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Capital requirements under the credit risk-based framework $\stackrel{\star}{\sim}$

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ABSTRACT

This work aims to study the hypothesis of lower capitalization of banks under the risk-based rules introduced in Basel II. In this sense, an assessment of the impact of these rules on the capital requirements for non-financial firms' credit risk is performed. A comparison with Basel I is presented and intervals of variation for the risk drivers such that capital requirements exceed the ones under Basel I are established. Data for a European country supports the hypothesis of a smaller capitalization of banks under the risk-based framework, as far as credit risk in concerned.

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1. Introduction

One of the key lessons of the recent financial crisis was that the banking sector was too levered, not being able to absorb market and credit losses. This turned out to be very costly in terms of taxpayers' money and highly disruptive to the real economy reflected, for example, in output losses and steep rises in unemployment. The minimization of the probability of these market disruptions occurrence, and therefore financial stability enhancement, sets the ground for banks' capital requirements regulation. The possibility that problems in one institution may spread and disrupt the normal function of the entire system reinforces the role of capital regulation. This regulation works at least in two ways: it provides a loss absorbing cushion for unexpected events and, if properly designed, introduces incentives for banks to limit the risk of their activities. Although the importance of high capital requirements for financial stability, regulation on capital has an impact on the return on equity (capital is the most expensive source of banks' funding) which potentially influences the competitive stance in the financial sector. Against this background, global harmonization of prudential supervision enhancing financial stability and ensuring a level playing field among banks in different countries is crucial.

The 1988 Basel Accord (Basel Committee on Banking Supervision, 1988) was the beginning of the convergence of the rather different approaches that countries adopted. In June 2004 a revision of this framework, commonly denominated Basel II, was published by the Basel Committee on Banking Supervision (Basel Committee on Banking Supervision, 2006a). These new rules were then laid down in European Union legislation and subsequently transposed into national laws. In the aftermath of the recent turmoil there is commitment by the G-20 economies to implement these Basel II rules by end-2011. Recently, new capital and liquidity regulation aiming to strengthen the resilience of the banking sector is being proposed, with general implementation beginning in 2013.

Basel II was extremely innovative in what concerns capital requirements associated with credit risk. One of the innovations concerns the use of credit ratings (either internal or external) for the assessment of capital requirements, which become sensitive to the credit quality of each specific exposure, not relying solely on credit type. In this sense, capital requirements became dependent on the quality of credit, inferred from estimates of risk drivers such as the *probability of default* and the *loss given default* of each exposure. Additionally, for some exposures the volume of



^{*} The analyses, opinions and findings of these papers represent the views of the authors, they are not necessarily those of the Banco de Portugal or the Eurosystem.

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corporate sales and the maturity of credit is also relevant for evaluating capital requirements. The post-crisis reforms, widely referred to as Basel III, do not include any amendment in this respect. Another important innovation of the Basel II accord concerns capital requirements that banks are required to hold capital for operational risk, also being unaffected by the post-crisis reforms.

This relation between capital requirements and credit quality established under Basel II is believed to have an economic procyclical effect. The idea is that when the economy is on the down side of the cycle credit risk measures tend to increase, resulting in higher capital requirements, as discussed in Marcucci and Quagliariello (2009), Bonfim (2009), Benford and Nier (2007), Heid (2007) and Kashyap and Stein (2004), among many others. As it tends to be difficult to raise capital in downturns, banks may be forced to reduce their lending activities, thus exacerbating shocks in the real economy.¹ In fact, an assessment of the capital requirement for the European banking system is of extreme importance. as European firms rely heavily on bank financing. Actually, for the euro area countries corporate loans represented in December 2008 around 90% of total corporate debt, defined by the sum of bank loans granted to and bonds issued by the corporate sector. In the US, bank loans have a smaller role in firms' financing, representing about 60% of firms' debt liabilities.

In this study, an assessment is made of the impact of the rules introduced in Basel II, and still compelling in the post-crisis reforms, regarding capital requirements associated with credit risk of non-financial firms. Intervals of variation for the above mentioned risk drivers are established such that capital requirements for firms' credit risk under these rules (hereafter denoted Basel II rules) are smaller than capital requirements under Basel I. The hypothesis of capital requirements for credit risk being smaller under Basel II than under Basel I is tested using data from Portugal. Considering the default rate as a proxy for the probability of default and using estimates of the loss given default for the Portuguese banking system, capital requirements for credit risk of non-financial firms are in general smaller under Basel II than the ones that would be required under Basel I. This result is driven by the fact that the capital requirements for the largest firms and for the small and medium-sized enterprises classified as retail are significantly lower than the ones under Basel I. Respecting the former, the result relies on the low probability of default, while for the latter the result relies on the approach adopted in Basel II concerning the retail class. The small and medium-sized firms categorized as corporate, in particular the ones presenting the lowest level of sales, exhibit the largest capital requirements of the system. This result is mainly driven by the high probability of default associated with these exposures.

Notwithstanding our data captures the recent decline in the firms' financial standing, with associated consequences on Basel II capital requirements, the conclusions of this study are in line with other studies carried out in different countries. Altman and Sabato (2005), considering small and medium-sized firms in the United States, Italy and Australia, concluded that capital requirements for firms classified as retail would be lower than under Basel I, while for small and medium-sized firms classified as corporate would be slightly higher than under Basel I. Using information for Spanish firms along the period 1994–2001, Saurina and Truch-

arte (2004) conclude that capital requirements driven by firms' credit risk would be 7.27%, versus 8% under Basel I. Fabi et al. (2005) use data on Italian firms for 2002, and conclude that overall capital requirements for firms' credit risk would be equal to 5.8%. The results of the fifth quantitative impact study (Basel Committee on Banking Supervision, 2006b), undertaken between October and December 2005 by the Basel Committee on Banking Supervision on 31 countries, show that minimum required capital for credit risk under Basel II would decrease relative to the Basel I Accord. Although the portfolio of credits to firms implies a decrease in minimum required capital, the main driver of this result is the mortgage portfolio, which is not analysed here.

