBank Deutsche Girozentrale AG	61,66%
Deutsche Bank AG	67,32%
DNB Bank ASA	79,97%
Erste Group Bank AG	86,68%
Hellenic Bank Public Company Limited	87,51%
HSBC Holdings Plc	79,10%
HSH Nordbank AG	82,06%
Hypo Real Estate Holding AG	92,74%
Jyske Bank A/S (Group)	72,89%
La Banque Postale	83,52%
Landesbank Baden-Wuerttemberg	81,24%
Lloyds Banking Group Plc	79,28%
Nederlandse Waterschapsbank NV	83,45%
Nordea Bank Danmark Group-Nordea Bank Danmark A/S	85,86%
Nykredit Realkredit A/S	86,30%
OP Financial Group	72,99%
OTP Bank Plc	79,73%
Raiffeisen Zentralbank Oesterreich AG - RZB	100,00%
RCI Banque SA	88,47%
Royal Bank of Scotland Group Plc (The)	75,51%
Skandinaviska Enskilda Banken AB	51,11%
Société Générale SA	72,46%
Sydbank A/S	74,52%
Volkswagen Financial Services AG	89,63%
AVERAGE	**81,60%**

	2014
	Credit RWA/Total RWA
Aareal Bank AG	88,36%
ABN AMRO Group N.V.	79,95%
Allied Irish Banks plc	94,42%
AXA Bank Europe SA/NV	79,96%
Banco Comercial Português, SA-Millennium bcp	90,05%
Banco Santander (Mexico) SA	68,15%
Bank BPH SA	100,00%
Bank Nederlandse Gemeenten NV, BNG	91,05%
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	90,80%
Bank of Ireland-Governor and Company of the Bank of Ireland	90,70%
Belfius Banque SA/NV-Belfius Bank SA/NV	79,91%
BPCE Group	86,75%
Caixa Geral de Depositos	87,82%
Commerzbank AG	80,66%
Cooperatieve Rabobank U.A.	86,68%
Criteria CaixaHolding SA	60,57%
De Volksbank N.V.	52,05%
DekaBank Deutsche Girozentrale AG	50,60%
Deutsche Bank AG	61,55%
DNB Bank ASA	80,67%
Erste Group Bank AG	85,05%
Hellenic Bank Public Company Limited	86,42%
HSBC Holdings Plc	78,32%
HSH Nordbank AG	77,97%
Hypo Real Estate Holding AG	92,44%
ING Groep NV	85,21%
Jyske Bank A/S (Group)	78,20%
La Banque Postale	80,73%
Landesbank Baden-Wuerttemberg	79,70%
Landwirtschaftliche Rentenbank	91,20%
Lloyds Banking Group Plc	78,74%
Nederlandse Waterschapsbank NV	64,72%
NLB dd-Nova Ljubljanska Banka d.d.	83,60%
Nordea Bank Danmark Group-Nordea Bank Danmark A/S	86,75%
Nova Kreditna Banka Maribor d.d.	86,02%
NRW.BANK	97,46%
Nykredit Realkredit A/S	85,15%
OP Financial Group	88,25%
OTP Bank Plc	82,02%
Raiffeisen Landesbanken Holding GmbH	84,40%
Raiffeisen Zentralbank Oesterreich AG - RZB	84,39%
Raiffeisenlandesbank Oberösterreich AG	93,34%
RCI Banque SA	88,79%
Royal Bank of Scotland Group Plc (The)	74,37%
SFIL	95,27%
Skandinaviska Enskilda Banken AB	79,49%
Société Générale SA	78,95%
Swedbank AB	81,07%
Sydbank A/S	68,19%
Volkswagen Financial Services AG	88,66%
AVERAGE	**82,11%**

	2015
	Credit RWA/Total RWA
Aareal Bank AG	87,73%
ABN AMRO Group N.V.	79,69%
Allied Irish Banks plc	91,54%
AXA Bank Europe SA/NV	80,75%
Banco Comercial Português, SA-Millennium bcp	89,36%
Banco Popular Espanol SA	92,14%
Banco Santander (Mexico) SA	73,40%
Bank für Arbeit und Wirtschaft und Österreichische Postsparkass	89,57%
Bank Nederlandse Gemeenten NV, BNG	79,68%
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	89,59%
Bank of Ireland-Governor and Company of the Bank of Ireland	89,68%
Barclays Plc	64,30%
Belfius Banque SA/NV-Belfius Bank SA/NV	77,29%
BPCE Group	86,89%
Caixa Geral de Depositos	89,11%
Commerzbank AG	80,41%
Cooperatieve Rabobank U.A.	86,17%
Criteria CaixaHolding SA	58,31%
De Volksbank N.V.	80,09%
DekaBank Deutsche Girozentrale AG	49,35%
Deutsche Apotheker- und Aerztebank eG	86,45%
Deutsche Bank AG	60,90%
DNB Bank ASA	79,69%
Erste Group Bank AG	84,89%
Hellenic Bank Public Company Limited	87,37%
HSBC Holdings Plc	79,41%
HSH Nordbank AG	71,66%
ING Groep NV	83,57%
Jyske Bank A/S (Group)	78,57%
La Banque Postale	80,83%
Landesbank Baden-Wuerttemberg	81,23%
Landesbank Hessen-Thueringen Girozentrale - HELABA	12,97%
Landwirtschaftliche Rentenbank	86,81%
Lloyds Banking Group Plc	77,41%
Nederlandse Waterschapsbank NV	71,12%
NLB dd-Nova Ljubljanska Banka d.d.	86,53%
Nordea Bank Danmark Group-Nordea Bank Danmark A/S	84,99%
Nova Kreditna Banka Maribor d.d.	86,93%
NRW.BANK	94,86%
Nykredit Realkredit A/S	85,11%
OP Financial Group	87,14%
OTP Bank Plc	79,77%
Precision Capital S.A.	79,04%
Raiffeisen Landesbanken Holding GmbH	82,61%
Raiffeisen Zentralbank Oesterreich AG - RZB	82,61%
Raiffeisenlandesbank Oberösterreich AG	93,53%
RCI Banque SA	89,63%
Royal Bank of Scotland Group Plc (The)	68,59%
SFIL	96,49%
SID - Slovene Export and Development Bank, Inc, Ljubljana - SID	86,78%
Skandinaviska Enskilda Banken AB	76,35%
Svenska Handelsbanken AB	83,64%
Swedbank AB	81,03%
Sydbank A/S	66,12%
Volkswagen Financial Services AG	87,94%
AVERAGE	**80,32%**

	2016
	Credit RWA/Total RWA
Aareal Bank AG	85,24%
ABN AMRO Group N.V.	79,78%
Allied Irish Banks plc	90,06%
AXA Bank Europe SA/NV	79,57%
Banco Comercial Português, SA-Millennium bcp	89,40%
Banco Popular Espanol SA	91,50%
Banco Santander (Mexico) SA	78,72%
Bank für Arbeit und Wirtschaft und Österreichische Postsparkass	90,12%
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	89,38%
Bank of Ireland-Governor and Company of the Bank of Ireland	83,66%
Bank of Valletta Plc	90,32%
Banque PSA Finance SA	86,96%
Barclays Plc	66,06%
Bayerische Landesbank	82,06%
Belfius Banque SA/NV-Belfius Bank SA/NV	76,93%
BFA Tenedora de Acciones SAU	87,09%
BFA Tenedora de Acciones SAU	87,09%
BPCE Group	87,24%
Caixa Geral de Depositos	88,45%
Commerzbank AG	77,09%
Cooperatieve Rabobank U.A.	84,64%
Criteria CaixaHolding SA	64,14%
De Volksbank N.V.	80,65%
DekaBank Deutsche Girozentrale AG	5,92%
Deutsche Apotheker- und Aerztebank eG	87,18%
Deutsche Bank AG	61,85%
DNB Bank ASA	78,87%
Erste Group Bank AG	80,46%
Hellenic Bank Public Company Limited	87,39%
HSBC Holdings Plc	76,49%
HSH Nordbank AG	81,82%
ING Groep NV	76,78%
Jyske Bank A/S (Group)	77,16%
La Banque Postale	78,18%
Landesbank Baden-Wuerttemberg	80,60%
Landesbank Hessen-Thueringen Girozentrale - HELABA	12,33%
Landwirtschaftliche Rentenbank	88,41%
Lloyds Banking Group Plc	77,31%
Nederlandse Waterschapsbank NV	61,13%
NLB dd-Nova Ljubljanska Banka d.d.	87,32%
Nova Kreditna Banka Maribor d.d.	86,06%
NRW.BANK	97,51%
Nykredit Realkredit A/S	87,10%
OP Financial Group	88,10%
Piraeus Bank SA	93,20%
Raiffeisen Zentralbank Oesterreich AG - RZB	82,68%
Raiffeisenlandesbank Oberösterreich AG	93,75%
RCI Banque SA	87,77%
Royal Bank of Scotland Group Plc (The)	71,08%
SFIL	96,54%
Skandinaviska Enskilda Banken AB	77,56%
Svenska Handelsbanken AB	79,46%
Swedbank AB	81,62%
Sydbank A/S	65,53%
Volkswagen Financial Services AG	87,57%
AVERAGE	**79,83%**

Appendix 2

Figure 3 RWA intensity and Credit RWA/Total RWA (2011-2016) for banks in 2014 and 2016 stress tests sample: data set

Orbis bank focus database (2017)

		RWA intensity	Credit RWA/Total RWA
2011	ABN AMRO Group N.V.	29,23%	85,90%
	Allied Irish Banks plc	61,67%	92,39%
	Banco Comercial Português, SA-Millennium bcp	59,32%	91,80%
	Bank Nederlandse Gemeenten NV, BNG	8,54%	93,51%
	Bank of Cyprus Public Company Limited-Bank of Cyprus Group	66,15%	90,32%
	Bank of Ireland-Governor and Company of the Bank of Ireland	43,32%	91,65%
	Barclays Plc	25,01%	62,72%
	Belfius Banque SA/NV-Belfius Bank SA/NV	22,81%	87,98%
	BPCE Group	36,16%	87,02%
	Commerzbank AG	35,75%	80,21%
	Cooperatieve Rabobank U.A.	30,56%	89,48%
	Danske Bank A/S	26,46%	78,19%
	De Volksbank N.V.	25,27%	84,27%
	DekaBank Deutsche Girozentrale AG	18,80%	67,58%
	Deutsche Bank AG	17,62%	68,84%
	DNB Bank ASA	54,18%	84,99%
	Erste Group Bank AG	54,29%	85,63%
	Hellenic Bank Public Company Limited	65,23%	89,45%
	HSBC Holdings Plc	47,33%	79,22%
	HSH Nordbank AG	33,77%	83,22%
	Jyske Bank A/S (Group)	40,20%	76,34%
	Lloyds Banking Group Plc	36,30%	85,78%
	Nederlandse Waterschapsbank NV	1,94%	84,56%
	Nordea Bank Danmark Group-Nordea Bank Danmark A/S	32,04%	87,69%
	OTP Bank Plc	81,71%	77,19%
	Royal Bank of Scotland Group Plc (The)	29,13%	62,69%
	Skandinaviska Enskilda Banken AB	35,08%	68,15%
	Société Générale SA	29,57%	78,25%
	Sydbank A/S	46,05%	74,02%
2012	ABN AMRO Group N.V.	30,81%	82,63%
	Allied Irish Banks plc	58,29%	92,88%
	Banco Comercial Português, SA-Millennium bcp	59,36%	92,00%
	Banco Santander (Mexico) SA	68,91%	62,12%
	Bank Nederlandse Gemeenten NV, BNG	8,25%	92,40%
	Bank of Cyprus Public Company Limited-Bank of Cyprus Group	69,54%	89,52%
	Bank of Ireland-Governor and Company of the Bank of Ireland	38,18%	91,86%
	Barclays Plc	25,96%	61,84%
	Belfius Banque SA/NV-Belfius Bank SA/NV	23,60%	88,27%
	BPCE Group	33,20%	84,87%
	Caixa Geral de Depositos	58,52%	92,15%
	Commerzbank AG	32,72%	83,88%
	Cooperatieve Rabobank U.A.	29,68%	88,58%
	Danske Bank A/S	23,51%	77,38%
	De Volksbank N.V.	25,32%	90,19%
	DekaBank Deutsche Girozentrale AG	18,19%	66,97%
	Deutsche Bank AG	16,50%	68,63%
	DNB Bank ASA	48,95%	83,47%
	Erste Group Bank AG	49,26%	85,86%
	Hellenic Bank Public Company Limited	60,70%	88,97%
	HSBC Holdings Plc	41,74%	79,93%
	HSH Nordbank AG	46,71%	87,05%
	Jyske Bank A/S (Group)	41,68%	76,16%
	Lloyds Banking Group Plc	33,56%	83,18%
	Nordea Bank Danmark Group-Nordea Bank Danmark A/S	33,15%	84,10%
	OTP Bank Plc	74,13%	80,24%
	Royal Bank of Scotland Group Plc (The)	35,02%	70,32%
	Skandinaviska Enskilda Banken AB	35,84%	54,32%
	Société Générale SA	25,91%	78,41%
	Swedbank AB	25,14%	83,71%
	Sydbank A/S	46,60%	75,74%

