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CREDIT RISK AND CAPITAL REQUIREMENTS FOR THE PORTUGUESE BANKING SYSTEM

Paula Antão
Ana Lacerda

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Please address correspondence to
Paula Antão
Economics and Research Department
Banco de Portugal, Av. Almirante Reis no. 71, 1150-012 Lisboa, Portugal;
Tel.: 351 21 313 0418, pantao@bportugal.pt

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Credit Risk and Capital Requirements for the Portuguese Banking System[1]

Paula Antão

Ana Lacerda

Abstract: In this study, an assessment of the impact of Basel II capital requirement rules driven by credit risk of non-financial firms is performed. Intervals of variation for the risk drivers are established such that capital requirements for firms' credit risk under Basel II exceed capital requirements under Basel I. Moreover, a characterization of the Portuguese Banking system, which includes a description of corporate credit and its associated probabilities of default, and the computation of capital requirements are performed.

Keywords: Basel II, Capital requirements, Credit Risk, Banking regulation and Banking system

JEL Classification: G21, G28

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1. Introduction

Capital requirements for banks are of foremost importance for financial stability in the sense that they are intended to minimise the probability of bank failure at reasonable cost. In fact, past episodes of widespread bank insolvency 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 role of capital requirements 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. Actually, given that capital, and in particular equity, is the most expensive source of banks' funding, capital requirements have an impact on the return on equity while potentially influencing the competitive stance in the financial sector. Against this background and given growing international capital mobility, global harmonization of prudential supervision, 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 (2006b)). These new rules were then laid down in EU legislation and subsequently transposed into Portuguese national law, coming into force in 2007.[2]

Basel II is based on three mutually reinforcing pillars. Pillar I presents capital requirements for credit, market and operational risk, introducing the main innovations of this revision. 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.* Additionally, the volume of corporate sales and the maturity of credit may also be relevant for evaluating capital requirements. Another important innovation is that banks are required to hold capital for operational risk. Pillar II concerns the supervision of banks. Banking supervisors are given more authority to evaluate the consistency and

[2] Given that the adoption of the new framework was optional in 2007, it was implemented by the majority of the Portuguese banks only in 2008.

robustness of banks' internal risk assessment methodologies. Finally, Pillar III introduces rules on the information banks are required to publish. This pillar is also called the market discipline pillar.

The relation between capital requirements and credit quality established under Basel II is believed to have an economic pro-cyclical effect.[3] 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 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. There may also be other negative shocks reflected in their capital base. In this context, an assessment of the capital requirement for the European banking system is of extreme importance, as European firms rely heavily on bank financing. This is the case of Portugal as, in December 2007, corporate loans represented more than 80% of total corporate debt, defined by the sum of bank loans granted to and bonds issued by the corporate sector. The importance of banks as a source of financing is even higher if commercial paper in banks' portfolios is also taken into account alongside loans granted, as the sum of these two financial instruments held by banks represents more than 85% of total corporate debt.

In this study, an assessment is made of the impact of Basel II rules regarding capital requirements by 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 Basel II exceed capital requirements under Basel I. Moreover, for the Portuguese banking system in 2007 we conclude that, if the observed default rate is used as a proxy for the probability of default, under Basel II capital requirements for exposures larger than one million euros to small and medium sized firms are generally higher than the ones assessed under Basel I. Capital requirements for exposures to large firms are similar to those for exposures smaller than one million euros to small and medium sized firms, being these classes the ones that exhibit the smallest capital requirements. For the Portuguese banking system, capital requirements being higher or lower than what is stipulated under Basel I is highly dependent on the assumed loss given default. In particular, using estimates of the loss given default in previous studies of Portuguese banks (always smaller than 52%) capital requirements for credit risk of non-financial firms are in general less than what is required under Basel I. Nevertheless,

[3] Benford and Nier (2007), Heid (2007) and Kashyap and Stein (2004), among many others, discuss the cyclicality impacts of Basel II using quite different approaches.

results should be interpreted with caution because the sample used is biased towards borrowers with better credit risk assessment, due to the lack of information on a subset of borrowers with higher than average credit risk.

This study is restricted to the analysis of credit risk of non-financial firms, and does not look at credit risk associated with other loans, at market risk and at operational risk. 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. However, capital requirements would be higher if operational risk is considered as, according to the Banco de Portugal (2008), in June 2008, the capital charge for operational risk accounted for 7% of overall capital requirements. Nevertheless, the overall analysis is representative as loans to non-financial firms represent about 45% of total loans granted by the Portuguese financial system to the non-financial private sector (non-financial firms and households) and considers the risk component with higher relevance in capital requirements.

The conclusions of this study are in line with studies carried out in other countries, despite the fact that our data captures the recent decline in the firms' financial standing. Using information for Spanish firms along the period 1994-2001, Saurina and Trucharte (2004) conclude that capital requirements driven by firms' credit risk would be 7.27%, versus 8% under Basel I. Fabi, Laviola, and Reedtz (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 (2006a)), undertaken between October and December 2005 by the Basel Committee on Banking Supervision on 31 countries,[4] 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 work is organized as follows. In section 2, a description of capital requirements for corporate sector credit risk is presented and compared with the situation under Basel I. In section 3, using data from the Portuguese banking system, a characterization of the

[4] The Fifth Quantitative Impact Study was performed on G10 countries, except the US, and other non-G10 countries including Portugal.

loans to firms and their rates of default is presented. In section 4, an evaluation of capital requirements for the Portuguese banking system is given. Finally, section 5 presents the main conclusions.