This study is restricted to the analysis of credit risk of nonfinancial firms and does not look at credit risk associated with other loans, at market risk and at operational risk. Nevertheless, our empirical analysis is crucial as loans to non-financial firms represent about 45% of total loans granted by the Portuguese financial system to non-financial firms and households and considers the risk component with higher relevance in capital requirements. Capital requirements are expected to decrease if credit risk associated with other loans is considered, as the majority of these other loans are mortgage loans which traditionally have lower values for the probability of default and the loss given default. On the other hand, capital requirements would be higher if operational risk is considered.

This work is organized as follows. In Section 2, a description of capital requirements for firms' credit risk within the framework introduced in Basel II is presented. Section 3 presents a comparison of the capital requirements for credit risk under this framework with the ones under Basel I. In Section 4, an evaluation of the capital requirements using Portuguese data is presented. A characterization of the loans to firms and their rates of default is also given. Finally, Section 5 presents the main conclusions.

2. Capital requirements within the Basel II risk-based framework

This section briefly discusses the risk-based framework of the regulatory capital for credit risk of non-financial firms introduced in Basel II, providing a general overview of the computation of capital requirements for credit risk.

The Basel II Accord retained key elements of the Basel I Accord, among them the basic structure of the 1996 Market Risk Amendment regarding the treatment of market risk (Basel Committee on Banking Supervision, 1996), the general requirement for banks to hold (regulatory) capital equivalent to at least 8% of their total risk-weighted assets and the capital definition. Under the postcrisis regulation there is no change in the value of the ratio (8%), although the definition of the regulatory capital has changed, aiming to increase the quality and international consistency of capital. The calculation of the risk-weighted assets is also kept unchanged in the post-crisis framework, after its redefinition in Basel II. In this sense, the total risk-weighted assets (RWA) are the sum of the riskweighted assets for credit risk and a 12.5 multiple of capital requirements for market risk (CR^{MR}) and operational risk (CR^{OR}). As far as credit risk is concerned, the risk-weighted assets are computed by applying a weight (k) to each exposure at default (EAD) and a 12.5 multiple. Hence, regulatory capital should satisfy,

Regulatory Capital	Regulatory Capital	< 0 07
Total Risk Weighted Assets	$\frac{12.5 * (k * EAD + CR^{MR} + CR^{OR})}{12.5 * (k * EAD + CR^{MR} + CR^{OR})}$	$\frac{1}{2} \geq 0/0.$

The weight k is the value of a function provided by the Committee (hereafter denoted risk weight function), where the inputs of this function are the risk drivers of each exposure. The weight dependence on the risk drivers is a major difference to the previous

¹ In order to account for the pro-cyclicality of the capital requirements, the postcrisis regulation proposes a countercyclical buffer above the regulatory minimum requirement, being only in effect in periods of excess credit growth. This buffer extends the capital conservation buffer, also proposed in the Basell III outline, which is intended to be used to absorb losses during periods of financial and economic stress. Banks are required to hold a capital conservation buffer of 2.5% in 2019, although a value of 0.625% is already required in 2016. Note that these buffers do not establish a minimum capital requirement as they only relate to dividend distributions, not constraining the operation of the bank.

regulation, as under Basel I exposures were characterized into only five different categories (in broad terms, these categories are sovereign, domestic public-sector entities, banks, mortgage lending and other loans to the private sector). Associated to each of these categories there was a different percentage of the EAD that added to the value of risk-weighted assets.

One of the motivations for the revision of the Basel I Accord was the insufficient risk sensitivity in the calculation of risk-weighted assets. In the post Basel I regulation there was a clear intention to gradually replace the one-size-fits-all framework. In this sense, according to the Basel II Accord banks may decide between two broad methodologies to compute the risk-weighted assets: the Standardized approach and the Internal Ratings-based (IRB) approach. These approaches differ in two main respects. The Standardized approach is based on external risk assessments produced by rating agencies while the IRB approach is based on banks' internal credit risk systems. Moreover, under the Standardized approach, risk weights are set by the Committee as a function of the external rating and take only discrete values (very similar to Basel I), while under the IRB approach risk weights are obtained by applying the risk weight function defined by the Committee, giving rise to a range of values for risk weights.

To implement the IRB approach, banks should categorize loans into broad classes of assets with different underlying risk characteristics, namely corporate, sovereign, banks and retail. Concerning credit to non-financial firms, the Accord distinguishes exposures to small and medium-sized firms (which are defined as firms with annual sales lower than 50 million euros) from exposures to larger firms. Exposures to small and medium-sized firms (SMEs) are categorized either in the retail class (if the size of the exposure is smaller than 1 million euros) or in the corporate class, while exposures to larger firms are always categorized in the corporate class. Nonetheless, it should be stressed that the regulatory treatment of SMEs classified as corporate departs from the one applied to larger firms, according to the level of sales.