2013	Aareal Bank AG	30,59%	89,63%
	ABN AMRO Group N.V.	29,30%	79,07%
	Allied Irish Banks plc	51,71%	94,49%
	Banco Comercial Português, SA-Millennium bcp	53,56%	91,80%
	Banco Popular Espanol SA	54,52%	91,25%
	Banco Santander (Mexico) SA	66,22%	63,82%
	Bank Nederlandse Gemeenten NV, BNG	8,79%	91,99%
	Bank of Cyprus Public Company Limited-Bank of Cyprus Group	77,53%	91,24%
	Bank of Ireland-Governor and Company of the Bank of Ireland	41,47%	90,69%
	Barclays Plc	32,93%	57,71%
	Belfius Banque SA/NV-Belfius Bank SA/NV	28,96%	81,04%
	BPCE Group	32,84%	85,33%
	Commerzbank AG	34,67%	83,43%
	Cooperatieve Rabobank U.A.	31,51%	90,04%
	Danske Bank A/S	26,41%	80,22%
	De Volksbank N.V.	19,56%	88,28%
	DekaBank Deutsche Girozentrale AG	19,35%	61,66%
	Deutsche Bank AG	18,64%	67,32%
	DNB Bank ASA	47,15%	79,97%
	Erste Group Bank AG	48,92%	86,68%
	Hellenic Bank Public Company Limited	68,91%	87,51%
	HSBC Holdings Plc	40,90%	79,10%
	HSH Nordbank AG	34,74%	82,06%
	Hypo Real Estate Holding AG	14,53%	92,74%
	Jyske Bank A/S (Group)	42,47%	72,89%
	La Banque Postale	28,09%	83,52%
	Landesbank Baden-Wuerttemberg	28,89%	81,24%
	Lloyds Banking Group Plc	32,30%	79,28%
	Nederlandse Waterschapsbank NV	1,71%	83,45%
	Nordea Bank Danmark Group-Nordea Bank Danmark A/S	31,20%	85,86%
	Nykredit Realkredit A/S	24,41%	86,30%
	OP Financial Group	40,93%	72,99%
	OTP Bank Plc	69,89%	79,73%
	Raiffeisen Zentralbank Oesterreich AG - RZB	50,02%	100,00%
	RCI Banque SA	59,75%	88,47%
	Royal Bank of Scotland Group Plc (The)	37,50%	75,51%
	Skandinaviska Enskilda Banken AB	36,91%	51,11%
	Société Générale SA	28,26%	72,46%
	Sydbank A/S	49,19%	74,52%
	Volkswagen Financial Services AG	90,72%	89,63%
2014	Aareal Bank AG	31,26%	88,36%
	ABN AMRO Group N.V.	28,34%	79,95%
	Allied Irish Banks plc	55,01%	94,42%
	AXA Bank Europe SA/NV	12,48%	79,96%
	Banco Comercial Português, SA-Millennium bcp	55,49%	90,05%
	Banco Santander (Mexico) SA	63,73%	68,15%
	Bank BPH SA	75,14%	100,00%
	Bank Nederlandse Gemeenten NV, BNG	7,61%	91,05%
	Bank of Cyprus Public Company Limited-Bank of Cyprus Group	84,79%	90,80%
	Bank of Ireland-Governor and Company of the Bank of Ireland	39,75%	90,70%
	Belfius Banque SA/NV-Belfius Bank SA/NV	25,47%	79,91%
	BPCE Group	32,12%	86,75%
	Caixa Geral de Depositos	60,98%	87,82%
	Commerzbank AG	38,54%	80,66%
	Cooperatieve Rabobank U.A.	31,11%	86,68%
	Criteria CaixaHolding SA	46,03%	60,57%
	De Volksbank N.V.	32,82%	52,05%
	DekaBank Deutsche Girozentrale AG	24,76%	50,60%
	Deutsche Bank AG	23,21%	61,55%
	DNB Bank ASA	43,96%	80,67%
	Erste Group Bank AG	51,25%	85,05%
	Hellenic Bank Public Company Limited	53,32%	86,42%
	HSBC Holdings Plc	46,31%	78,32%
	HSH Nordbank AG	35,88%	77,97%
	Hypo Real Estate Holding AG	20,42%	92,44%
	ING Groep NV	30,28%	85,21%
	Jyske Bank A/S (Group)	32,57%	78,20%
	La Banque Postale	24,74%	80,73%
	Landesbank Baden-Wuerttemberg	30,86%	79,70%
	Landwirtschaftliche Rentenbank	20,15%	91,20%
	Lloyds Banking Group Plc	28,04%	78,74%
	Nederlandse Waterschapsbank NV	2,02%	64,72%
	NLB dd-Nova Ljubljanska Banka d.d.	59,10%	83,60%
	Nordea Bank Danmark Group-Nordea Bank Danmark A/S	31,17%	86,75%
	Nova Kreditna Banka Maribor d.d.	54,01%	86,02%
	NRW.BANK	31,60%	97,46%
	Nykredit Realkredit A/S	24,61%	85,15%
	OP Financial Group	38,26%	88,25%
	OTP Bank Plc	62,52%	82,02%
	Raiffeisen Landesbanken Holding GmbH	54,30%	84,40%
	Raiffeisen Zentralbank Oesterreich AG - RZB	54,35%	84,39%
	Raiffeisenlandesbank Oberösterreich AG	65,25%	93,34%
	RCI Banque SA	59,84%	88,79%
	Royal Bank of Scotland Group Plc (The)	33,86%	74,37%
	SFIL	7,04%	95,27%
	Skandinaviska Enskilda Banken AB	23,34%	79,49%
	Société Générale SA	27,03%	78,95%
	Swedbank AB	19,53%	81,07%
	Sydbank A/S	47,58%	68,19%
	Volkswagen Financial Services AG	91,33%	88,66%

2015	Aareal Bank AG	32,16%	87,73%
	ABN AMRO Group N.V.	27,67%	17,46%
	AXA Bank Europe SA/NV	15,82%	80,75%
	Banca Monte dei Paschi di Siena SpA-Gruppo Monte dei Paschi	41,91%	28,77%
	Banco Comercial Português, SA-Millennium bcp	57,84%	89,36%
	Banco Popolare - Società Cooperativa-Banco Popolare	37,13%	27,17%
	Banco Popular Espanol SA	47,96%	43,03%
	Bank für Arbeit und Wirtschaft und Österreichische Postsparkas	46,11%	89,57%
	Bank Nederlandse Gemeenten NV, BNG	8,56%	36,50%
	Bank of Cyprus Public Company Limited-Bank of Cyprus Group	84,51%	89,59%
	Barclays Plc	32,00%	20,41%
	Bayerische Landesbank	32,27%	41,78%
	Belfius Banque SA/NV-Belfius Bank SA/NV	26,57%	44,19%
	BFA Tenedora de Acciones SAU	38,93%	19,14%
	Caixa Geral de Depositos	59,74%	89,11%
	Commerzbank AG	37,21%	28,49%
	Cooperatieve Rabobank U.A.	31,79%	22,05%
	Danske Bank A/S	25,32%	15,69%
	De Volksbank N.V.	18,36%	80,09%
	DekaBank Deutsche Girozentrale AG	28,88%	25,58%
	Deutsche Apotheker- und Aerztebank eG	25,32%	86,45%
	Deutsche Bank AG	24,39%	29,15%
	DNB Bank ASA	45,64%	20,03%
	Erste Group Bank AG	49,21%	20,54%
	Hellenic Bank Public Company Limited	53,51%	87,37%
	HSH Nordbank AG	38,57%	71,66%
	ING Groep NV	38,15%	29,92%
	Jyske Bank A/S (Group)	32,56%	48,94%
	KBC Groep NV/ KBC Groupe SA-KBC Group	34,61%	14,67%
	Landesbank Hessen-Thueringen Girozentrale - HELABA	31,85%	6,82%
	Landwirtschaftliche Rentenbank	16,88%	86,81%
	Nederlandse Waterschapsbank NV	2,19%	71,12%
	NLB dd-Nova Ljubljanska Banka d.d.	67,06%	86,53%
	Nordea Bank Danmark Group-Nordea Bank Danmark A/S	31,97%	41,16%
	Nova Kreditna Banka Maribor d.d.	53,37%	86,93%
	NRW.BANK	30,33%	29,12%
	Nykredit Realkredit A/S	22,49%	4,13%
	Precision Capital S.A.	28,82%	79,04%
	Raiffeisen Landesbanken Holding GmbH	52,09%	78,58%
	Raiffeisen Zentralbank Oesterreich AG - RZB	52,11%	82,61%
	Raiffeisenlandesbank Oberösterreich AG	61,38%	93,53%
	RCI Banque SA	57,36%	89,63%
	Royal Bank of Scotland Group Plc (The)	29,75%	31,88%
	SFIL	6,78%	96,49%
	SID - Slovene Export and Development Bank, Inc, Ljubljana - SID	38,58%	86,78%
	Skandinaviska Enskilda Banken AB	22,87%	25,85%
	Svenska Handelsbanken AB	18,76%	36,37%
	Sydbank A/S	47,61%	66,12%
	UniCredit SpA	45,40%	27,39%
	Unione di Banche Italiane Scpa-UBI Banca	52,34%	51,97%
	Volkswagen Financial Services AG	89,35%	14,25%
2016	Aareal Bank AG	30,48%	85,24%
	ABN AMRO Group N.V.	26,42%	79,78%
	Allied Irish Banks plc	56,72%	90,06%
	AXA Bank Europe SA/NV	16,76%	79,57%
	Banco Comercial Português, SA-Millennium bcp	54,95%	89,40%
	Banco Popular Espanol SA	43,52%	91,50%
	Banco Santander (Mexico) SA	50,52%	78,72%
	Bank für Arbeit und Wirtschaft und Österreichische Postsparkas	43,07%	90,12%
	Bank of Cyprus Public Company Limited-Bank of Cyprus Group	85,09%	89,38%
	Bank of Ireland-Governor and Company of the Bank of Ireland	41,26%	83,66%
	Bank of Valletta Plc	42,89%	90,32%
	Banque PSA Finance SA	30,57%	86,96%
	Barclays Plc	30,14%	66,06%
	Bayerische Landesbank	30,74%	82,06%
	Belfius Banque SA/NV-Belfius Bank SA/NV	26,44%	76,93%
	BFA Tenedora de Acciones SAU	40,38%	87,09%
	BFA Tenedora de Acciones SAU	40,38%	87,09%
	BPCE Group	31,65%	87,24%
	Caixa Geral de Depositos	58,81%	88,45%
	Commerzbank AG	39,66%	77,09%
	Cooperatieve Rabobank U.A.	31,88%	84,64%
	Criteria CaixaHolding SA	43,27%	64,14%
	De Volksbank N.V.	17,58%	80,65%
	DekaBank Deutsche Girozentrale AG	27,70%	5,92%
	Deutsche Apotheker- und Aerztebank eG	24,49%	87,18%
	Deutsche Bank AG	22,40%	61,85%
	DNB Bank ASA	44,33%	78,87%
	Erste Group Bank AG	48,89%	80,46%
	Hellenic Bank Public Company Limited	53,19%	87,39%
	HSBC Holdings Plc	36,09%	76,49%
	HSH Nordbank AG	33,90%	81,82%
	ING Groep NV	37,19%	76,78%
	Jyske Bank A/S (Group)	31,05%	77,16%
	La Banque Postale	25,93%	78,18%
	Landesbank Baden-Wuerttemberg	31,77%	80,60%
	Landesbank Hessen-Thueringen Girozentrale - HELABA	32,00%	12,33%
	Landwirtschaftliche Rentenbank	15,89%	88,41%
	Lloyds Banking Group Plc	26,36%	77,31%
	Nederlandse Waterschapsbank NV	3,16%	61,13%
	NLB dd-Nova Ljubljanska Banka d.d.	65,31%	87,32%
	Nova Kreditna Banka Maribor d.d.	51,32%	86,06%
	NRW.BANK	31,00%	97,51%
	Nykredit Realkredit A/S	24,94%	87,10%
	OP Financial Group	32,97%	88,10%
	Piraeus Bank SA	65,36%	93,20%
	Raiffeisen Zentralbank Oesterreich AG - RZB	50,47%	82,68%
	Raiffeisenlandesbank Oberösterreich AG	59,10%	93,75%
	RCI Banque SA	57,18%	87,77%
	Royal Bank of Scotland Group Plc (The)	28,57%	71,08%
	SFIL	6,87%	96,54%
	Skandinaviska Enskilda Banken AB	23,28%	77,56%
	Svenska Handelsbanken AB	17,46%	79,46%
	Swedbank AB	18,30%	81,62%
	Sydbank A/S	43,36%	65,53%
	Volkswagen Financial Services AG	91,98%	87,57%