2. Capital Requirements for Credit Risk

This section discusses the Basel II framework in respect to capital requirements for credit risk in non-financial firms. It starts by briefly recalling the fundamentals of the Basel II Accord and provides a general overview of the computation of capital requirements for credit risk. The second part of this section presents a comparison of capital requirements under Basel I and Basel II for firms' credit risk as a function of the risk components underlying the Basel II setting.

2.1. Overview of capital requirements within the Basel II framework

The final version of the Basel II Accord, dated June 2004, is the result of a long process characterized by an intense dialogue between the Basel Committee on Banking Supervision, called here the Committee, the banking industry and national regulators. The Committee released several proposals for consultation and also conducted several quantitative impact studies on its proposals, aimed at measuring the impact of the new rules. The final version of the text came out of this dialogue with considerable improvements.

The development process of this new framework started in 1996 as capital requirements for market risk were first introduced in the Basel I Accord (Basel Committee on Banking Supervision (1996)). In its initial stage, three complementary pillars were established. The first one, on minimum capital requirements, aims to establish a better correspondence between regulatory capital and economic risk of exposures. It also introduces the need of minimum capital requirements for operational risk. The second pillar, on the supervisory review process, intends to ensure that banks have adequate capital to support the risk in their business, giving supervisors the role of evaluating if banks are assessing well their capital needs. The third pillar, on market discipline, develops a set of disclosure requirements which will allow market participants to assess the capital adequacy of institutions. In later stages, the Committee announced a formula for calculating capital charges, as a function of credit risk measures. The

initially single formula proposed by the Committee introduced more risk sensitiveness to the computation of risk weighted assets, but it was found to be suboptimal. In the final version of the Basel II capital rules, the main risk function is adjusted to each portfolio of exposures resulting in a different treatment in terms of capital requirements, across segments of credit. Finally, with respect to the treatment of credit losses, initial proposals called for banks to hold enough capital to absorb expected and unexpected credit losses. However, the final version of the Accord adopts an approach based solely on unexpected losses, while banks are expected to provision expected losses.

The Basel II Accord retains 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 definition of eligible capital and the general requirement for banks to hold total capital equivalent to at least 8% of their total risk-weighted assets. Hence, under Basel II, as under Basel I, the eligible capital needs to be equal to or more than 8% of the risk-weighted assets, *i.e.*, it follows the rule

$$\frac{\text{Eligible Capital}}{\text{Total Risk Weighted Assets}} \geq 8\% \, .$$

While the definition of eligible capital was almost kept unchanged from Basel I to Basel II, the calculation of the total risk-weighted assets has been significantly changed. The total risk-weighted assets are the sum of the risk-weighted assets for credit risk and a 12.5 multiple of capital requirements for market risk and operational risk.[5] As far as credit risk is concerned, the risk-weighted assets are computed by applying a weight to each exposure. This weight 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 regulation, as under Basel I, the weights to be applied were set for very broad categories of credit risk. The weights used were 0, 10, 20, 50 and 100%. As an illustration, corporate credit used to be weighted at 100% for all exposures, a situation that was widely recognized as not reflecting the heterogeneity of risks within the portfolio of corporate credit.

[5] In this sense capital requirements are the sum of three components: 8% of the risk-weighted assets for credit risk, capital requirements for market risk and capital requirements for operational risk.

One of the motivations for the revision of the Basel I Accord was the insufficient risk sensitivity in the calculation of risk-weighted assets. Since the first proposals, there was a clear intention to replace the "one-size-fits-all" framework of the Basel I Accord with a variety of options. Hence, according to the final version of 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.[6] These approaches differ in two main respects. First, 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. Second, 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). Under the Internal Ratings-based approach, risk weights are obtained by applying the risk weight function defined by the Committee that gives rise to a range of values for risk weights. Although banks may decide on which methodology to use, they may have an incentive to use the more sophisticated ones, as they should reflect more accurately the risk of the credit exposure. Once a bank adopts the IRB approach for part of its credits[7], as it is acceptable that it may not be practicable to implement it all at once, it is expected that this approach would be gradually implemented across all other credits. Moreover, once a more advanced approach is adopted, a voluntary return to less sophisticated approaches must be approved by the supervisor.

To implement the IRB approach, banks should categorize credits into broad classes of assets with different underlying risk characteristics. The classes of assets are corporate, sovereign, banks, retail and equity. Although there is a class denoted corporate, some exposures to firms are not classified here. In its final version, the Accord distinguishes between exposures to small and medium sized firms (which are defined as firms with annual sales lower than 50 million euros) and 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 their level of sales.

[6] The IRB methodology has to be validated by the national supervision authority.
[7] The first authorization for the use of the IRB approach requires that more than 50% of the credits are considered and among the classes considered almost all the credit must be included.