As already mentioned, under the IRB methodology the riskweighted assets for credit risk result from internally estimated risk parameters and from the risk-weight functions supplied by the Committee in the Basel II Accord (Basel Committee on Banking Supervision, 2006a).² Regarding the risk weight function, the Accord presents two different versions: one for sovereign, corporate and bank exposures (on paragraphs 272 and 273) and another one for retail exposures (on paragraph 330). For sovereign, corporate and bank exposures, the risk weight associated with each exposure is a function of its probability of default (PD), its loss given default (LGD), its maturity (M) and, for corporate exposures, the value of annual sales of the borrowing firm (S). For firms with annual sales smaller (higher) than or equal to 5 (50) million euros, S is considered to be equal to 5 (50).³ The risk weights are positively related with PD, LGD and *M*. In fact, the risk weight function is a linear function of the LGD, everything else constant. The same applies for M. For retail exposures, the risk weight associated with a given exposure is a function of its PD and its LGD, not being dependent on the maturity of the credit as well as on the level of annual sales.

Regarding the estimation of the risk parameters, the Committee made two approaches available: the Foundation approach and the Advanced approach. Under the Foundation approach, banks are required to use their own estimate of the probability of default and rely on supervisory estimates for all other risk parameters. Under the Advanced approach, banks must use their own estimates for the PD, LGD, EAD and *M*. These two approaches apply to all credit classes with the exception of retail exposures. For retail exposures banks need to provide estimates of all risk parameters, implying that for this type of exposures only the IRB Advanced approach can be used.

Although the costs of developing and implementing the IRB approach can be substantial, banks may have an incentive to use this more sophisticated approach, as it should reflect more accurately the risk of the credit exposure. In fact, this approach may translate in a competitive advantage for banks whose credit portfolio presents better credit risk drivers (e.g., lower probability of default) as it would result in lower capital requirements. In addition, exposures of smaller size to smaller firms may also lead to smaller capital requirements, as the risk weight function is less demanding. This effect is expected to be more evident for smaller banks as their credit portfolio tends to be more concentrated in smaller exposures. Note that the asymmetry of the risk-weight functions presented in Basel II may lead to a biased behavior of banks to grant smaller credits, e.g. categorized as retail, in order to minimize capital requirements. This behavior may lead to a decrease in the financing cost of banks which can be passed through to the economy (via more competitive loan pricing on the retail class) or simply be added to the profit margin of the bank. This may also have implications for the financial stability of the banking system, as capital requirements may not reflect the credit risk of banks' portfolio.

3. A comparison between Basel I and Basel II capital requirements

This section presents a comparison of capital requirements concerning firms' credit risk under the risk-based framework introduced in Basel II with the ones of Basel I. The focus of this study is the risk weight function, since it provides the risk-weighted assets and therefore the required capital.⁴ In what follows we establish regions for the PD and LGD such that Basel II capital requirements for firms' credit risk are smaller than the ones established under Basel I. Moreover, we also proceed with a comparison of capital requirements if a given credit is considered retail or corporate, ceteris paribus. In the analysis presented in this section LGD lies between 45% and 75%. These limits, although somewhat arbitrary, correspond to the values of LGD established by the Committee under the Foundation approach for senior and for subordinated claims on firms, respectively. The use of these limits does not prove to restrict the analysis and were used only for presentation purposes, as the relevant risk-weight functions are smooth on the LGD.

Capital requirements under Basel II are higher (smaller) than capital requirements under Basel I for extremely high (small) values of the LGD and PD. For non-extreme values of LGD and PD, the comparison of capital requirements under Basel II and Basel I for the corporate class is highly dependent on the estimates of the relevant risk parameters. This effect is not so obvious for credit categorized as retail. In fact, for the set of values for the PD and the LGD presented in the literature (see, for instance, Grunert and

² Underlying these risk-weight functions there is a probability of bank insolvency, arising from credit losses, accepted by supervisors. The minimum capital requirement is set to ensure that unexpected losses exceed the level of capital with a probability of 0.1%, which is set as the probability of bank insolvency under Basel II. The expected part of credit losses should be covered by provisions.

³ This risk weight function is scaled by an ad hoc factor of 1.06 to offset significant decreases in capital requirements, as the Committee was concerned with significant changes in the aggregate level of regulatory capital in the banking system resulting from Basel II rules.

⁴ As our analysis is restricted to credit granted to non-financial firms, the comparison of capital requirements under Basel I and under Basel II rules collapses in comparing the value of the risk weight function (k) with 8%. Under Basel I, as the total amount of corporate credit used to add to the total RWA, the minimum capital held was given by RWA^I × 8% = EAD × 8%. Under Basel II rules, the RWA for credit risk are given by RWA^{II} = $k \times 12.5 \times EAD$, where k is supplied by the Committee. Therefore, under Basel II, minimum capital held for firms credit risk becomes RWA^{II} × 8% = $k \times 22.5 \times EAD \times 8\% = k \times 24.5$.

Weber, 2009; Tarashev and Zhu, 2007; Jacobson et al., 2005; Saurina and Trucharte, 2004; Dietsch and Petey, 2004), capital requirements for retail exposures are smaller under Basel II than under Basel I. The asymmetry of capital requirements for exposures to firms classified as retail or as corporate is illustrated in Fig. 1, as the set of parameters (PD and LGD) for the corporate sector such that capital requirements are higher under Basel II than under Basel I is larger than the set of parameters for the retail class.

For the corporate class it is also relevant to analyse the role of firm sales and maturity of exposures. The set of values for PD and LGD leading to higher capital requirements under Basel II becomes larger with firm sales and the maturity of the credit. An implication of this result is that for the same values of PD and LGD, if a firm with higher sales is considered banks may need to hold more capital than under Basel I. whereas if a firm with smaller sales is considered, capital requirement may be smaller than under Basel I. The interpretation of this result is that the existence of credit to firms with higher sales, which under Basel II could be seen as a proxy for firm size, may lead to an increase in risk of bank's credit portfolio, as banks are concentrating their loans in a smaller number of large firms and are not maximizing diversification gains. Concerning the maturity of the exposures, as credits with longer maturities tend to be riskier, the enlargement of this set is in line with the Basel II purposes that capital requirements should reflect risk.