Appendix 3

Figure 5 Credit risk RWA intensity and IRB usage (2014 EU wide stress test exercise) data set

Orbis bank focus database and EBA stress test templates (2017)

	2014 EU wide stress test exercise	
	Credit risk RWA intensity	IRB usage rate
Aareal Bank AG	21,40%	67,65%
ABLV Bank	37,61%	0,00%
ABN AMRO Bank N.V.	24,55%	93,51%
ALIOR BANK SA	64,32%	0,00%
Allied Irish Banks plc	32,03%	64,24%
Alpha Bank	58,87%	0,00%
AXA Bank Europe SA	13,29%	60,12%
Banca Carige S.P.A. - Cassa di Risparmio di Genova e Imperia	52,88%	0,00%
Banca Monte dei Paschi di Siena S.p.A.	37,96%	51,28%
Banca Piccolo Credito Valtellinese	55,53%	0,00%
Banca Popolare Dell'Emilia Romagna - Società Cooperativa	55,95%	0,00%
Banca Popolare Di Milano - Società Cooperativa A Responsabilità Limitata	65,07%	0,00%
Banca Popolare di Sondrio	63,53%	0,00%
Banca Popolare di Vicenza - Società Cooperativa per Azioni	45,40%	0,00%
Banco Bilbao Vizcaya Argentaria	47,24%	45,63%
Banco BPI	49,42%	0,00%
Banco Comercial Português	48,19%	56,22%
Banco de Sabadell	44,30%	38,47%
Banco Financiero y de Ahorros	35,49%	40,99%
Banco Mare Nostrum	38,55%	0,00%
Banco Popolare - Società Cooperativa	34,59%	61,87%
Banco Popular Español	53,93%	47,24%
Banco Santander	42,77%	49,21%
BANK BPH SA	69,53%	0,00%
BANK HANDLOWY W WARSZAWIE SA	42,07%	0,00%
Bank Nederlandse Gemeenten N.V.	8,67%	0,00%
BANK OCHRONY SRODOWISKA SA	53,34%	0,00%
Bank of Cyprus Public Company Ltd	51,96%	0,00%
Bank of Valletta plc	40,13%	0,00%
Bankinter	43,97%	41,53%
Banque et Caisse d'Epargne de l'Etat	26,33%	95,33%
Banque PSA Finance	63,62%	64,23%
Barclays plc	35,04%	83,89%
BAWAG P.S.K. Bank für Arbeit und Wirtschaft und Österreichische Postsparkasse AG	36,91%	40,26%
Bayerische Landesbank	30,90%	74,64%
Belfius Banque SA	26,70%	89,52%
BNP Paribas	40,82%	67,29%
BPI France (Banque Publique d'Investissement)	68,86%	0,00%
C.R.H. - Caisse de Refinancement de l'Habitat	10,29%	0,00%
Caixa Geral de Depósitos	51,31%	0,00%
Caja de Ahorros y M.P. de Zaragoza	40,37%	0,00%
Caja de Ahorros y Pensiones de Barcelona	51,25%	60,21%
Cajas Rurales Unidas	41,34%	0,00%
Catalunya Banc	30,01%	40,19%
Commerzbank AG	33,00%	70,83%
Coöperatieve Centrale Raiffeisen-Boerenleenbank B.A.	28,50%	93,30%
Co-operative Central Bank Ltd	39,39%	0,00%
Credito Emiliano S.p.A.	49,80%	29,46%
Danske Bank	24,55%	81,68%
DekaBank Deutsche Girozentrale	19,95%	52,55%
Deutsche Apotheker- und Ärztebank eG	19,99%	88,98%
Deutsche Bank AG	25,13%	79,26%
Dexia NV*	23,23%	69,36%
DNB Bank Group	37,88%	76,09%
DZ Bank AG Deutsche Zentral-Genossenschaftsbank	24,80%	53,47%
Erste Group Bank AG	39,52%	57,03%
Eurobank Ergasias	40,94%	31,25%
GETIN NOBLE BANK SA	63,95%	0,00%
Groupe BPCE	36,11%	59,81%
Groupe Crédit Agricole	35,41%	75,87%
Groupe Crédit Mutuel	34,79%	71,78%

	2014 EU wide stress test exercise	
	Credit risk RWA intensity	IRB usage rate
HASPA Finanzholding	58,75%	0,00%
Hellenic Bank Public Company Ltd	44,94%	0,00%
HSBC Holdings plc	41,69%	67,70%
HSH Nordbank AG	24,09%	97,79%
Hypo Real Estate Holding AG	19,98%	90,90%
Iccrea Holding S.p.A	23,25%	0,00%
IKB Deutsche Industriebank AG	53,57%	0,00%
ING Bank N.V.	29,81%	95,58%
Intesa Sanpaolo S.p.A.	45,02%	48,10%
Investar (Holding of Argenta Bank- en Verzekeringsgroep)	13,50%	78,40%
Jyske Bank	35,36%	72,87%
KBC Group NV	30,44%	94,94%
KfW IPEX-Bank GmbH	62,73%	53,06%
Kutxabank	52,75%	0,00%
La Banque Postale	23,72%	0,00%
Landesbank Baden-Württemberg	24,19%	65,65%
Landesbank Berlin Holding AG	27,34%	60,61%
Landesbank Hessen-Thüringen Girozentrale	29,19%	72,20%
Landeskreditbank Baden-Württemberg-Förderbank	27,27%	0,00%
Landwirtschaftliche Rentenbank	18,37%	0,00%
Liberbank	34,43%	0,00%
Lloyds Banking Group plc	30,62%	77,56%
Mediobanca - Banca di Credito Finanziario S.p.A.	68,21%	0,00%
MPCA Ronda	40,82%	0,00%
Münchener Hypothekenbank eG	19,41%	67,11%
National Bank of Greece	45,58%	24,71%
NCG Banco	43,52%	0,00%
Nederlandse Waterschapsbank N.V.	1,47%	0,00%
Norddeutsche Landesbank-Girozentrale	31,82%	54,05%
Nordea Bank AB (publ)	27,46%	76,58%
Nova Kreditna Banka Maribor d.d.	42,51%	0,00%
Nova Ljubljanska banka d. d.	40,17%	0,00%
NRW.Bank	28,70%	0,00%
Nykredit	21,38%	92,84%
OP-Pohjola Group	39,11%	88,67%
Österreichische Volksbanken-AG with credit institutions affiliated according to Article 10 of the CRR	50,67%	0,00%
OTP Bank Ltd	54,85%	0,00%
Permanent tsb plc.	27,65%	66,94%
Piraeus Bank	52,44%	0,00%
POWSZECHNA KASA OSZCZEDNOSCI BANK POLSKI S.A. (PKO BANK POLSKI)	66,01%	0,00%
Precision Capital S.A. (Holding of Banque Internationale à Luxembourg and KBL European Private Bankers S.A.)	24,36%	61,15%
Raiffeisen Zentralbank Österreich AG	51,83%	49,30%
Raiffeisenlandesbank Niederösterreich-Wien AG	39,25%	0,00%
Raiffeisenlandesbank Oberösterreich AG	63,90%	0,00%
RCI Banque	50,32%	66,09%
Royal Bank of Scotland Group plc	43,43%	68,32%
SID - Slovenska izvozna in razvojna banka	26,22%	0,00%
Skandinaviska Enskilda Banken AB (publ) (SEB)	25,04%	77,52%
SNS Bank N.V.	21,11%	66,86%
Société de Financement Local	6,46%	81,37%
Société Générale	37,33%	80,93%
Svenska Handelsbanken AB (publ)	15,57%	76,81%
Swedbank AB (publ)	21,66%	85,23%
Sydbank	53,47%	82,42%
The Governor and Company of the Bank of Ireland	40,86%	71,89%
UniCredit S.p.A.	42,13%	49,88%
Unione Di Banche Italiane Società Cooperativa Per Azioni	48,18%	53,74%
Veneto Banca S.C.P.A.	57,01%	0,00%
Volkswagen Financial Services AG	80,35%	0,00%
WGZ Bank AG Westdeutsche Genossenschafts-Zentralbank	21,52%	42,38%
Wüstenrot Bank AG Pfandbriefbank	30,01%	0,00%
Wüstenrot Bausparkasse AG	25,87%	0,00%

Appendix 4

Figure 6 Credit risk RWA intensity and IRB usage (2016 EU wide stress test exercise) data set

Orbis bank focus database and EBA stress test templates (2017)

	2016 EU wide stress test exercise	
	Credit risk RWA intensity	IRB Approach usage
Erste Group Bank AG	39,24%	67,39%
Raiffeisen-Landesbanken-Holding GmbH	42,66%	41,21%
Belfius Banque SA	26,09%	88,46%
KBC Group NV	26,58%	97,15%
Bayerische Landesbank	26,89%	84,35%
Commerzbank AG	34,36%	73,62%
DekaBank Deutsche Girozentrale	20,91%	52,28%
Deutsche Bank AG	25,77%	80,44%
Landesbank Baden-Württemberg	24,92%	76,54%
Landesbank Hessen-Thüringen Girozentrale	27,82%	75,71%
NRW.BANK	24,88%	0,00%
Norddeutsche Landesbank Girozentrale	30,42%	55,26%
Volkswagen Financial Services AG	82,53%	0,00%
Danske Bank	24,35%	72,65%
Jyske Bank	26,67%	90,70%
Nykredit Realkredit	18,96%	92,46%
BFA Tenedora de Acciones S.A.U.	35,51%	48,48%
Banco Bilbao Vizcaya Argentaria S.A.	46,42%	42,24%
Banco Popular Español S.A.	43,74%	51,72%
Banco Santander S.A.	39,66%	47,62%
Banco de Sabadell S.A.	35,93%	49,79%
Criteria Caixa, S.A.U.	54,07%	67,27%
OP Osuuskunta	32,29%	80,84%
BNP Paribas	34,73%	69,62%
Groupe BPCE	32,41%	63,10%
Groupe Crédit Agricole	35,70%	76,41%
Groupe Crédit Mutuel	33,85%	70,52%
La Banque Postale	20,85%	0,00%
Société Générale S.A.	35,35%	76,11%
OTP Bank Nyrt.	46,26%	0,00%
Allied Irish Banks plc	39,90%	52,11%
The Governor and Company of the Bank of Ireland	40,13%	71,98%
Banca Monte dei Paschi di Siena S.p.A.	42,28%	55,05%
Banco Popolare - Società Cooperativa	38,23%	61,39%
Intesa Sanpaolo S.p.A.	48,80%	49,55%
UniCredit S.p.A.	38,24%	50,63%
Unione Di Banche Italiane Società Per Azioni	48,97%	54,06%
ABN AMRO Group N.V.	20,71%	94,68%
Coöperatieve Centrale Raiffeisen-Boerenleenbank B.A	29,23%	96,89%
ING Groep N.V.	28,97%	95,92%
N.V. Bank Nederlandse Gemeenten	7,06%	0,00%
DNB Bank Group	40,85%	83,00%
Powszechna Kasa Oszczędności Bank Polski SA	52,97%	0,00%
Nordea Bank - group	21,72%	78,31%
Skandinaviska Enskilda Banken - group	22,73%	81,17%
Svenska Handelsbanken - group	15,19%	81,35%
Swedbank – group	15,19%	81,18%
Barclays Plc	33,96%	66,14%
HSBC Holdings	39,13%	72,14%
Lloyds Banking Group Plc	26,43%	81,06%
The Royal Bank of Scotland Group Public Limited Company	30,72%	79,28%