For each class of assets, the risk-weighted assets for credit risk result from the internally estimated risk parameters and the risk weight functions[8] supplied by the Committee. Regarding the risk weight function, the Accord provides two different versions: one for sovereign, corporate and bank exposures and another one for retail exposures. For the first, this function is

$$K = \left\{ LGD \times N\left[\left(\frac{1}{1-R} \right)^{0.5} NI(PD) + \left(\frac{R}{1-R} \right)^{0.5} NI(0.999) \right] - LGD \times PD \right\} \left\{ \frac{1+(M-2.5)\times b(PD)}{1-1.5b(PD)} \right\} \times 1.06 \quad (1)$$

where R is defined as follows

$$R = 0.12\frac{1-e^{-50\,PD}}{1-e^{-50}} + 0.24\left[1-\frac{1-e^{-50\,PD}}{1-e^{-50}}\right] - 0.04\left[1-\frac{S-5}{45}\right],$$

S is a function of annual sales of the firm concerned (expressed in millions of euros), M is the maturity of the exposure (expressed in years), b is defined as $b(PD) = \left[0.11852 - 0.05478\ln(PD)\right]^2$, N denotes the standard normal cumulative distribution, NI denotes the inverse of the standard normal cumulative distribution, PD is the probability of default and LGD is the loss given default. The function S equals annual sales in millions of euros if annual sales are between 5 and 50 million euros, it equals 5 if annual sales are smaller than or equal to 5 million euros and it equals 50 if annual sales are higher than or equal to 50 million euros. The sales adjustment (corresponding to the third term on the R definition) applies only to corporate exposures.

Capital requirements are positively related with PD, LGD, M and R. The positive relationship of capital requirements on M is dependent on the loss given default and on the level of sales. In fact, a change in the maturity of the credit has a higher impact on capital requirements for higher values of S and LGD. Notice that R is the correlation coefficient representing the degree of co movement in credit risk of all exposures in the portfolio. This coefficient is derived from the asymptotic risk factor model underlying

[8] The source of these functions is the conditional VAR. The IRB approach of Basel II to determining how much capital a bank should hold focuses on the probability of bank insolvencies arising from credit losses that supervisors are willing to accept. In their lending activity, banks know that there are always some borrowers that default on their credits. The expected part of credit losses should be covered by provisions, while the unexpected losses should be covered by capital. For this reason, the minimum capital requirement is set to ensure that unexpected losses exceeds the level of capital with a probability of 0.1%, which is set as the probability of bank insolvency under Basel II.

capital requirements under Basel II. Finally, the factor 1.06 is an ad-hoc adjustment introduced in 2004 by the Basel Committee. The Committee had a goal with the adoption of the Basel II capital rules of neither significantly decreasing nor increasing the aggregate level of regulatory capital in the banking system. However, the minimum required capital resulting from the changes occurred between the third consultative paper (mid-2003) and the final text of the Accord decreased. Subsequently, the Committee decided to introduce a scaling factor of 1.06 to offset the mentioned decrease in capital requirements[9].

Capital requirements for retail exposures are

$$K = \left\{ LGD \times N\left[\left(\frac{1}{1-R} \right)^{0.5} NI(PD) + \left(\frac{R}{1-R} \right)^{0.5} NI(0.999) \right] - LGD \times PD \right\} \qquad (2)$$

where

$$R = 0.03\frac{1-e^{-35PD}}{1-e^{-35}} + 0.16\left[1 - \frac{1-e^{-35PD}}{1-e^{-35}} \right].$$

Although our study concerns firms, this risk function is relevant as exposures lower than one million euros to SMEs will be classified as retail. In this case capital requirements are not dependent on the maturity of the credit as well as on the level of annual sales. The correlation (R), which is not dependent on the level of annual sales, proves to be smaller than the one for corporate exposures. The rationale behind this differentiated treatment to small business is that the default risk of smaller firms is assumed to be mostly idiosyncratic, implying a smaller correlation when compared to larger firms. Additionally, for the same increase in the level of PD the correlation exhibits a smaller decrease than in the case of the corporate exposure.

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, the loss given default, the exposure at default (EAD) and the effective maturity. These two approaches apply to

[9] Later, in May 2006, the committee decided to keep the 1.06 scaling factor unchanged, although the results from the fourth and fifth quantitative impact studies would suggest an update of this figure.

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.

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

The focus of this study is the risk weight function, since it provides the risk-weighted assets and therefore the capital requirements.[10] In what follows we will establish regions for the PD and LGD such that Basel II capital requirements for firms' credit risk are higher 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 order to establish regions for LGD, we consider it to take values in the region between 45% and 75%. These limits, although somewhat arbitrary, were benchmarks established by the Committee under the Foundation approach, given that for senior claims on corporates, not secured by recognised collateral, an LGD level of 45% was assigned, while for subordinated claims on corporates a level of 75% for the LGD was assigned.[11]

In Figure 1 we establish regions for the parameters PD and LGD such that Basel I is more demanding than Basel II, and vice versa. We consider capital requirements for exposures to firms classified under the retail class, hereafter denoted retail for simplification, and for exposures to firms classified as corporate. For the corporate class a maturity of 0.5 and a level of annual sales smaller than or equal to 5 million euros were considered. In general, for very high (small) values of the LGD and PD capital requirements under Basel II are higher (smaller) than capital requirements under Basel I. For the values of PD and LGD in the grey area capital requirements under Basel II are higher than capital requirements under Basel I, for both classes of credit. The dashed area identifies the values of PD and LGD such that Basel II results in higher capital requirements for the corporate class but not for the retail class. Finally, the