These results are illustrated in Fig. 2. On the left-hand side we consider firms with annual sales smaller than or equal to 5 million euros, while on the right-hand side we consider firms with annual sales higher than or equal to 50 million euros. For the values of PD and LGD in the white area capital requirements under Basel II are higher than capital requirements under Basel I, for all the maturities being considered. For combinations of PD and LGD belonging to the dashed areas, capital requirements under Basel II are higher if the maturity of the credit is equal to 5 years and smaller if the maturity is 0.5 years. Hence, two credits with the same PD and LGD will have different capital requirements depending on their

maturity. If a maturity of 5 years is considered, the resulting capital requirement may be higher than 8%, while a maturity of 0.5 years could lead to capital requirements lower than 8%. Finally, the stripped area identifies the set of PD and LGD such that the capital requirements under Basel II are smaller than the ones under Basel I, regardless of the maturity of the credit as the Accord establish a maximum value for M of 5 years. The comparison of both charts in Fig. 2 allows us to conclude on the impact of firms sales on capital requirements: as the value of sales increases, the set of values of PD and LGD for which capital requirements under Basel II exceed the ones for Basel I becomes larger.

As stressed above, an exposure being classified as retail or corporate is crucial for the level of capital requirements, as different risk-weight functions are used. This is of extreme relevance for banks with high exposure to firms with annual sales smaller than ε 5 million and credit exposure of about ε 1 million, as these credits are on the edge of being classified as retail or corporate. Concerning this classification two features should be emphasized. The first feature concerns the non-negligible difference in capital requirements of whether one exposure is classified in the retail class or in the corporate class. The second feature concerns the different sensitivity of capital requirements to the PD that banks have to estimate in the IRB methodology.

Under Basel II capital requirements associated with credits in the corporate class are expected to be higher than the ones under Basel I. The opposite occurs for credits in the retail class, as previously emphasized. For corporate credit, the expected positive impact increases with the loss given default and the probability of default as well as the sales level of the firm and the maturity of the credit, while for the retail class the difference in capital requirements under the two frameworks is expected to decrease with the LGD and the PD. As an illustration, for values of the probability of default and loss given default commonly found in the literature (2% and 50%, respectively), maturity of 2.5 years and sales of 5 million euros, capital requirements can be either 5.2% if the exposure is retail or 8.3% if the exposure is corporate, as presented



Fig. 1. Comparing capital requirements under Basel I (K^{II}) and Basel II (K^{II}) for exposures to firms classified as retail and as corporate. For the corporate class, maturity is assumed to be 0.5 years and annual sales are assumed to be smaller than or equal to 5 million euros.



Fig. 2. Comparing capital requirements under Basel I (K^I) and Basel II (K^{II}) for the corporate class.



Fig. 3. Changing from retail to corporate class. On the left-hand side, an LGD of 50%, a PD of 2%, a maturity of 2.5 and annual sales smaller than or equal to 5 million euros are considered. On the right-hand side, for each of the identified level of sales, the area above the line represents the combinations of maturity and probability of default such that the capital requirements for the corporate class are higher than for retail. An LGD of 50% is considered.

on the left-hand side of Fig. 3. The set of risk parameters such that capital requirements for retail exceed the ones for corporate exposures is very narrow. In fact, for an LGD of 50% and any level of sales, this situation is only conceivable for maturities smaller than 6 months and probabilities of default smaller than 0.3%, as illustrated on the right-hand side of Fig. 2. This example illustrates the importance of the classification of exposures, as it has an impact on the capital ratio of the bank. In fact, as already mentioned, in order to minimize capital requirements banks may prefer to grant smaller credits, e.g. categorized as retail.

The second feature concerns the different sensitivity of capital requirements to the risk drivers estimated by banks, namely the LGD and the PD. For all credit classes, the risk weight function is multiplicative on the LGD, which contrasts with the different sensitivity observed with respect to the PD. In this case, the sensitivity is different across credit classes, although generally decreasing with the PD for all credit classes. The retail class is the one for which capital requirements exhibit the smallest sensitivity to a gi-

ven change in the probability of default. In fact, for a wide range of values for the probability of default, a change in one percentage point in the probability of default will result in a change smaller than 0.5% points in capital requirements. The corporate class exhibits a higher sensitivity of capital requirements to the PD, being dependent on the values of sales and maturity. As an example, for retail exposures an increase in the probability of default from 3% to 5% leads to an increase in capital requirements of 0.3%, for an LGD of 50%. If the corporate class is being considered, with a maturity of 2.5 years, this increase can go up to 3.1%. These results are illustrated in Fig. 4. The left-hand side of Fig. 4 presents capital requirements, while the different sensitivity, measured by the slope of the risk weight function, is plotted on the right-hand side, considering an LGD of 50%. The nature of the results does not change with the assumed value for the LGD, as capital requirements are multiplicative on the level of LGD.

This evidence emphasizes the importance of prudential supervision in validating bank internal systems for the estimation of the



Fig. 4. The sensitivity of capital requirements to the probability of default. It is assumed a maturity of 2.5 years and an LGD of 50%.



Fig. 5. Decomposition of the total loans to firms, as of December 2007. Unused credit lines are excluded in the decomposition presented on the right-hand side.

risk drivers – in line with the supervision procedures established under the Pilar II of Basel II – because, as stressed above, there may exist an important impact in capital requirements. Special attention should be devoted to the largest firms considered in the corporate class, as the risk weight function tends to be more sensitive to the PD and PDs are likely to lie in the region of values where the sensitivity of the risk weight function is higher.