Appendix 5

Figure 7 RWA intensity and IRB usage (2014 EU wide stress test exercise) data set

Orbis bank focus database and EBA stress test templates (2017)

	2014 EU wide stress test exercise	
	RWA intensity	IRB usage rate
Aareal Bank AG	30,59%	67,65%
ABN AMRO Group N.V.	29,30%	93,51%
Allied Irish Banks plc	51,71%	64,24%
AXA Bank Europe SA/NV	13,17%	60,12%
Banca Monte dei Paschi di Siena SpA-Gruppo Monte dei Paschi di Siena	42,44%	51,28%
Banco Comercial Português, SA-Millennium bcp	53,56%	56,22%
Banco de Sabadell SA	44,59%	38,47%
Banco Popolare - Società Cooperativa-Banco Popolare	39,13%	61,87%
Banco Popular Espanol SA	54,52%	47,24%
Banco Santander (Mexico) SA	66,22%	49,21%
Bank of Ireland-Governor and Company of the Bank of Ireland	41,47%	71,89%
Banque PSA Finance SA	75,94%	64,23%
Barclays plc	32,93%	83,89%
Bayerische Landesbank	34,27%	74,64%
Belfius Banque SA/NV-Belfius Bank SA/NV	28,96%	89,52%
BPCE Group	32,84%	59,81%
Commerzbank AG	34,67%	70,83%
Credito Emiliano SpA-CREDEM	52,41%	29,46%
Danske Bank A/S	26,41%	81,68%
DekaBank Deutsche Girozentrale AG	19,35%	52,55%
Deutsche Apotheker- und Aerztebank eG	31,38%	88,98%
Deutsche Bank AG	18,64%	79,26%
DNB Bank ASA	47,15%	76,09%
DZ Bank AG-Deutsche Zentral-Genossenschaftsbank	22,15%	53,47%
Erste Group Bank AG	48,92%	57,03%
Eurobank Ergasias SA	49,15%	31,25%
HSBC Holdings Plc	40,90%	67,70%
HSH Nordbank AG	34,74%	97,79%
Hypo Real Estate Holding AG	14,53%	90,90%
Intesa Sanpaolo	44,12%	48,10%
Jyske Bank A/S (Group)	42,47%	72,87%
KBC Groep NV/ KBC Groupe SA-KBC Group	38,22%	94,94%
Landesbank Baden-Wuerttemberg	28,89%	65,65%
Landesbank Hessen-Thueringen Girozentrale - HELABA	30,33%	72,20%
Lloyds Banking Group Plc	32,30%	77,56%
Norddeutsche Landesbank Girozentrale NORD/LB	34,10%	54,05%
Nordea Bank Danmark Group-Nordea Bank Danmark A/S	31,20%	76,58%
Nykredit Realkredit A/S	24,41%	92,84%
OP Financial Group	40,93%	88,67%
Permanent TSB Plc	43,53%	66,94%
Raiffeisen Zentralbank Oesterreich AG - RZB	50,02%	49,30%
RCI Banque SA	59,75%	66,09%
Royal Bank of Scotland Group Plc (The)	37,50%	68,32%
SFIL	7,17%	81,37%
Skandinaviska Enskilda Banken AB	36,91%	77,52%
Société Générale SA	28,26%	80,93%
Svenska Handelsbanken AB	19,83%	76,81%
Swedbank AB	24,16%	85,23%
Sydbank A/S	49,19%	82,42%
UniCredit SpA	50,10%	49,88%
Unione di Banche Italiane Scpa-UBI Banca	49,13%	53,74%

Appendix 6

Figure 8 RWA intensity and IRB usage rate (2016 EU wide stress test exercise) data set

Orbis bank focus database and EBA stress test templates (2017)

	2016 EU wide stress test exercise	
	RWA intensity	IRB usage rate
ABN AMRO Group N.V.	27,67%	94,68%
Allied Irish Banks plc	56,78%	52,11%
Banca Monte dei Paschi di Siena S.p.A.	65,93%	55,05%
Banco de Sabadell S.A.	57,84%	49,79%
Banco Popolare - Società Cooperativa	37,13%	61,39%
Banco Popular Español S.A.	47,96%	51,72%
Banco Santander S.A.	56,08%	47,62%
Bank of Ireland-Governor and Company of the Bank of Ireland	40,70%	71,98%
Barclays Plc	32,00%	66,14%
Bayerische Landesbank	32,27%	84,35%
Belfius Banque SA	32,27%	88,46%
BFA Tenedora de Acciones S.A.U.	26,57%	48,48%
BNP Paribas	38,93%	69,62%
BPCE Group	33,55%	63,10%
Commerzbank AG	37,21%	73,62%
Criteria Caixa, S.A.U.	35,38%	67,27%
Danske Bank	56,29%	72,65%
DekaBank Deutsche Girozentrale	18,36%	52,28%
Deutsche Bank AG	24,39%	80,44%
DNB Bank Group	45,64%	83,00%
Erste Group Bank AG	49,21%	67,39%
HSBC Holdings	53,51%	72,14%
ING Groep N.V.	65,25%	95,92%
Intesa Sanpaolo S.p.A.	42,02%	49,55%
Jyske Bank	17,47%	90,70%
KBC Group NV	34,61%	97,15%
Landesbank Baden-Württemberg	31,82%	76,54%
Landesbank Hessen-Thüringen Girozentrale	31,85%	75,71%
Lloyds Banking Group Plc	27,62%	81,06%
Norddeutsche Landesbank Girozentrale NORD/LB	35,18%	55,26%
Nordea Bank Danmark Group-Nordea Bank Danmark A/S	31,97%	78,31%
Nykredit Realkredit A/S	22,49%	92,46%
OP Financial Group	33,42%	80,84%
Raiffeisen Landesbanken Holding GmbH	52,09%	41,21%
Royal Bank of Scotland Group Plc (The)	29,75%	79,28%
Skandinaviska Enskilda Banken AB	22,87%	81,17%
Svenska Handelsbanken AB	18,76%	81,35%
Swedbank AB	18,11%	81,18%
UniCredit SpA	45,40%	50,63%
Unione di Banche Italiane Scpa-UBI Banca	52,34%	54,06%

Appendix 7

Figure 9 CET 1 Capital depletion and RWA intensity (2014 stress test exercise)

Orbis bank focus database and EBA stress test templates (2017)

	2014 EU wide stress test exercise	
	CET 1 Capital depletion	RWA intensity
Aareal Bank AG	-3,76%	30,59%
ABLV Bank AS	-18,10%	48,27%
ABN AMRO Group N.V.	-15,72%	29,30%
Alior Bank Spólka Akcyjna	-37,86%	75,51%
Allied Irish Banks plc	-48,22%	51,71%
Alpha Bank AE	-42,37%	69,08%
AXA Bank Europe SA/NV	-59,21%	13,17%
Banca Carige SpA	-161,40%	51,12%
Banca Monte dei Paschi di Siena SpA-Gruppo Monte dei Paschi di Siena	-101,26%	42,44%
Banca Piccolo Credito Valtellinese-Credito Valtellinese Soc Coop	-51,63%	64,42%
Banca Popolare Dell'Emilia Romagna - Società Cooperativa	-35,50%	64,42%
Banca Popolare di Milano SCaRL	-41,08%	86,34%
Banca Popolare di Sondrio Societa Cooperativa per Azioni	-40,96%	72,49%
Banca Popolare di Vicenza Societa per azioni	-57,32%	62,03%
Banco BPI SA	-22,26%	49,22%
Banco Comercial Português, SA-Millennium bcp	-70,96%	53,56%
Banco de Sabadell SA	-19,04%	44,59%
Banco Popolare - Società Cooperativa-Banco Popolare	-37,84%	39,13%
Banco Popular Espanol SA	-24,14%	54,52%
Banco Santander (Mexico) SA	-10,09%	66,22%
Bank BPH SA	-23,29%	81,72%
Bank Handlowy w Warszawie S.A.	-6,45%	61,86%
Bank Nederlandse Gemeenten NV, BNG	-5,16%	8,79%
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	-79,80%	77,53%
Bank of Valletta Plc	-14,80%	49,47%
Banque PSA Finance SA	-1,27%	75,94%
Barclays Plc	-4,45%	32,93%
Bayerische Landesbank	-11,77%	34,27%
Belfius Banque SA/NV-Belfius Bank SA/NV	-35,81%	28,96%
BPCE Group	-22,19%	32,84%
Caixa Geral de Depositos	-40,14%	0,06%
Commerzbank AG	-17,22%	34,67%
Credito Emiliano SpA-CREDEM	-10,51%	52,41%
Danske Bank A/S	-11,60%	26,41%
De Volksbank N.V.	-46,02%	19,56%
DekaBank Deutsche Girozentrale AG	-27,48%	19,35%
Deutsche Apotheker- und Aerztebank eG	-0,36%	31,38%
Deutsche Bank AG	-10,36%	18,64%
DNB Bank ASA	4,31%	47,15%
DZ Bank AG-Deutsche Zentral-Genossenschaftsbank	-16,94%	22,15%
Erste Group Bank AG	-18,37%	48,92%
Eurobank Ergasias SA	-183,69%	49,15%
Getin Noble Bank SA	-13,58%	74,55%
Groupe Crédit Mutuel	-0,21%	74,55%

	2014 EU wide stress test exercise	
	CET 1 Capital depletion	RWA intensity
Hellenic Bank Public Company Limited	-109,51%	68,91%
HSBC Holdings Plc	6,80%	40,90%
HSH Nordbank AG	-33,01%	34,74%
Hypo Real Estate Holding AG	-33,27%	14,53%
Iccrea Holding SpA	-29,48%	30,05%
IKB Deutsche Industriebank AG	-28,79%	56,89%
Intesa Sanpaolo	-22,68%	44,12%
Jyske Bank A/S (Group)	2,13%	42,47%
KBC Groep NV/ KBC Groupe SA-KBC Group	-27,91%	38,22%
La Banque Postale	1,59%	28,09%
Landesbank Baden-Wuerttemberg	-36,88%	28,89%
Landesbank Baden-Wuerttemberg	-10,67%	28,89%
Landesbank Hessen-Thueringen Girozentrale - HELABA	-14,46%	30,33%
Landwirtschaftliche Rentenbank	-5,41%	16,54%
Lloyds Banking Group plc	-32,07%	32,30%
Mediobanca SpA-MEDIOBANCA - Banca di Credito Finanziario Società per Azioni	-11,86%	71,90%
Nederlandse Waterschapsbank NV	-7,09%	1,71%
Norddeutsche Landesbank-Girozentrale	-10,88%	34,10%
Nordea Bank Danmark Group-Nordea Bank Danmark A/S	-6,16%	31,20%
Nykredit Realkredit A/S	-14,03%	24,41%
OP Financial Group	-17,77%	40,93%
OTP Bank Plc	-21,15%	69,89%
Permanent TSB Plc	-91,55%	43,53%
Piraeus Bank SA	-55,96%	64,16%
Powszechna Kasa Oszczednosci Bank Polski SA - PKO BP SA	0,76%	78,75%
Raiffeisen Zentralbank Oesterreich AG - RZB	-19,27%	50,02%
Raiffeisenlandesbank Niederösterreich-Wien AG	-28,54%	53,77%
Raiffeisenlandesbank Oberösterreich AG	-20,47%	70,47%
RCI Banque SA	-20,44%	59,75%
Royal Bank of Scotland Group Plc (The)	-38,85%	37,50%
SFIL	-16,16%	7,17%
SID	-36,72%	54,51%
Skandinaviska Enskilda Banken AB	7,95%	36,91%
Société Générale SA	-16,14%	28,26%
Svenska Handelsbanken AB	8,57%	19,83%
Swedbank AB	0,46%	24,16%
Sydbank A/S	3,36%	49,19%
The Governor and Company of the Bank of Ireland	-22,70%	49,19%
UniCredit SpA	-24,88%	50,10%
Unione di Banche Italiane Scpa-UBI Banca	-29,69%	49,13%
Veneto Banca scpa	-51,09%	66,77%
Volkswagen Financial Services AG	-20,82%	90,72%
WGZ Bank AG Westdeutsche Genossenschafts-Zentralbank	-17,42%	90,72%
Wüstenrot Bausparkasse AG	-31,00%	32,88%