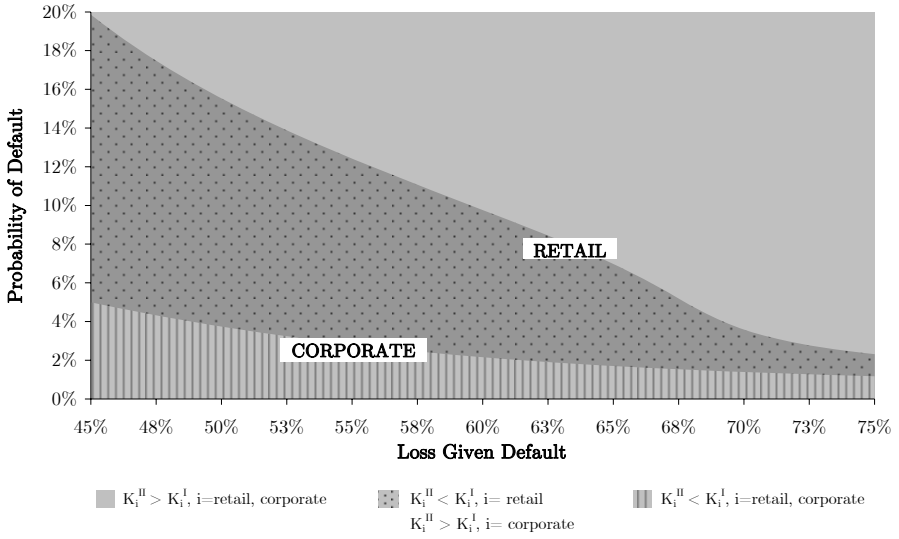
[10] The comparison of capital requirements under Basel I and Basel II collapses in comparing K (as defined in equations (1) and (2)) with 8%. Under Basel I, as the corporate credit used to be weighted at 100% the minimum capital held is $RWA^{I} \times 8\% = EAD \times 8\%$. Under Basel II, the risk weighted-assets for credit risk are given by $RWA = K \times 12.5 \times EAD$, where K is supplied by the Committee. Therefore, under Basel II, minimum capital held for firms credit risk becomes $RWA^{II} \times 8\% = K \times 12.5 \times EAD \times 8\% = K \times EAD$.

[11] These levels of LGD can be adjusted on the presence of eligible collateral.

striped area identifies the set of PD and LGD values such that capital requirements under Basel II are smaller, for both types of classes. In conclusion it should be stressed that although a 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, the same does not hold if credit is categorized as retail. In fact, for values of PD and LGD presented in the literature[12] banks set capital requirements smaller than the ones under Basel I.

Figure 1

Comparing capital requirements under Basel I (K^I) and Basel II (K^{II}) for exposures to firms classified as retail and as corporate



Notes: The corporate class is assumed to have a maturity of 0.5 years and annual sales smaller then or equal to 5 million euros.

A complementary analysis is presented in Figure 2 where we establish regions for the parameters PD and LGD such that Basel I is more demanding than Basel II, and vice versa, for the corporate class as a function of firm sales and the maturity of exposures. 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. The set of values for PD and LGD leading to higher minimum capital requirements under Basel II becomes larger with the maturity of the credit. 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.

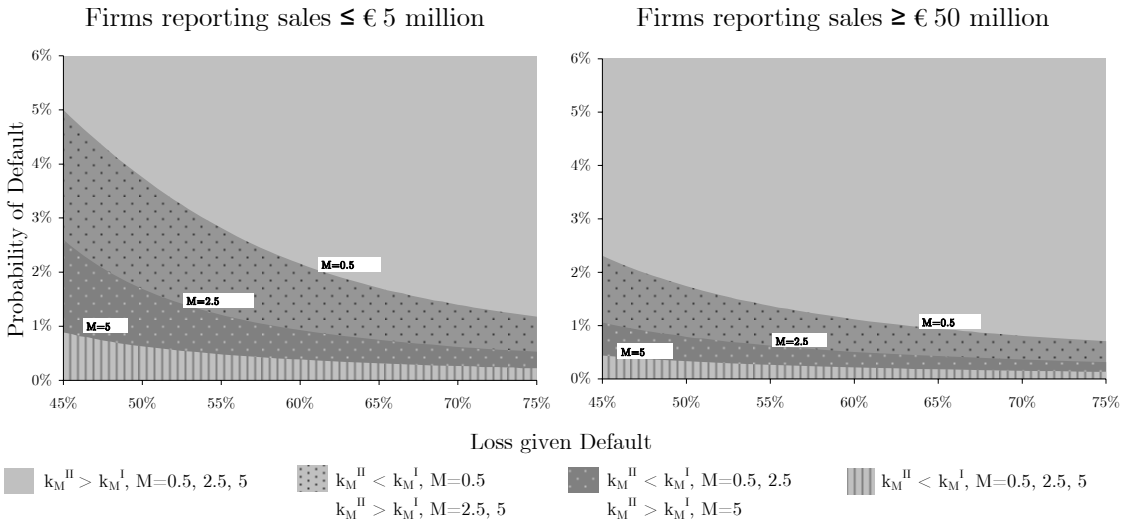
[12] See, for instance, Tarashev and Zhu (2007), Fernandes (2006), Antunes (2005), Jacobson, Lindé and Roszbach (2005), Saurina and Trucharte (2004), Dietsch and Petey (2004).

For the values of PD and LGD in the grey area the minimum capital requirements under Basel II are higher than the minimum capital requirements under Basel I, for all the maturities being considered. For combinations of PD and LGD belonging to the dashed areas, the minimum 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 minimum capital requirements depending on their maturity. In this specific case, if a credit with a maturity of 5 years is considered, the resulting minimum capital requirement will be higher than 8%, while if a credit with a maturity of 0.5 years is considered, the resulting minimum capital requirement will be lower than 8%. Finally, the stripped area identify the set of PD and LGD such that the minimum capital requirements under Basel II are smaller, for maturities of 5 years.