4. Evidence on capital requirements

In this section, using data from Portuguese banks, we assess the implications on capital requirements, driven by firms' credit risk, of the implementation of the IRB methodology. Results are compared with the capital requirements under Basel I. It is also presented a characterization of the loans to non-financial firms and their respective rates of default.

4.1. Characterization of loans and rates of default

This subsection presents a characterization of loans in December 2007 and a description of default rates in 2008. The definition of default used in this work is in line with the one established in the Basel II Accord.

The following analysis relies mostly on the Central Credit Register, which brings together information provided by all credit institutions operating in Portugal, accounting for more than 200 institutions. The database collates monthly information on all loans granted to non-financial corporations, as well as credit lines, with an amount outstanding higher than 50 euros. Additional data relies on the Portuguese Central Balance-Sheet Database, providing the information on annual sales necessary to calibrate the risk weight function of the corporate exposures. Our final sample consists of 400,000 outstanding loans to non-financial firms by December 2007, corresponding to about 230,000 firms.

4.1.1. Loans to firms

In order to characterize loans to firms, we begin by decomposing them by maturity and by credit class, as defined in Basel II. In terms of maturity, the decomposition is performed in the following categories: short-term loans, medium and long-term loans, overdue loans, unused credit lines, and other loans. The majority of loans granted by Portuguese banks correspond to medium and long-term loans, as reported on the left-hand side of Fig. 5. As for credit classes, under the IRB approach for corporate credits, banks are allowed to distinguish exposures to small and medium size firms (SMEs) from those to large firms. Exposures to SMEs, defined here as firms with reported annual sales smaller than 50 million euros, are divided into three classes according to the amount of credit granted and annual sales. Hence, four credit classes are identified in the IRB approach:



Fig. 6. Default rates. The default rate corresponds to the number of exposures in a given economic sector exhibiting default in 2008 over the total number of exposures in that economic sector. Utilities include gas, electricity, water, post and telecommunications.

- 1. the *SME_retail* class, which includes credits smaller than one million euros to firms with annual sales smaller than 50 million euros;⁵
- 2. the *SME_1* class, which includes credits higher than one million euros to firms with annual sales smaller than 5 million euros;
- 3. the *SME_2* class, which includes credits higher than one million euros to firms with annual sales between 5 and 50 million euros;
- 4. and the *Corporate* class, which includes credits of any size to firms with annual sales higher than 50 million euros.

According to this decomposition most loans are granted to SMEs, where the retail is the most representative class (see the right-hand side of Fig. 5).⁶ Loans to firms with more than 50 million euros of annual sales account for 10% of total credit to firms.

4.1.2. The rate of default

In what follows we present a characterization of the observed rate of default of non-financial firms over the year 2008. The definition of default used is in line with the one in Basel II. In that context, for a financial group, an exposure is considered to be in default whenever the firm is overdue more than 500 euros over three consecutive months. For the assessment of the default rate over 2008 only exposures that did not exhibit default over 2007 are considered.

Although the industry is not a risk component as defined in Basel II, it is going to have a significant role in our risk assessment analysis. In fact, the concentration of the Portuguese banking system in a few economic activity sectors with associated different default profiles is a persistent fact which has been reported in the Banco de Portugal Financial Stability Report (e.g. Banco de Portugal (2008)) for the last few years. The highest rate of default is observed in exposures to firms in the construction sector, that together with real estate represent around 40% of credit granted to non-financial firms. The smallest rate of default occurs in exposures to firms in agriculture and fishing. This information is presented in Fig. 6 where the horizontal axis represents the median exposure of each industry. The area of each bubble is proportional to the number of exposures in each industry.

A possible relationship between the observed rate of default and the size of the firm is also explored, as the literature documents this relationship in other countries. Firm size is proxied by annual sales, in line with Basel II. In this sense, a characterization of the rate of default for different classes of firms' sales, as well as the exposure level, is presented in Table 1.⁷ The default rate corresponds to the number of exposures in a given class exhibiting default in 2008 over the number of exposures in the same class. Moreover, the number of exposures over the total number of exposures as well as the value of loans over total value of loans is also reported. For the Portuguese banking system, 3.6% of the exposures exhibited default in 2008. The amount in default accounts for 3.6% of total credit.⁸

From Table 1 it is observed that the rate of default decreases with the firms' sales. Hence, taking firms' sales as a proxy for the firms' size we can say that larger firms exhibit a lower rate of default on their loans. This is in line with Dietsch and Petey (2004) and Jacobson et al. (2005), among others, who have also reported similar evidence in different countries. The relationship between

⁵ There are other conditions that credits must follow to be considered as retail exposures. For instance, the retail portfolio must follow the so-called *granularity criterion*, i.e., it needs to be *sufficiently diversified to reduce risks*.

⁶ Only 78.5% of total loans are allocated by credit class, as there is no information available on annual sales for the remaining. Sales reported as null were not considered. Saurina and Trucharte (2004), where 8 years of data are considered, have an average exposure coverage of 73.9%.

⁷ The absence of information on the economic sector and sales for some exposures results in the exclusion of 12.3% of reported exposures, corresponding to 20% of loans. Notice that this number is lower than the one presented in Fig. 5, as only loans of firms that did not default during 2007 are considered.

⁸ The reduction in the sample size as there is no information on the economic sector and sales creates a bias, as observations not considered correspond to firms with higher default rate. If all the data was considered, 4.8% of the exposures reported in December 2007 would exhibit default in 2008, while the amount in default would be 4.1% of the total loans.

Table 1
The default rate of Portuguese firms in 2008 by firm's sales and exposure size.