Appendix 8

Figure 10 CET 1 Capital depletion and RWA intensity (2016 stress test exercise) data set

Orbis bank focus database and EBA stress test templates (2017)

	2016 EU wide stress test exercise	
	CET 1 Capital depletion	RWA intensity
ABN AMRO Group N.V.	-24,25%	27,67%
Allied Irish Banks plc	-50,83%	56,78%
Banca Monte dei Paschi di Siena S.p.A.	-118,87%	41,91%
Banco de Sabadell S.A.	-28,65%	42,55%
Banco Popolare - Società Cooperativa	-29,31%	37,13%
Banco Popular Español S.A.	-46,05%	47,96%
Banco Santander S.A.	-29,87%	56,08%
Barclays Plc	-25,93%	32,00%
Bayerische Landesbank	-38,59%	32,27%
Belfius Banque SA	-19,22%	26,57%
BFA Tenedora de Acciones S.A.U.	-26,62%	38,93%
Commerzbank AG	-41,05%	37,21%
Criteria Caixa, S.A.U.	-16,46%	48,87%
Danske Bank	-9,73%	25,32%
DekaBank Deutsche Girozentrale	-24,73%	28,88%
Deutsche Bank AG	-30,12%	24,39%
DNB Bank Group	-0,09%	45,64%
Erste Group Bank AG	-26,70%	49,21%
Groupe BPCE	-18,96%	33,55%
HSBC Holdings	-18,20%	45,77%
ING Groep N.V.	-18,20%	38,15%
Intesa Sanpaolo S.p.A.	-14,90%	42,02%
Jyske Bank	-4,58%	32,56%
KBC Group NV	-11,17%	34,61%
La Banque Postale	-9,33%	24,79%
Landesbank Baden-Württemberg	-33,21%	31,82%
Landesbank Hessen-Thüringen Girozentrale	-17,65%	31,85%
Lloyds Banking Group Plc	-10,26%	27,62%
N.V. Bank Nederlandse Gemeenten	-21,45%	8,56%
Norddeutsche Landesbank Girozentrale	-29,92%	35,18%
Nordea Bank - group	-3,91%	31,97%
NRW.BANK	-3,67%	30,33%
Nykredit Realkredit	-4,93%	22,49%
OP Osuuskunta	-15,97%	33,42%
OTP Bank Nyrt.	-29,44%	61,35%
Powszechna Kasa Oszczędności Bank Polski SA	-13,65%	69,48%
Raiffeisen-Landesbanken-Holding GmbH	-35,29%	52,09%
Skandinaviska Enskilda Banken - group	6,61%	22,87%
Svenska Handelsbanken - group	-0,14%	18,76%
Swedbank – group	1,27%	18,11%
The Governor and Company of the Bank of Ireland	-35,17%	40,70%
The Royal Bank of Scotland Group Public Limited Company	-37,48%	29,75%
UniCredit S.p.A.	-30,45%	45,40%
Unione Di Banche Italiane Società Per Azioni	-26,60%	52,34%
Volkswagen Financial Services AG	-14,99%	89,35%

Appendix 9

Figure 11 CET 1 Capital depletion due to Credit risk and Credit risk RWA intensity (2014 stress test exercise)

Orbis bank focus database and EBA stress test templates (2017)

	2014 EU wide stress test exercise	
	CET 1 Capital depletion due to credit risk	Credit risk RWA intensity
Aareal Bank AG	-15,12%	21,40%
ABLV Bank	-46,60%	37,61%
ABN AMRO Bank N.V.	-47,28%	24,55%
ALIOR BANK SA	-90,31%	64,32%
Allied Irish Banks plc	-46,84%	32,03%
Alpha Bank	-65,64%	58,87%
AXA Bank Europe SA	-63,47%	13,29%
Banca Carige S.P.A. - Cassa di Risparmio di Genova e Imperia	-196,41%	52,88%
Banca Monte dei Paschi di Siena S.p.A.	-150,23%	37,96%
Banca Piccolo Credito Valtellinese	-88,25%	55,53%
Banca Popolare Dell'Emilia Romagna - Società Cooperativa	-69,78%	55,95%
Banca Popolare Di Milano - Società Cooperativa A Responsabilità Limitata	-54,55%	65,07%
Banca Popolare di Sondrio	-100,41%	63,53%
Banca Popolare di Vicenza - Società Cooperativa per Azioni	-66,10%	45,40%
Banco Bilbao Vizcaya Argentaria	-43,54%	47,24%
Banco BPI	-31,23%	49,42%
Banco Comercial Português	-56,00%	48,19%
Banco de Sabadell	-43,61%	44,30%
Banco Financiero y de Ahorros	-45,20%	35,49%
Banco Mare Nostrum	-71,60%	38,55%
Banco Popolare - Società Cooperativa	-121,32%	34,59%
Banco Popular Español	-54,65%	53,93%
Banco Santander	-62,53%	42,77%
BANK BPH SA	-32,34%	69,53%
BANK HANDLOWY W WARSZAWIE SA	-18,34%	42,07%
Bank Nederlandse Gemeenten N.V.	-5,00%	8,67%
BANK OCHRONY SRODOWISKA SA	-31,80%	53,34%
Bank of Cyprus Public Company Ltd	-62,16%	51,96%
Bank of Valletta plc	-39,30%	40,13%
Bankinter	-55,73%	43,97%
Banque et Caisse d'Epargne de l'Etat	-6,82%	26,33%
Banque PSA Finance	-26,78%	63,62%
Barclays plc	-31,31%	35,04%
BAWAG P.S.K. Bank für Arbeit und Wirtschaft und Österreichische Postspar	-24,79%	36,91%
Bayerische Landesbank	-20,52%	30,90%
Belfius Banque SA	-17,71%	26,70%
BNP Paribas	-36,30%	40,82%
BPI France (Banque Publique d'Investissement)	-2,24%	68,86%
C.R.H. - Caisse de Refinancement de l'Habitat	0,00%	10,29%
Caixa Geral de Depósitos	-45,17%	51,31%
Caja de Ahorros y M.P. de Zaragoza	-38,40%	40,37%
Caja de Ahorros y Pensiones de Barcelona	-40,96%	51,25%
Cajas Rurales Unidas	-34,56%	41,34%
Catalunya Banc	-70,25%	30,01%
Commerzbank AG	-28,48%	33,00%
Coöperatieve Centrale Raiffeisen-Boerenleenbank B.A.	-36,98%	28,50%
Co-operative Central Bank Ltd	162,52%	39,39%
Credito Emiliano S.p.A.	-31,81%	49,80%
Danske Bank	-38,63%	24,55%
DekaBank Deutsche Girozentrale	-9,12%	19,95%
Deutsche Apotheker- und Ärztebank eG	-18,69%	19,99%
Deutsche Bank AG	-16,25%	25,13%
Dexia NV*	-13,06%	23,23%
DNB Bank Group	-18,15%	37,88%
DZ Bank AG Deutsche Zentral-Genossenschaftsbank	-27,11%	24,80%
Erste Group Bank AG	-64,55%	39,52%
Eurobank Ergasias	-160,48%	40,94%
GETIN NOBLE BANK SA	-62,46%	63,95%
Groupe BPCE	-31,07%	36,11%
Groupe Crédit Agricole	-32,75%	35,41%
Groupe Crédit Mutuel	-20,42%	34,79%

	2014 EU wide stress test exercise	
	CET 1 Capital depletion due to credit risk	Credit risk RWA intensity
HASPA Finanzholding	-10,95%	58,75%
Hellenic Bank Public Company Ltd	-215,61%	44,94%
HSBC Holdings plc	-33,40%	41,69%
HSH Nordbank AG	-11,70%	24,09%
Hypo Real Estate Holding AG	-9,93%	19,98%
Iccrea Holding S.p.A	-81,37%	23,25%
IKB Deutsche Industriebank AG	-33,29%	53,57%
ING Bank N.V.	-33,56%	29,81%
Intesa Sanpaolo S.p.A.	-61,39%	45,02%
Investar (Holding of Argenta Bank- en Verzekeringsgroep)	-17,56%	13,50%
Jyske Bank	-36,33%	35,36%
KBC Group NV	-38,11%	30,44%
KfW IPEX-Bank GmbH	-29,70%	62,73%
Kutxabank	-14,71%	52,75%
La Banque Postale	-32,89%	23,72%
Landesbank Baden-Württemberg	-19,58%	24,19%
Landesbank Berlin Holding AG	-48,43%	27,34%
Landesbank Hessen-Thüringen Girozentrale	-29,50%	29,19%
Landeskreditbank Baden-Württemberg-Förderbank	-15,11%	27,27%
Landwirtschaftliche Rentenbank	-1,74%	18,37%
Liberbank	-76,94%	34,43%
Lloyds Banking Group plc	-72,70%	30,62%
Mediobanca - Banca di Credito Finanziario S.p.A.	-68,36%	68,21%
MPCA Ronda	-36,55%	40,82%
Münchener Hypothekenbank eG	-48,62%	19,41%
National Bank of Greece	-167,14%	45,58%
NCG Banco	-56,82%	43,52%
Nederlandse Waterschapsbank N.V.	-4,64%	1,47%
Norddeutsche Landesbank-Girozentrale	-25,76%	31,82%
Nordea Bank AB (publ)	-35,23%	27,46%
Nova Kreditna Banka Maribor d.d.	-53,12%	42,51%
Nova Ljubljanska banka d. d.	-71,49%	40,17%
NRW.Bank	-5,39%	28,70%
Nykredit	-21,61%	21,38%
OP-Pohjola Group	-31,13%	39,11%
Österreichische Volksbanken-AG	-32,97%	50,67%
OTP Bank Ltd	-90,78%	54,85%
Permanent tsb plc.	-60,32%	27,65%
Piraeus Bank	-61,20%	52,44%
POWSZECHNA KASA OSZCZEDNOSCI BANK POLSKI S.A.	-51,49%	66,01%
Precision Capital S.A.	-10,41%	24,36%
Raiffeisen Zentralbank Österreich AG	-60,29%	51,83%
Raiffeisenlandesbank Niederösterreich-Wien AG	-11,86%	39,25%
Raiffeisenlandesbank Oberösterreich AG	-31,27%	63,90%
RCI Banque	-92,71%	50,32%
Royal Bank of Scotland Group plc	-44,66%	43,43%
SID - Slovenska izvozna in razvojna banka	-36,73%	26,22%
Skandinaviska Enskilda Banken AB (publ) (SEB)	-16,60%	25,04%
SNS Bank N.V.	-34,82%	21,11%
Société de Financement Local	-4,01%	6,46%
Société Générale	-35,16%	37,33%
Svenska Handelsbanken AB (publ)	-19,04%	15,57%
Swedbank AB (publ)	-19,37%	21,66%
Sydbank	-39,72%	53,47%
The Governor and Company of the Bank of Ireland	-64,70%	40,86%
UniCredit S.p.A.	-58,47%	42,13%
Unione Di Banche Italiane Società Cooperativa Per Azioni	-59,44%	48,18%
Veneto Banca S.C.P.A.	-69,96%	57,01%
Volkswagen Financial Services AG	-34,04%	80,35%
WGZ Bank AG Westdeutsche Genossenschafts-Zentralbank	-13,96%	21,52%
Wüstenrot Bank AG Pfandbriefbank	-11,81%	30,01%
Wüstenrot Bausparkasse AG	-7,73%	25,87%