Comparing both charts in Figure 2, we may conclude that as the value of sales increases, the set of values of PD and LGD for which the minimum capital requirements under Basel II exceed the ones for Basel I also increases. 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, the minimum capital requirement would 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 not maximizing diversification gains.

Figure 2

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

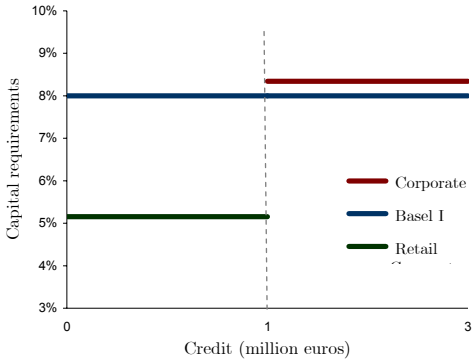


As stressed above, the classification of exposures as retail or corporate is crucial for the level of capital requirements. Moreover, two additional features concerning this classification should be emphasized. This is of extreme importance for firms with annual sales smaller than €5 million and credit exposure of about €1 million, as they are on the edge of being classified as retail or corporate.The first feature concerns the discontinuity in capital requirements when one exposure changes from the retail class to the corporate class, or vice-versa, as different risk functions are used. The second feature concerns the different sensitivity of capital requirements to the probability of default.

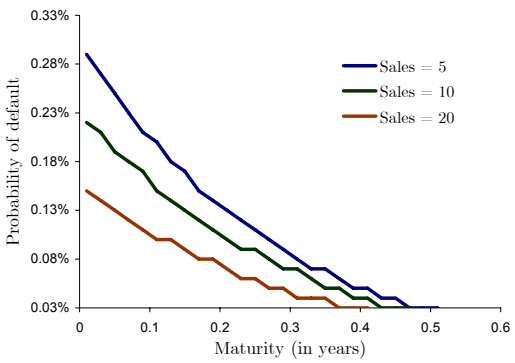
The above mentioned discontinuity in the minimum capital requirements, when credit moves from the retail portfolio to the corporate class, results from the characteristics of the different risk functions established in the Accord. This non negligible discontinuity in the capital requirement is generally positive and increases with the loss given default as well as the sales level of the firm and the maturity of the credit. For values of the parameters reported in the literature (loss given default of 50% and probability of default of 2%), maturity of 2.5 years and sales of €5 million, capital requirements can be either 5.2% or 8.3% depending on the exposure being classified as retail or corporate, as illustrated on the left hand side of Figure 3.

Figure 3
Changing from retail to corporate class

Jump in capital requirements



Indifference lines of capital requirements



Notes: On the left panel, 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 panel, an LGD of 50% is considered.

This example illustrates the importance of an adequate classification of exposures, as pricing decisions should be closely related to capital requirements. For instance, for the same level of sales and maturity of the exposure, a credit below the one-million euro threshold has a lower capital requirement, which can be passed through to costumers via more competitive loan pricing or simply by adding to the profit margin of the bank. As such, certain concerns may arise about the proper operation of a "level playing field" and / or undercapitalization of some banks based on its capacity to correctly classify the exposures to non-financial firms.

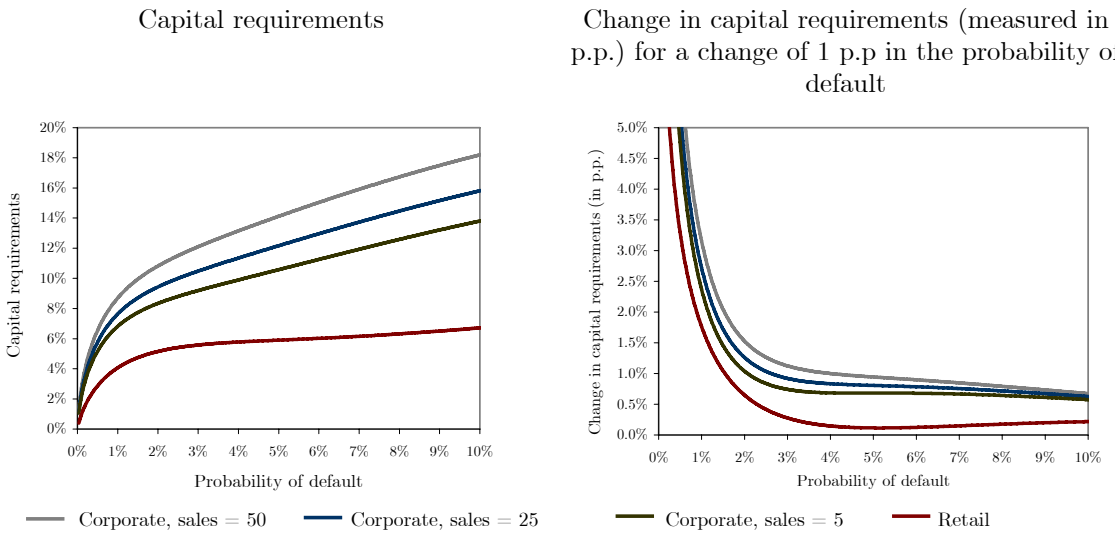
However, we should stress that for some combinations of the maturity of the credit and probability of default it is possible that when moving from retail class to corporate class capital requirements could decrease, once again in a discontinuous way. However, this can only be observed for a limited set of the risk parameters. For instance, for an LGD of 50%, this situation is only conceivable for small values of sales, maturities smaller than six months and probabilities of default smaller than 0.3%, as illustrated on the right-hand side of Figure 3. For each level of sales the area above the line represents the combinations of maturity and probability of default such that a movement from the retail to the corporate class will lead to an increase in the capital requirements.