		Exposure amount (in euros)					All exposures
		<10 ⁴	10 ⁴ -10 ⁵	$10^{5} - 10^{6}$	1-10 M	>10 M	
Sales amount (in euros)						
<5 M	Default rate	2.6	4.3	4.6	6.4	6.2	3.9
	Exposures	28.8	44.2	16.9	1.9	0.1	91.9
	Loans	0.4	6.2	18.6	17.6	10.9	53.8
5-50 M	Default rate	0.4	0.9	1.4	2.3	2.2	1.4
	Exposures	0.8	1.4	3.7	1.3	0.1	7.4
	Loans	0.0	0.2	5.9	12.7	14.1	33.0
>50 M	Default rate	0.0	0.6	0.7	0.8	0.9	0.6
	Exposures	0.1	0.1	0.2	0.3	0.1	0.8
	Loans	0.0	0.0	0.4	3.8	9.1	13.3
All firms							
,	Default rate	2.6	4.1	4.0	4.4	3.4	3.6
	Exposures	29.7	45.7	20.8	3.5	0.3	100.0
	Loans	0.4	6.4	25.0	34.1	34.1	100.0

The default rate corresponds to the number of exposures in a given class exhibiting default in 2008 over the total number of exposures belonging to the same class. Exposures (loans) correspond to the number of exposures (value of loans) in a given class as a percentage of the total number of exposures (value of loans). All values in percentage.

the observed rate of default and the size of the exposure, for the adopted classes of exposure, is non-monotonic. The highest default rate is observed for exposures between 1 and 10 million euros, while the smallest is observed for exposures smaller than ten thousand euros and higher than ten million euros. The exposures to firms with sales higher than 50 M present the smallest default rates, increasing with the exposure size. The relationship between the observed rate of default and the size of the exposure still holds if the exposures for which there is no information on the economic sector and sales are also considered. In addition, default rates would increase, confirming the bias of our sample towards better creditors and reinforcing the importance of conducting robustness tests with the entire dataset.

In Table 2, information on the rate of default, the number of the exposures as well as the size of the exposures is also reported as per the four classes of credit previously described. The adoption of this classification, in line with Basel II, results in an asymmetric distribution of loans with a clear concentration in the SME_retail class, as already shown in Fig. 5. In fact, the SME_retail class includes 95.8% of the number of credit exposures and accounts for 31.7% of total loans. The highest rate of default is observed for exposures classified as SME_1. Over and against this, the Corporate class presents the lowest default rate. This class, although originated by only 0.8% of the number of exposures, accounts for 13.3% of the total amount of loans, supporting the evidence of concentration of credit granted by the Portuguese banking system in larger firms.

4.2. Capital requirements for the Portuguese banking system

This subsection begins by presenting evidence of the implementation of the IRB methodology on capital requirements. Robustness

Table 2

The default rate of Portuguese firms in 2008 by credit class.

	SME_retail	SME_1	SME_2	Corporate
Exposure amount (\in M)	<1	>1	>1	>50
Sales amount (\in M)	<50	<5	5–50	
Default rate	3.6	6.5	2.3	0.6
Exposures	95.8	2.0	1.4	0.8
Loans	31.7	28.3	26.7	13.3

The default rate corresponds to the number of exposures in a given class exhibiting default in 2008 over the total number of exposures belonging to the same class. Exposures (loans) correspond to the number of exposures (value of loans) in a given class as a percentage of the total number of exposures (value of loans). All values in percentage.

tests on this analysis are performed. This is followed by a comparison between the results on capital requirements at December 2007 and similar estimates at December 2006.

4.2.1. Capital requirements

The assessment of capital requirements concerning firms' credit risk is carried out using the observed rate of default in 2008, described in the previous subsection, as a proxy for the probability of default. For each class of credit and for each economic sector a different probability of default is assigned, in line with the fact that in 2008 the rates of default exhibited heterogeneous behavior across these two dimensions.⁹

As described in Section 2 the computation of capital requirements under Basel II involves the knowledge of other risk components regarding each credit exposure, among them the maturity of the credit and the loss given default. In terms of credit maturity, a maturity of half a year for the short-term and a maturity of 2 years and a half for the long-term is used. At a later stage, simulations with different maturities are also performed.¹⁰ In reference to the loss given default, we first take as benchmark the values 45% and 75%, as discussed in Section 3. For the purpose of computing capital requirements, these values for the LGD are quite conservative as, in general, they are higher than the average values estimated for different countries.¹¹ The results of the fifth quantitative impact study (Basel Committee on Banking Supervision, 2006b) show that the average LGDs in the corporate portfolio is 39.8%, while for the SME corporate portfolio the average LGD for G10 large banks is 35.0%. More recently, Grunert and Weber (2009) found evidence of an LGD of 28% for a German bank. Using data over the period 1995-2000 from a Portuguese commercial bank, Dermine and Neto de Carvalho (2006) concluded the mean cumulative recovery rate to be 71%. Using the same data, Bastos (2010) presents mean recovery rates between 50% and 70%, depending on the recovery horizon. Additionally, using a more comprehensive data set, covering credit information reported by Portuguese financial institutions over the period between 1995 and 2001. Antunes (2005) concludes that a rough estimate of the LGD would be 46%.

The characterization of capital requirements is performed for the different credit classes, as defined in Basel II, as well as for different

 $^{^{9}\,}$ When the observed default rate is 0%, we assume the probability of default to be 0.03%, in line with Basel II.

¹⁰ The simulated values for the long-term maturity are restricted as Basel II defines the maximum considered maturity to be 5 years.