Appendix 10

Figure 12 CET 1 Capital depletion due to Credit risk and Credit risk RWA intensity (2016 stress test exercise)

Orbis bank focus database and EBA stress test templates (2017)

	2016 EU wide stress test exercise	
	CET 1 Capital depletion due to credit risk	Credit risk RWA intensity
ABN AMRO Group N.V.	-28,42%	20,71%
Allied Irish Banks plc	-46,37%	39,90%
Banca Monte dei Paschi di Siena S.p.A.	-90,38%	42,28%
Banco Bilbao Vizcaya Argentaria S.A.	-47,03%	46,42%
Banco de Sabadell S.A.	-46,76%	35,93%
Banco Popolare - Società Cooperativa	-58,02%	38,23%
Banco Popular Español S.A.	-35,27%	43,74%
Banco Santander S.A.	-54,51%	39,66%
Barclays Plc	-33,32%	33,96%
Bayerische Landesbank	-17,73%	26,89%
Belfius Banque SA	-8,61%	26,09%
BFA Tenedora de Acciones S.A.U.	-30,29%	35,51%
BNP Paribas	-24,75%	34,73%
Commerzbank AG	-18,82%	34,36%
Coöperatieve Centrale Raiffeisen-Boerenleenbank B.A	-27,00%	29,23%
Criteria Caixa, S.A.U.	-33,61%	54,07%
Danske Bank	-30,44%	24,35%
DekaBank Deutsche Girozentrale	-6,93%	20,91%
Deutsche Bank AG	-15,13%	25,77%
DNB Bank Group	-15,97%	40,85%
Erste Group Bank AG	-39,47%	39,24%
Groupe BPCE	-19,59%	32,41%
Groupe Crédit Agricole	-18,61%	35,70%
Groupe Crédit Mutuel	-14,55%	33,85%
HSBC Holdings	-25,67%	39,13%
ING Groep N.V.	-21,72%	28,97%
Intesa Sanpaolo S.p.A.	-38,58%	48,80%
Jyske Bank	-28,58%	26,67%
KBC Group NV	-18,80%	26,58%
La Banque Postale	-16,15%	20,85%
Landesbank Baden-Württemberg	-9,79%	24,92%
Landesbank Hessen-Thüringen Girozentrale	-13,03%	27,82%
Lloyds Banking Group Plc	-34,78%	26,43%
N.V. Bank Nederlandse Gemeenten	-6,34%	7,06%
Norddeutsche Landesbank Girozentrale	-26,31%	30,42%
Nordea Bank - group	-23,90%	21,72%
NRW.BANK	-1,72%	24,88%
Nykredit Realkredit	-16,76%	18,96%
OP Osuuskunta	-9,91%	32,29%
OTP Bank Nyrt.	-60,95%	46,26%
Powszechna Kasa Oszczędności Bank Polski SA	-46,80%	52,97%
Raiffeisen-Landesbanken-Holding GmbH	-53,03%	42,66%
Skandinaviska Enskilda Banken - group	-5,67%	22,73%
Société Générale S.A.	-23,79%	35,35%
Svenska Handelsbanken - group	-12,69%	15,19%
Swedbank – group	-6,83%	15,19%
The Governor and Company of the Bank of Ireland	-44,23%	40,13%
The Royal Bank of Scotland Group Public Limited Company	-20,99%	30,72%
UniCredit S.p.A.	-48,66%	38,24%
Unione Di Banche Italiane Società Per Azioni	-49,84%	48,97%
Volkswagen Financial Services AG	-17,36%	82,53%

Dipartimento di Economia e Finanza

Indirizzo Finance

Cattedra di Risk Management and Compliance

Banking regulation: coherence between stress test exercise and RWA-based capital requirements

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Summary

Banking regulation is deeply affected by two different regulatory tools intended to assess the level of risk: the stress test exercise program and the RWA-based risk assessment framework. The objectives and the underlying methodologies of these tools are different, nonetheless each one has an important role for the regulatory and supervisory activities inside the banking sector. The risk assessment provided by these tools generates results that are used for the evaluation of the banking activity and contribute to assess the required capitalization of the single bank. In the last two decades, while the role of internal models estimates in the capital requirements framework was increasing, regulators started to realize that RWA-based calculation had several drawbacks. In fact, the development of a structured stress test program conducted by the competent authority represented one of the solutions to the liabilities of the Basel Committee RWA-based framework. After the financial crisis, both the ECB and the FED developed a program made of periodic stress test exercises. A selected set of large banks were required to be submitted to the stress test (with a given frequency) in order to verify the resilience of each single bank against the occurrence of an adverse scenario. Aggregate stress test outcome data were collected to estimate the effects of the adverse scenario on the whole banking sector.

The application of these regulatory tools aimed to assess risk allowed to calibrate the intervention of the banking authority; such activities pursued the objective of a capital solidity augmentation inside banking sector. One of the main concern of the banking regulation was to guarantee a proper capitalization of all banks. In fact, Basel III prescriptions increased the minimum threshold amount and the quality of the capital instruments to be held. Furthermore, Basel Committee established a 3% minimum Leverage Ratio to be kept at all times for each internationally active bank. These regulatory prescriptions were a direct response to the 2007-08 world-wide financial crisis, that underlined an insufficient level of capitalization compared to the riskiness of the portfolio of banks. The whole RWA framework that prescribes the internal models implementation (under regulatory approval) in Basel II document became effective in order to develop a capital requirement calculation method based on the risk-weighting procedure. The number of banks using internal models increased during the last decade; at the same time, the quantity of exposures treated with internal models and the level of sophistication of these models grew significantly.

The coexistence of the two risk assessment tools generated a mismatch in terms of riskiness evaluation of the overall exposures of the banks; the following set of analysis is aimed to identify the discrepancy between these tools in the European banking sector.

Historical data analysis

The international banking sector went through a long transition period after the financial crisis; during that period, the changes of the regulation and the outcome of the supervisory activities had a huge impact on the banks' activities. In particular, in the last decade the European banking sector showed many significant trends highly influenced by the Basel framework.

A collection of historical data for many different sets of European large banks is able to show the trends inside the banking sector in the post-crisis period. The reference lapse of time goes from 2011 to 2016. As previously mentioned, the capital solidity of the banks represented one of the main concerns of the regulators, therefore two capitalization indicators were analyzed: the Leverage ratio and the CET 1 Ratio. The Leverage ratio was defined as the ratio between the Equity and the Total Assets of the bank, while the CET 1 Ratio was defined as the ratio between the Common Equity Tier 1 Capital and the Total RWA.

These two ratios have been observed during the reference period together with the movements of their respective numerator and denominator variables. Several sub-samples of the 2014 stress test exercise sample[85] (123 banks) were used in the analysis, in order to identify the trends of the variables.

Data set pointed out that the Leverage ratio increased for the majority of the banks in the samples and the two components of the ratio behaved differently: Equity increased only for half of the banks in the sample, while the Total Assets decreased for most of them. Because of that, decrease of the financial leverage was observed and it was mainly driven by the decrease of the overall exposures of the banks. Therefore, this indicator of banks' capitalization was not actually raised up by a higher level of Equity capital held by the banks, but instead it was influenced by the reduction of the Total Assets. Such a contraction in the banks' activity was one of the symptoms of the worldwide economic recession following the 2007-2008 financial crisis.

A similar pattern was recognized in the change of the CET 1 Ratio during the reference period; this indicator increased for most of the banks in the selected sample but the movements of the numerator and the denominator variables had the same direction. Indeed, both the CET 1 Capital and the amount of RWA decreased:

$$\text{CET 1 Ratio} \uparrow = \frac{\text{CET 1 Capital} \downarrow}{\text{RWA} \downarrow} \tag{1}$$

The numerator and the denominator variables increased for most of the banks during the reference period, but at the same time the ratio increased, therefore the movement of the denominator had a greater impact. The reduction of the RWA amount was the main driver of the increase of the CET 1 Ratio. This indicator of bank's capitalization increased in the reference period and it was steered by the reduction of the RWA amount, instead of being driven by further core capital issued by the banks.

The historical data collected in this analysis outlined that the European banking sector actually went through a period in which the level of bank's capitalization measured by these two indicators improved. By looking at the movements of the variables involved, this change in the

[85]Several samples of banks were used in the different stages of the empirical analysis; it was due to data availability of the database (mainly Orbis Bank Focus), but it allowed not to constraint the analysis on a single specific set of European banks. In fact, some of the banks belonging to the 2014 EU wide stress test sample had unusual trends of the variable because of the peculiar characteristics of their national economies. Nonetheless, all the groups of banks were sub-samples of the 2014 EU-wide stress test exercise sample (123 banks).

level of capital solidity was not pushed by an effective enhancement of the capital raised by banks. It was an effect of the decrease of Total Assets and of the RWA amounts.

The RWA amount is included in another important indicator of the banking sector: RWA intensity. Such a measure is the ratio of the RWA amount and the Total Assets of a bank. It is intended to quantify the proportion between the risk-weighted exposure, calculated within the actual regulatory framework for capital requirements, and the actual exposures. In this sense, the RWA intensity is assumed to provide a measure of the riskiness of the overall exposures of a single bank derived through the risk-weighting process.

Banks have high RWA intensity value because they have high percentage of RWA compared to their Total Assets amount: this implies that they assign more risk-weights to their overall exposure. The RWA based risk assessment framework prescribes many different approaches and methodologies referred to several types of exposures and types of risk, then the RWA calculation depends on the specific features of the regulatory framework referred to each particular type of asset and on the portfolio composition. The use of validated internal models also represents a key driver of the RWA calculation, since every bank develops its own models to estimate risk parameters. Because of that, RWA intensity value is influenced by many factors, therefore banks with lower RWA intensity value may not have less risky overall exposures. If a bank uses its own validated internal models for the majority of its exposure amount, it could have calibrated them in a way such that the RWA calculated on the assets ends to be lower ceteris paribus. From this point of view, the evaluation of the RWA intensity needs to take into account the potential lowering effect of the internal models on the RWA calculation.

The historical data collected for the RWA intensity in the reference period pointed out that most of the European banks decreased their RWA intensity. Since the trends of the numerator and the denominator of the ratio, respectively RWA and Total Assets, have been already analyzed during the reference period, the RWA intensity could be summarized as follows:

$$\text{RWA intensity} \downarrow = \frac{\text{RWA}\downarrow}{\text{Total Assets}\downarrow} \tag{2}$$

Both the RWA amount and the Total Assets amount decreased during the reference period, but the ratio of these two variables decreased too. This means that the RWA intensity measure was driven down by the effect of the RWA reduction. The decrease of the RWA intensity indicator in the European banking sector in the reference period outlines a reduction of the proportion between RWA and the Total Assets: given the same amount of overall exposures, banks calculate lower amount of RWA, ceteris paribus. This tendency could be explained by a change of the portfolio composition of the banks: if a bank chooses less risky assets, the risk weights assigned to them will be lower. Holding less risky assets have a negative impact on the bank's performance since the return on the assets is usually positively correlated with the riskiness. Therefore, banks with less risky assets are assumed to achieve lower returns: on the other side, if a bank calculates a lower RWA amount, it reduces the minimum level of capital requirements. Equity capital issuing process represents a cost for the bank and forces it to achieve higher returns to compensate equity instruments holders (who usually require higher returns compared to debt holders), then banks recognize an advantage in calculating lower RWA amount.