The second feature concerns the different sensitivity of capital requirements to the probability of default. For instance, for an LGD of 50% and a maturity of 2.5 years, if retail exposures are being considered an increase in the probability of default from 3% to 5% leads to an increase in the minimum capital requirements of 0.3%. If the corporate class is being considered this increase can go up to 3.1%. On the left panel of Figure 4 it is presented the minimum capital requirements considering a maturity of credit of two and a half years and an LGD of 50%. The different sensitivity, measured by the slope of the risk weighted function, is plotted on the right panel of Figure 4, considering an LGD of 50%. Among all credit classes, the retail class is the one for which capital requirements exhibit the smallest sensitivity for a given 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 percentage points in the minimum capital requirements. The sensitivity of the minimum capital requirements for the corporate class is also dependent on the values of sales and maturity. LGD was assumed to be 50% for

simplification matters because the assumed value does not change the nature of the results, as minimum capital requirements are multiplicative on the level of LGD.

Figure 4

The sensitivity of capital requirements to the probability of default



Notes: It is assumed a maturity of 2.5 years and an LGD of 50%.

3. Characterization of Loans to Portuguese Firms and their Rates of Default

This section presents a characterization of loans to Portuguese firms and their rates of default. It begins with a characterization of loans in December 2007 followed by a description of default rates in 2008, taking a definition of default in line with the one established in the Basel II Accord.

3.1 Loans to firms

The following analysis relies mostly on a Credit Register dataset managed by Banco de Portugal (*Central de Responsabilidades de Crédito*). This brings together information provided by all credit institutions operating in Portugal. The dataset collates monthly information on all loans granted to non-financial corporations, as well as credit lines, with an amount outstanding higher than 50 euros.[13] The information on loans is categorized by type of loan and this allows for a decomposition into short-term loans (loans with a maturity lower than one year), medium and long-term loans (loans with a maturity higher than one year), others (loans for which the maturity is not specified),

[13] Although not considered in this study, this data set also contains information on loans granted to households, public administration and non-incorporated business, as well as information on securitized operations.

overdue loans and unused credit lines.[14] The additional data for this work comes from the Central Balance Sheet Database (*Central de Balanços*), providing the information on annual sales necessary to calibrate the corporate function specified in equation (1). The starting point of the exercise was the credit portfolio of firms in December 2007, stratified according to the level of annual sales for the year 2007. Annual sales for 2006 were taken whenever the value for 2007 was missing in the database. After combining these databases, the sample for December 2007 has around 400 000 observations, *i.e.*, credit exposures to non-financial firms, corresponding to about 230 000 firms.

In Portugal in December 2007, 201 financial institutions from more than 20 financial groups were reporting to the Credit Register. Out of the 201 financial institutions, 55 do not belong to any financial group and 102 financial institutions belong to the SICAM, the Portuguese agricultural savings' banking group. This group, although being the largest in terms of the number of financial institutions, grants less than 3% of the outstanding loans to firms. The five major financial groups operating in Portugal grant more than 68% of the total outstanding loans to firms.

In order to characterize loans to firms we begin by decomposing them in the following categories: short-term loans, medium and long-term loans, overdue loans, unused credit lines, and other loans. Short-term loans have a maturity smaller than one year and medium and long-term loans have a maturity higher than one year. This decomposition which is presented for the Portuguese banking system as a whole also studies the heterogeneity exhibited across financial groups[15]. Figure 5 reports the information for the Portuguese banking system on the left-hand-side while the decomposition of the total loans across financial groups is reported on the right-hand side. The values reported on the right-hand side of Figure 5 are percentiles 5, 25, 75 and 95. Medium and long-term loans have the largest share in the Portuguese banking system, representing more than 50% of total loans, as reported on the left hand side of Figure 5. A similar conclusion is obtained when considering each financial group individually. In fact, for the median institution the medium-long term debt represents 50% of firms' total loans and short-term loans represent 28% of firms' total loans. Using the difference between the percentiles 5 and 95 as a simple measure of heterogeneity across

[14] The short term loans further breakdown into commercial liabilities, finance at discount and other short term liabilities. In addition, it is possible to identify the portion of overdue loans which are under litigation.

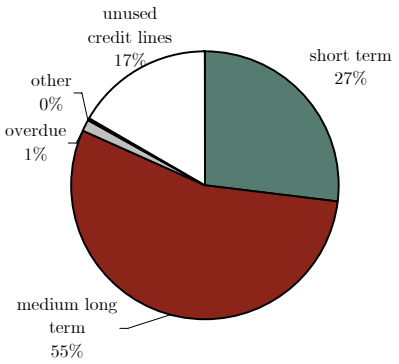
[15] If an institution does not belong to a financial group it is labelled as a financial group itself, resulting in a total of 79 financial groups.

financial groups, it is possible to say that there is more heterogeneity across financial groups for medium and long-term credit than for the other categories. Notice that the residual category "other" is not graphed across financial groups due to its very small dimension for all groups.