¹¹ The use of higher LGD values may be seen as downturn LGD.

levels of LGD and different maturities. This analysis emphasizes the heterogeneity across financial groups operating in Portugal. We compute capital requirements for each financial group as a weighted average of the capital requirement of each credit exposure, where the weights are the ratio of each EAD over the total EAD in the financial group. The EAD includes short-term, medium and long-term loans. The capital requirements associated with each exposure depend on the amount of the exposure, maturity, annual sales, and economic sector. The influence of the economic sector on capital requirements results from the fact that the PD, which is an input of the risk weight function, may be different across economic sectors.

Using empirical distributions obtained by recourse to a Gaussian kernel that weights financial groups by their total loans to firms, capital requirements for the banking system and for each of the four credit classes are presented in Fig. 7. The LGD assumption proves to be crucial to the determination of capital requirements. Results show that, for the majority of banks, capital requirements driven by firms' credit risk would be lower than the ones under Basel I if LGD equals 45%, while the opposite situation would be obtained for an LGD of 75%. If capital requirements are assessed by credit class, the Corporate and the SME_retail classes are those that have smaller capital requirements, under the assumption of a common LGD across classes. In the case of the SME_retail class, although it presents a high probability of default, the functional form of the risk weight function induces this result. In the Corporate case, although the functional form of the risk weight function would lead to the highest capital requirements among different classes (everything else the same), its lowest probability of default induces the result. Regarding exposures to SMEs, it should be stressed that capital requirements for exposures higher than 1 M euros and sales smaller than 5 M are above those obtained considering all credits at the bank level, although capital



Fig. 7. Capital requirements of Portuguese banks, by credit class. The empirical distribution is obtained by recourse to a Gaussian kernel that weights institutions by loans to firms. The maturity of short-term loans was assumed to be 0.5 years while the maturity of long-term loans was assumed to be 2.5 years.

requirements for the SME_retail class are below. Capital requirements of the SME_2 class are below the ones for the SME_1 because the probability of default is much lower, although the risk weight function is more demanding. In a comparison of the SME_1 class with the SME_retail class, capital requirements are smaller for the SME_retail because the risk weight function is less demanding and the probability of default is lower. This corroborates the results presented in Section 3 concerning the importance of an exposure classification. In short, if the probabilities of default were the same for all classes, capital requirements for firms classified as Corporate would be higher than those for the SME_2, which in turn would be higher than those for SME_1. The SME_retail class would result in the lowest capital requirements. However, as presented in Fig. 7, due to the heterogeneous probabilities of default this is not observed. In particular, the probability of default of the Corporate class is so much smaller than the retail one that capital requirements turn out to be similar. Results also suggest that capital requirements associated with the retail class tend to exhibit smaller heterogeneity across banks than capital requirements for the remaining classes. For all credit classes, heterogeneity of capital requirements across banks increases with the LGD.

4.2.2. Robustness analysis

In order the test the robustness of the previous result we assess the implications of the postulated assumptions on the exposures' maturity, the exclusion of the exposures for which there is no available information on annual sales and the use of different probabilities of default. Information on the Portuguese banking system, where each financial group is weighted by its total amount of loans to non-financial firms, is also provided.

Under different assumptions on the maturity of loans, the result that for most institutions capital requirements for firms' credit risk is lower than 8% if an LGD of 45% is considered is still valid (Fig. 8). If an LGD of 75% is considered, capital requirements under Basel II are higher than 8%, as before. It is also observed that the heterogeneity across banks increases with the average maturity of exposures.

Given the estimates of LGD in previous studies for Portugal, our results suggest that capital requirements for the Portuguese banking system would be lower than 8%, if only firms' credit risk is considered. In fact, if the short-term maturity is assumed to be 0.5 years and the long-term maturity is assumed to be 2.5 years, results show that capital requirements driven by firms' credit risk for the banking system are lower than the ones under Basel I as long as the LGD is lower than 52%. The assumption of higher values for the maturity (which are close to the highest values accepted in Basel II for the purpose of capital requirements evaluation), do not lead to a different conclusion as long as the LGD is lower than 47%, which is consistent with the values for the LGD presented in previous studies on Portuguese banks.

The second robustness check concerns the bias of the sample towards better creditors, which is a drawback of the previous analysis. In this context, the exposures with no information available were divided into two groups, as a function of exposure size. The exposures smaller than 1 million euros were classified as SME_retail¹² (around 3% of total loans), while all the others were classified as Corporate (around 17% of total loans), the most conservative scenario for exposures higher than 1 M euros. The probability of default assigned to exposures in these groups was the amount in default as a

¹² This classification is not the most conservative one as exposures lower than 1M euros may belong to the Corporate class. This situation was discarded because for the sample with information available on sales, only 1.3% of the loans lower than 1M euros were classified as Corporate. Hence, given the impossibility of distinguishing the exposures smaller than 1M euros between SME_retail and Corporate, the classification of the whole group as Corporate would lead to a less precise evaluation of capital requirements.



Fig. 8. Capital requirements of Portuguese banks, for different values of M and LGD. The empirical distribution is obtained by recourse to a Gaussian kernel that weights institutions by loans to firms.



Fig. 9. Robustness analysis of capital requirements of the banking system. The empirical distribution is obtained by recourse to a Gaussian kernel that weights institutions by loans to firms. The maturity of short-term loans was assumed to be 0.5 years while the maturity of long-term loans was assumed to be 2.5 years. An LGD of 45% is considered.

percentage of credit in December 2008. For exposures smaller than 1 M euros, the observed rate of default was 13.2%, while exposures higher than 1 M euros exhibited a default rate of 5.2%. Both values are clearly above the ones observed for exposures initially classified in these two credit classes. In this conservative scenario, we observe an increase in capital requirements as well as an increase in the heterogeneity across banks (Fig. 9). For the benchmark LGD of 45%, there is a non-negligible number of banks exhibiting capital requirements higher than 8%. In fact, for firms' credit risk, capital requirements of the banking system remain below those under Basel I only if the recovery rate is assumed to be around or higher than 54%.