RWA intensity and internal models implementation

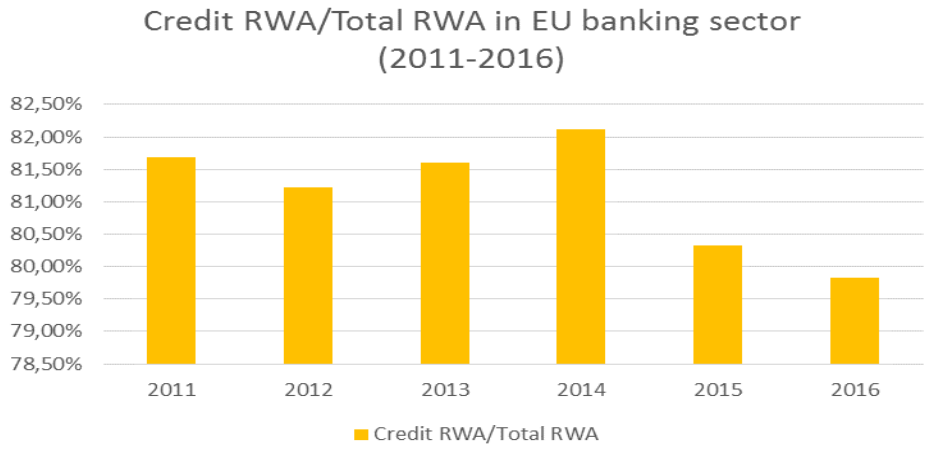
Another element that could explain the trend of the RWA intensity value in the European banking sector is the level of internal models implementation. The calibration of internal models gives the opportunity to calculate lower amount of RWA on the assets and this mechanism allows to reduce the level of capital requirements. Because of that, banks recognize an incentive in the internal models implementation: they are able to contain the burden of capital instruments to be held according to the Basel capital requirements without reducing the riskiness of their exposures.

The trends observed for the CET 1 Ratio and the RWA intensity in the reference period were caused by the reduction of the RWA amount of the banks; in order to verify how the implementation of internal models affected the change of RWA amount, a series of analysis have been conducted.

The relationship between the RWA intensity level and the role of internal models in the RWA calculation requires to be analyzed by focusing on a specific type of asset: the assets affected by Credit risk. Indeed, the Credit risk exposures have been the largest part of banks' portfolio in the European sector: the amount of RWA calculated on assets affected by Credit risk represented nearly 80% of the Total RWA on average[86] in the reference period (2011-2016) as shown below:

[86]Each average value was calculated in the sample with an equally weighted mean for each year of the reference period.

Figure 1 Credit RWA/Total RWA in EU banking sector 2011-2016



Source: Orbis Bank Focus database 2017

The Credit risk exposures have a central role in the overall RWA calculation not only for their weight in the overall portfolio composition of the European banks, but also for the many different regulatory approaches prescribed for these types of asset. In general, latest Basel Agreement defined 3 distinct regulatory approaches for the Credit risk: the Standardized Approach, where the risk parameters are determined with the use of external ratings, and the IRB Approaches. The IRB Approaches for Credit risk are divided into Foundation Approach and the Advanced Approach, depending on the number of risk parameters to be internally estimated by the banks. A set of minimum requirements have been established by the regulators for the constitution of internal models of the banks. In fact, from the first introduction of validated internal models, model building activities reached a high level of sophistication in the banking sector. If the internal estimates are not intended (or are not able) to improve the accuracy in the risk parameters estimation, and they are implemented mainly to reduce capital requirements, regulators identify a potential source of so-called model risk.

Another reason that justifies a focus on the assets affected by Credit risk is that the Credit risk exposures usually represented the main driver of losses in the stress test simulation. The results of the two latest stress test exercises clearly show the weight of the Credit risk exposure on the overall[87] stress test outcome:

[87]The CET 1 Ratio change due to the Credit risk exposures has been bigger (in absolute value) than the overall change of the CET 1 Ratio for many banks in the samples. This was possible because several other drivers had a positive impact in the stress test simulation.

Table 1 2014 and 2016 EU wide stress test exercise results on aggregate level: overall outcome and Credit risk losses

Adverse Scenario full period outcome 2014 and 2016 EU wide stress tests

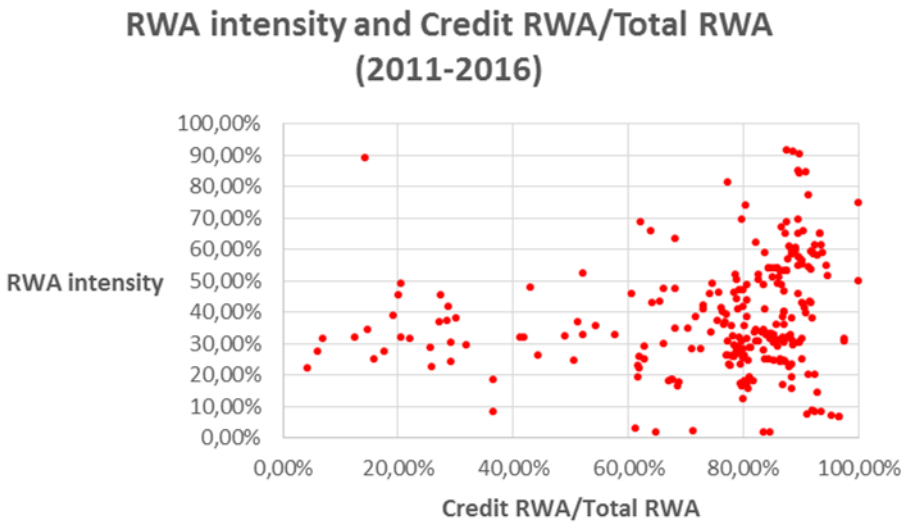
2014 EU wide stress test exercise	initial CET 1 Ratio (2013)	Final CET 1 Ratio (2016)	Δ CET 1 Ratio (2013-2016)	Δ CET 1 Ratio due to credit risk losses (2013-2016)
Total	**11,12%**	**8,42%**	**-2,70%**	**-4,40%**

2016 EU wide stress test exercise	initial CET 1 Ratio (2015)	Final CET 1 Ratio (2018)	Δ CET 1 Ratio (2015-2018)	Δ CET 1 Ratio due to credit risk losses (2015-2018)
Total	**13,19%**	**9,36%**	**-3,83%**	**-3,71%**

Source: EBA templates, 2014 and 2016 EU wide stress test results (2017)

The level of the Credit risk exposure is able to influence the RWA intensity. In particular, the ratio between the Credit risk RWA and the Total RWA gives a measure of the portion of risk-weighted exposure calculated on assets affected by Credit risk on the overall RWA amount. This measure can be compared with the RWA intensity value for each bank. Historical data for the European banking sector in the reference period (2011-2016) are collected; a large sub-sample of both the 2014 and 2016 stress test exercise samples is considered for the analysis. A wide data set is obtained, therefore it is possible to infer the tendency of the whole European banking sector. Such data set is represented on a scatter plot graph as follows:

Figure 2 RWA intensity and Credit RWA/Total RWA (2011-2016) for banks in 2014 and 2016 stress tests sample



Source: Orbis Bank Focus database 2017

The majority of the points (each one correspondent to a single large European bank observed in one year) lies in the lower right area of the Cartesian plane; this means that in the European banking sector high portion of Credit risk RWA were often associated with low level of RWA intensity. This empirical evidence could be explained with the impact of IRB Approaches on the RWA amount calculation.

If the analysis is concentrated on the Credit risk exposures, it is possible to identify the relationship between this category of assets and the regulatory framework prescribed for it. The following indicator is defined to summarize the use of internal models in the calculation of Credit risk RWA amount:

$$\text{IRB usage rate} = \frac{\text{Exposure under Foundation IRB Approach+Exposures under Advanced IRB Approach}}{\text{Total Exposure values}} \quad (3)$$

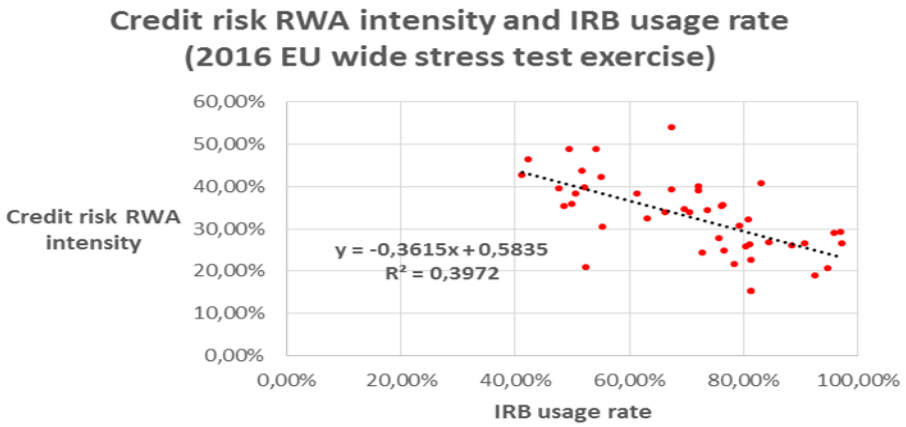
This indicator allows to quantify the portion of Credit risk Exposures calculated with IRB Approaches (i.e. Foundation and Advanced Approach); this indicator needs to be compared with the ratio of RWA amount calculated for assets affected by Credit risk and the total Credit risk exposure. Such a variable is defined as follows:

$$\text{Credit risk RWA intensity} = \frac{\text{Risk Exposure amounts for Credit risk}}{\text{Exposure values for Credit risk}} \quad (4)$$

It is intended to represent the RWA intensity value solely referred to the assets affected by Credit risk.

Data reported in the templates published after the last two EU wide stress test exercises (2014 and 2016) are collected for these variables: banks not applying IRB Approaches for their Credit risk exposures are excluded from the samples. The scatter plot graphs built on the data set referred to each stress test exercise outlined an empirical evidence that can be visualized in a scatter plot graph; for example, the following figure shows the 2016 data set graph:

Figure 3 Credit risk RWA intensity and IRB usage (2016 EU wide stress test exercise)



Source: EBA templates, 2014 and 2016 EU wide stress test results (2017)

The linear regression[88] executed on the data set generates a linear model based on the following formula:

$$y = \alpha + \beta * x + \mu \quad (5)$$

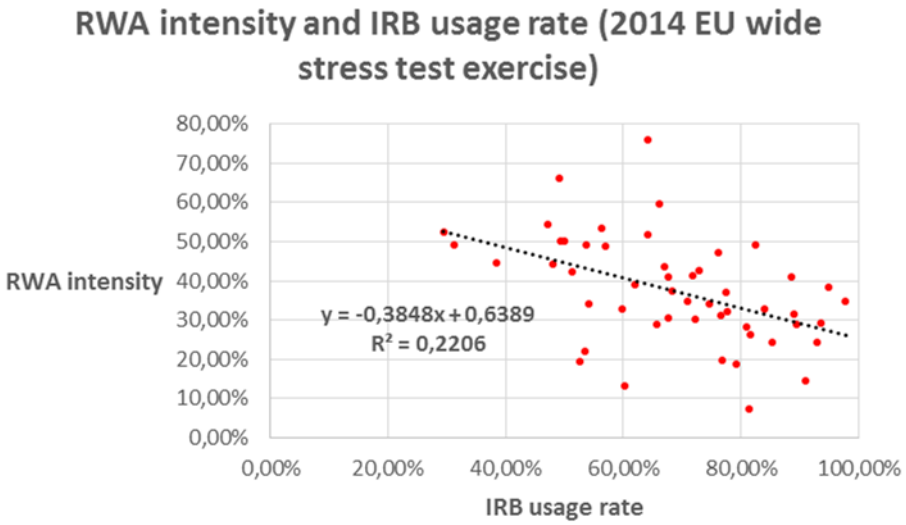
[88]The OLS method is used for all the linear regressions in the empirical analysis.

In this linear equation α represents the intercept, μ the stochastic error, y the explained variable and x the explanatory variable.