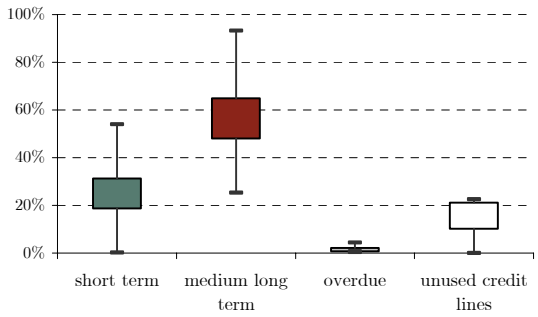
Figure 5

Decomposition of the total loans to firms, as of December 2007

Banking system



Across financial groups

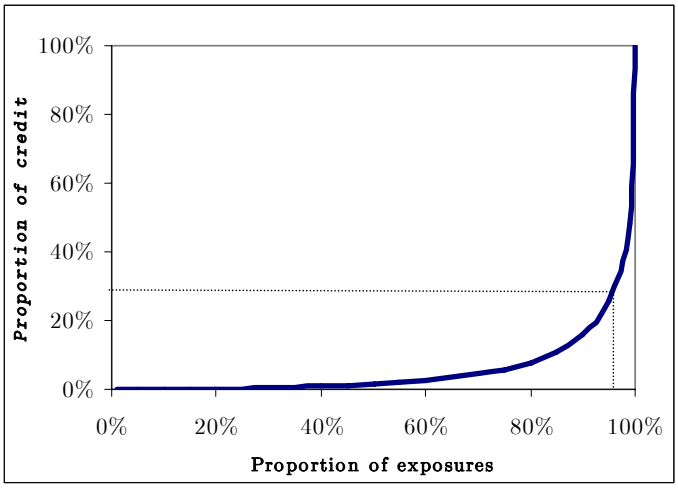


Note: The residual category "other" is not depicted on the right-hand side of the figure because of its very small dimension. The values depicted on the right-hand side of the figure correspond to percentiles 5, 25, 75 and 95. The analysis is performed across 79 financial groups.

Total loans can also be decomposed according to the exposure size. As discussed in several Banco de Portugal Financial Stability Reports (e.g. Banco de Portugal (2007)), the credit portfolio of the Portuguese banking system is "*highly concentrated on large firms*", where the size of the firm is proxied by the size of its total credit. In fact, it is observed that only 4% of the total number of exposures is higher than one million euros, corresponding to 71% of the total amount of credit. Figure 6 illustrates the degree of concentration of loans. The concentration observed on exposures larger than one million euros is still more evident if the size of the total credit per firm is considered, instead of the exposure size to a given banking group. In this case, it is observed that 80% of the outstanding amount of credit corresponds to liabilities of firms whose total credit is over one million euros. Moreover, these firms correspond to 6% of the total number of firms with outstanding banking credit[16]. Results are similar if securitized operations are considered. The degree of concentration of credit is a risk element also deserving particular attention for a macro-prudential analysis of the banking system, which will not be investigated in this work.

[16] For a discussion on this topic see Banco de Portugal (2007).

Figure 6
Concentration of the loans to firms, as of December 2007



For the purpose of computing minimum capital requirements, it is important to consider not only the exposure size but also the level of firms' annual sales which, following Basel II, is taken as a proxy for the size of firms. Under the IRB approach for corporate credits, banks are allowed to distinguish between exposures to small and medium size firms (SMEs) and those to large firms. SMEs are defined here as firms with reported annual sales smaller than €50 million. Loans extended to SMEs can then be divided into three classes according to the amount of credit granted and annual sales: retail exposure, as long as the total exposure to the banking group is smaller than €1 million, and two other corporate categories, as long as the total exposure is higher than €1 million, for different levels of sales. Summing up, the four classes in which the total credit is divided are as follows:

1. the *SME_Retail* class, which includes credits smaller than one million euros to firms with annual sales smaller than 50 million euros,[17]
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 millions euros.

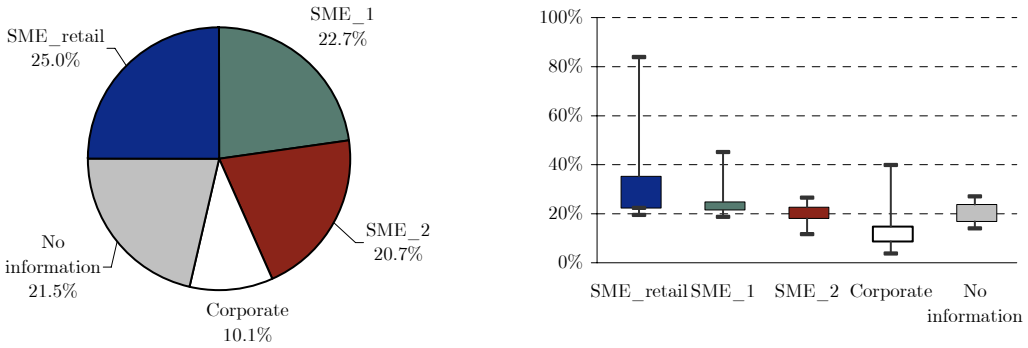
[17] There are other conditions that credits must follow to be considered as retail exposures. For instance, the retail portfolio must follow the so-called "granularity criterion", that is, it needs to be "sufficiently diversified to reduce risks", which may imply the setting of limits to aggregate exposures to one counterparty.