The third robustness check concerns the use of different probabilities of default, namely the consideration of a single probability of default per different homogeneous groups of exposures and a single probability of default for all exposures. The reason underlying this robustness test is the potential error of grouping heterogeneous exposures and assigning them the same probability of default, as the risk-weight functions are non-linear on the probability of default (see Fig. 4).¹³ In this context, the following homogeneous groups were considered: (i) per economic sector and exposure size; (ii) per sales level and exposure size and (iii) per credit classes. The exposure size classes, as well as the level of sales classes, are as defined in Table 2. For these alternatives, we observe an increase in the level of capital requirements for the majority of banks, leading to an increase of around 0.6 pp for the banking system if an LGD of 45% is considered. Fig. 9 illustrates the case where the PD is the same per credit class. We also assessed the impact on capital requirements of using a unique rate of default for the whole economy of 3.6% (as pointed in Section 4.1). In this case, capital requirements for firms' credit risk will exhibit an increase of 1.0 pp, for an LGD of 45%. Concerning the banking system, a recovery rate higher than 54% assures that capital requirements are smaller than 8%. These results show the dependence of capital requirements on the aggregation of exposures into homogeneous groups in terms of PD, stressing the importance of the portfolio of loans to non-financial firms stratification.

4.2.3. Time-consistency of capital requirements

Using the same approach, capital requirements driven by firms' credit risk for the Portuguese banking system were also computed for December 2006, in which case the observed rate of default in 2007 was used as a proxy for the probability of default. The comparison of capital requirements for two consecutive years allows a decomposition of its change into two important components,

¹³ Capital requirements is a weighted average of the capital requirements associated with each exposure, each of them being dependent on its own PD. Assigning an average PD would result in different capital requirements, as the function is nonlinear on the PD. Moreover, considering different groups of exposures will lead to different results.

namely, changes in the composition of credit portfolio and changes in the probability of default. In our data, it is observed a relevant increase in default rates, especially in the exposures classified as SME_1, resulting in an increase of 0.26 pp in capital requirements, for an LGD of 50%. This increase can go up to 0.4 pp if an LGD of 75% is considered.¹⁴ Most of this increase in capital requirements (around 85%) is due to an increase in the probability of default. The remaining effect can be justified by changes in the portfolio structure.

5. Conclusions

The Basel II Accord introduces capital adequacy rules that seek an improved alignment between regulatory capital and economic risk, as compared with the Basel I Accord. One of the most important changes is the assessment of capital requirements for credit risk-based on internal risk ratings, allowing banks to develop internal methodologies to quantify the creditworthiness of their clients. These methodologies will allow for the computation of two of the most important risk components needed for the computation of risk-weighted assets: the probability of default and the loss given default. Then, for each credit portfolio, and using some additional information, a risk weight function provided by the Basel Committee translates these risk components into capital requirements.

This work aims at studying the impact of the adoption of riskbased measures for the assessment of capital requirements for firms' credit risk as introduced in Basel II. It starts by establishing regions of values for the probability of default and the loss given default for which Basel II rules would be more demanding in terms of capital requirements for firms' credit risk than Basel I. We conclude that capital requirements for exposures classified as corporate being higher or lower than the ones under Basel I is dependent on the values assumed for the PD and the LGD. On the other side, credit to firms classified as retail, and for commonly accepted values for PD and LGD, has associated capital requirements that are below those under Basel I. In this sense, our analysis stresses the incentives that bank may have to grant credit classified as retail, discarding other business opportunities, because capital requirements associated with the retail class are smaller, for the same values of the risk drivers.

Using the observed rate of default in 2008 as a proxy for the probability of default in 2007, assessed by economic sector and class of credit as defined in Basel II, we showed that capital requirements for the Portuguese banking system associated with loans to non-financial firms are lower than the ones under Basel I, for recovery rates commonly referred to in the literature. Among the SMEs, the SME_retail class is the one that exhibits the lowest capital requirement, despite having a high rate of default. The Corporate class displays very similar capital requirements to the retail class, which can be justified by the fact that it exhibits the smallest rate of default, although it presents the more demanding risk weight function. The highest capital requirements are associated with exposures higher than 1 M euros to firms with sales smaller than 5 M, being above 8% for all values of LGD used.

As there is no precise information available for the maturity of exposures, different assumptions were made. Under extreme assumptions for maturity, assuming a recovery rate of 53% leads to capital requirements for firms' credit risk lower than those under Basel I. In addition, given the non-existence of information on annual sales for all exposures, a robustness check on the inclusion of these observations was carried out. Finally, using a different segmentation for the estimation of the probability of default, we observe an increase in capital requirements. Under these different scenarios, a recovery rate of 54% or more assures that capital requirements are still lower than under Basel I.

It should be stressed that our analysis only considers the credit risk of non-financial firms, leaving aside the remaining loan portfolio, among which are mortgage loans. Market and operational risk are not assessed at all in this study. The treatment of mortgage loans is of extreme importance for the assessment of capital requirements in the Portuguese banking system, as mortgage loans represent around half of the total credit granted by banks. We believe that the inclusion of mortgage loans would result in lower capital requirements, given that these credits have collateral (resulting in lower LGD) and are classified as retail. On the other hand, the capital charge for operational risk would add up a nonnegligible amount to capital requirements presented in this work.

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¹⁴ This increase is underestimated as the proportion of firms with no available information on annual sales (which are the firms with the highest probability of default) is higher in 2007 than in 2006.