Considering the Credit risk RWA intensity as the explained variable (y) and the IRB Usage rate as the explanatory variable (x), the estimated linear models implies a negative coefficient (the estimate linear model is reported in Figure 3) and a negatively sloped tendency line. According to such linear model, banks with high IRB usage rate had low Credit risk RWA intensity value. The R^2 obtained in the regression (0,397) outlines a good fitness of the data to the model despite of the sample size (45 banks), and the distribution of points shows that the Credit risk RWA intensity tends to decrease as far as the IRB usage rate grows. A high IRB usage rate is associated with low amount of RWA calculated on assets affected by Credit risk. Similar results have been obtained for the 2014 EU wide stress test exercise, that involved a larger sample of banks (72 out of 123 banks implementing internal models for Credit risk exposures).

If the Credit risk exposures usually represents the largest part of the banks total assets, the overall RWA is expected to be affected by the level of IRB Approach implementation. Other types of exposures are included in the Total Assets amount, but the use of internal models allows to reduce significantly the amount of RWA calculated for the Credit risk exposure. In this sense, it is useful to observe if the overall RWA intensity is lower for banks that uses intensively internal models. Data have been collected for the last two EU wide stress test exercises: the following scatter plot graph is referred to the 2014 stress test.

Figure 4 RWA intensity and IRB usage (2014 EU wide stress test exercise)



Source: EBA templates, 2014 EU wide stress test results and Orbis Bank Focus database (2017)

Even in this case the tendency line outlines a negative coefficient of the estimated linear model. The analysis on the overall RWA intensity remarks the results obtained for the Credit risk RWA intensity, demonstrating how the other types of exposure do not mitigate the effect of IRB

usage rate on the overall RWA amount: banks using more internal estimates calculate lower overall RWA amount, therefore they are subjected to lower capital requirements.

This phenomenon has spread in the European banking sector during the last decade. For instance, in the samples of banks submitted to the last two EU wide stress test exercise (2014 and 2016) the portion of banks using IRB Approaches grew significantly: 72 out of 123 banks (58,53%) in 2014 and 45 out of 51 banks (88,23%) in 2016. Because of that, regulators took several measures to control the internal models developed by banks. Basel Committee clearly established the set of Minimum Requirements[89] for the internal models of IMM[90] banks: the regulatory framework required a series of methodological and conceptual principles designed to constraint the model building activity. Despite of that, the internal models of the banks reached a level of sophistication that forced the regulators to verify the accuracy of the internal estimates. The validation of the internal models started not to be sufficient to avoid the use of IRB Approach aimed to reduce the level of capital requirements: therefore banking regulations began several review processes intended to evaluate the internal models of the banks. The TRIM (Targeted Review of Internal Models), represents one of the most important process put in place to evaluate the effect of internal models implementation in the banking sector, in terms of capital solidity and model risk. It consists of a two-year (2017-2018[91]) project made of internal models review missions executed by ECB staff cooperating with national supervisors, external auditors and consultants.

The regulation observed the effect of the use of internal models inside the banking sector and tried to balance the drawbacks of the RWA-based risk assessment framework with another instrument aimed to assess risk in the banking activity: the stress test exercise.

RWA intensity and stress test exercise results

The stress test program developed by the EBA started in the late years of the last decade and led to 3 stress test exercises after 2010 (2011, 2014 and 2016); the results were published by the authority generating a huge turmoil in the financial markets. Results on individual basis represented the main concern of the banks submitted to the test, because all the market players observed their performance in the simulation. The structure of EU wide stress test exercise implied projections over two different kinds of scenario: a baseline scenario (assumed to replicate normal market conditions) and an adverse scenario. The last one involved a set of stressed macroeconomic and financial variables (e.g. interest rates) intended to replicate future adverse market conditions: the scenario generation process conducted by the authority was the result of a series of quantitative studies and it was aimed to replicate a context of distressed financial markets, like the one observed during the 2007-2008 crisis. The aim of the authority was to assess the resilience of the overall banking sector through the analysis of the simulation made on the aggregate sample of banks submitted to the test. At the same time, banking authority evaluated data referred to the individual performance of the single banks in the projected period to calibrate the measure of intervention on

[89]Section H of "International Convergence of Capital Measurement and Capital Standards", 2004, Basel Committee on Banking Supervision.
[90]Internal method banks: i.e. banks using IRB Approaches for capital requirements calculation.
[91]There is the possibility of an extension to a third year (2019).

each one. The publication of the results after each stress test had a huge impact on the markets, due to the wide set of information provided by the authority.

Some of the banks submitted to the stress test had very poor performance in the simulation: indeed the results outlined severe capital losses during the projected years. Because of that, the banking authority and the financial institutions started to wonder if the stress test performance was coherent with the level of risk implied by the actual Basel capital requirement framework.

In particular, many banks satisfying capital requirements, according to the RWA-based regulatory framework, experienced huge amount of losses in the full period (3 years) stress test simulation. In some cases, the amount of losses was so high that most of the core capital of the banks would have depleted in the projections.

In order to verify the discrepancy between the results of the stress test exercise and the riskiness outlined by the Basel capital requirements framework, an empirical analysis is conducted: two different measures are provided, each one referred to one regulatory tool, the RWA-based framework and the stress test exercise respectively.

The indicator selected to synthetize the riskiness of the asset with the risk-weighting methodology is the overall RWA intensity. The measure referred to the stress test is intended to summarize the outcome of the simulation. The main indicator used by the EBA to evaluate the performance of the banks is the change of CET 1 Ratio. Given that it represents a ratio between two variables (Common Equity Tier 1 Capital and Total RWA) that actually changed their amount in the simulation, another measure was preferred. Such a measure is called CET 1 Capital depletion and it is defined as follows:

$$\text{CET 1 Capital depletion} = \frac{\Delta \text{ CET 1 Capital}^{92}}{\text{CET 1 Capital initial value}} \tag{6}$$

Data have been collected for the full-period projections (3 years) in the adverse scenario for the 2014 and 2016 EU wide stress test exercises. The CET 1 Capital depletions is considered a measure (% value) that represents the portion of initial core capital lost in the adverse scenario simulation. Therefore banks experiencing a CET 1 Capital depletion close to 100% were likely to face bankruptcy in such a scenario, because they could lost all their core capital in the projected years.

If the RWA-based risk assessment and the riskiness outlined by the outcome of a stressed scenario coincide, banks with the highest RWA intensity should have the worst performance in the stress test. Capital requirements calculated on the amount of RWA are intended to cover the unexpected losses that could arise in case of severe economic scenarios. The stress test exercise tries to quantify the capital depletion in an adverse scenario occurrence. If the riskiness implied by these two different indicators were reconcilable, the outcome of the stress test results would be coherent with the RWA-based riskiness assessment. In particular, the CET 1 Capital depletion

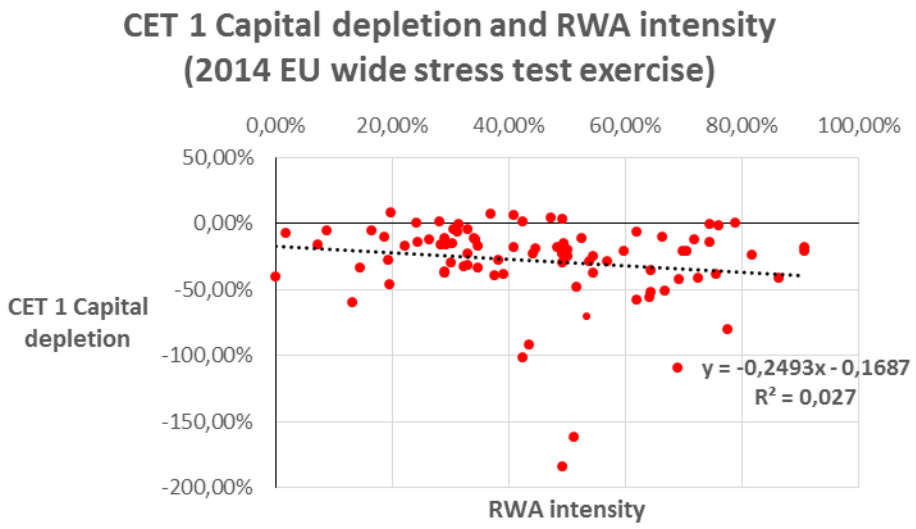
[92] Δ CET 1 Capital represents the difference between the final value of the CET 1 Capital of the bank observed for the last projected year of the stress test exercise, and the initial value of the CET 1 Capital of the bank reported at 31st December of the last year before the stress test exercise.

calculated on the stress test results data set should increase (in absolute value[93]) together with the level of RWA intensity.

Data for the RWA intensity observed in the last year before the test and the CET 1 Capital depletion in the simulation are collected and compared (for 2014 and 2016 EU wide stress test exercises), then a simple scatter plot graph allows to verify the coherence between the two measures.

For instance, the scatter plot graph for the 2014 stress test exercise is shown:

Figure 5 CET 1 Capital depletion and RWA intensity (2014 stress test exercise)



Source: EBA templates, 2014 EU wide stress test results and Orbis Bank Focus database (2017)

The linear regression made on the data set (the equation of the linear model is reported in Figure 5) assumes the CET 1 Capital depletion as the explained variable (y) and the overall RWA intensity as the explanatory variable (x).

The estimated linear model obtained from a 88 banks subsample of 2014 EU wide stress test exercise outlined results that seem to confirm the discrepancy between the two measures: the R^2 is low (0,027) and the tendency line is only slightly negative sloped. Moreover, the points are distributed uniformly under the x-axis, meaning that banks with different level of RWA intensity had similar overall stress test outcome. At the same time, the worst performing banks have a RWA intensity bounded in the range between 40% and 60%. The analysis is repeated for the 2016 stress test and even in this case the discrepancy between the two measures of risk is clear. Furthermore, when the linear model is estimated considering the Credit risk RWA intensity and the CET 1

[93]The CET 1 Capital depletion has a negative percentage value, therefore as far as the RWA intensity increases, the CET 1 Capital depletion is expected to decrease (increase in absolute value).

Capital depletion due to assets affected by Credit risk (in 2014 and 2016 EU wide stress test exercises), such conclusions are confirmed.

On top of this data analysis, the empirical evidence allows to identify the divergence between the two risk assessment regulatory tools.

Conclusions

The RWA-based risk assessment framework and the stress test exercise led to divergent results on individual basis. Such a discrepancy could be explained by the methodological and conceptual difference between these regulatory tools. The stress test exercise provides one single adverse scenario which banks are submitted to; in this sense banks are evaluated under the same stressed market conditions, but the projections made on each bank depend on their specific exposures to different kinds of risk and their level of capitalization before the stress test. The RWA calculation made by banks relies on risk parameters estimates (PD, EAD, LGD) that are often obtained with an historical simulation process: this methodology requires losses calculation made through a backward-looking multi-scenario approach. The use of internal models for the risk parameters estimation differentiates any single bank from the other, then it is more difficult to verify if each one has calculated the proper RWA amount. Nonetheless, the capital requirements framework is intended to quantify the capital required to cover against losses in worst-case scenarios. In this sense, the discrepancy observed in the empirical analysis underlines one of the key element of the debate that is taking place in the financial markets regarding these two regulatory tools. The RWA based framework is aimed to estimate the proper level of capital to be issued by banks to absorb losses in severe economic scenarios. The use of validated internal models is considered a tool aimed to increase the accuracy of the risk parameters estimates made by banks, but it is actually exploited to reduce the RWA calculated on the assets. At the same time, stress test results outlined banks sufficiently capitalized according to the Basel framework that had very poor performance: these banks recorded losses so large that they were likely to face bankruptcy in the projected years. This phenomenon generates a new type of risk that is representing a huge concern for the regulators: model risk. The risk implied by the implementation of banks' internal models. The use of internal estimates in the RWA calculation could led to underestimate the required level of capitalization of the bank; because of that, the growing number of banks implementing validated internal models constitutes a potential threat for the banking sector stability. The debate concerning model risk that has arisen in the financial markets in the last decade will surely generate a response from the regulation in the next years.

Regulators will supposedly try to mitigate the effects of the internal models use of the banks on the capital requirements calculation. Moreover, the stress test mechanism will probably be reformed in order to overcome the limits of the actual scenario generation process. Financial markets and supervisory authority will search ways to integrate the results of both these risk assessment tools in order to have a more balanced evaluation of the risk of the banks' activities.