According to this decomposition,[18] most loans are granted to SMEs, where the retail is the most representative class (see the left hand side of Figure 7). Loans to firms with more than €50 million of annual sales account for 10% of total credit to firms. On the right-hand side of Figure 7 the same information is presented across financial groups. The heterogeneity across financial groups is higher for the loans granted to the smallest type of firms. In fact, it is observed that, for the retail class, the percentile 25 of the distribution is 22% and the percentile 75 is 35% implying that for the middle 50% institutions, the weight of the retail class ranges between 22 and 35% of their total loans to firms. The difference between percentiles 25 and 75 is smaller for the other credit classes. In addition, for 5% of the institutions the retail class represents more than 84% of their total loans to firms. There is also some heterogeneity in the corporate class of credit. For instance, for the lower 5% of institutions the corporate class represents less than 4% of their loans to firms while, for the top 5% of institutions it represents more than 40%. The analogous values for the SME_1 and SME_2 credit classes are less wide. The exposures for which there is no information on sales are dispersed among the financial groups representing, on average, 22% of the loans of each financial group.

Figure 7

Decomposition of loans to firms by corporate class, as of December 2007

Banking system Across financial groups



Note: The "No information" class refers to loans to firms for which data on annual sales is not available. Unused credit lines are excluded. The values depicted on the right-hand side of the figure correspond to percentiles 5, 25, 75 and 95. The analysis is performed across 79 financial groups.

Table 1 presents a decomposition of loans by corporate class and maturity, excluding unused credit lines. This table also decomposes loans overdue across credit classes. As

[18] 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 eight years of data are considered, have an average exposure coverage of 73.9%.

already mentioned, most loans have a maturity higher than one year. The debt maturity pattern is the same for those loans where a credit class can not be allocated due to the lack of information on annual sales, as these loans are mainly medium and long-term credit. Regarding the observed overdue in December 2007, it is concentrated on firms for which it is not possible to obtain information on sales. In any case, these firms will be excluded from the calculation of capital requirements, which assumes the ex-ante full coverage of overdue loans by provisions.

Table 1
Distribution of loans by corporate class and maturity
(as a percentage of total loans)

	SME_retail	SME_1	SME_2	Corporate	No information	Total
medium and long-term	13.4%	17.0%	13.9%	6.5%	15.2%	66.0%
short-term	11.4%	5.6%	6.7%	3.6%	5.1%	32.4%
overdue	0.2%	0.1%	0.0%	0.0%	1.2%	1.6%
Total	25.0%	22.7%	20.7%	10.1%	21.5%	100.0%

Note: unused credit lines are excluded. The residual category "other" is assumed to have medium and long-term maturity.

Finally, a decomposition of loans by corporate class and industry is presented. The industry is not a risk component as defined in Basel II but there are two main reasons to proceed with this characterization. First, the concentration of the Portuguese banking system in a few economic activity sectors, namely construction and real estate, is a persistent fact which has been reported in the Banco de Portugal Financial Stability Report (*e.g.* Banco de Portugal (2007)) for the last few years. The concentration in the real estate sector is even more severe if mortgage loans are considered, as they account for about 45% of the total loans of the Portuguese banking system to the non-financial sectors. Nevertheless, this fact has not been considered a serious vulnerability of the Portuguese financial system, since mortgage loans tend to have lower risk, as they are secured by property and real estate prices in Portugal are not believed to be overvalued as they are in some other European countries. The second reason to proceed with this characterization is related to the estimation of the probability of default of exposures (to be done in the next subsection) as, in an attempt to construct homogenous portfolios, a segmentation per economic sector is conducted.

As expected, in December 2007, loans to firms belonging to the real estate and construction sectors represented the major share of total loans, accounting for more than 38% of total loans to firms (see Table 2). In addition, these firms are mostly

classified in the SMEs classes. In fact, the retail and the SME_1 are the most important classes for almost all economic sectors. Finally, it is not possible to characterize in terms of annual sales almost half of the loans granted to firms in the "other services provided to firms" sector, and this is, in fact, a drawback for our analysis, given that loans granted this sector represent more than 14% of total loans to firms.

Table 2
Distribution of loans by corporate class and economic sector
(as a percentage of total loans)

	SME_retail	SME_1	SME_2	Corporate	No information	Total
Construction	4.3%	6.4%	3.6%	1.9%	3.3%	19.5%
Real estate	1.9%	6.9%	4.6%	0.7%	5.3%	19.4%
Whol. retail trade	7.5%	1.2%	2.4%	1.7%	2.2%	14.9%
Other services provided to firms	1.4%	4.3%	0.8%	0.9%	7.0%	14.4%
Manufacturing	5.4%	1.0%	3.5%	1.9%	1.4%	13.2%
Other services	1.5%	0.8%	1.6%	0.9%	1.1%	5.8%
Transport	1.0%	0.4%	2.3%	1.7%	0.2%	5.6%
Other economic sectors	1.8%	1.8%	1.9%	0.5%	1.2%	7.3%
No economic sector	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%

Notes: The category "Other economic sectors" includes economic sectors representing less than 4% of the total loans to firms; the "No economic sector" refers to loans to firms not possible to characterize in terms of economic sector. Unused credit lines are excluded.

Summing up, in December 2007, the majority of firms' loans obtained through the Portuguese banking system were characterized by having a maturity higher than one year and being concentrated in five large financial groups. In addition, about 25% of loans to firms could be recognized as retail exposure, and more than 38% of total loans to firms were granted to firms in real estate and construction sectors.

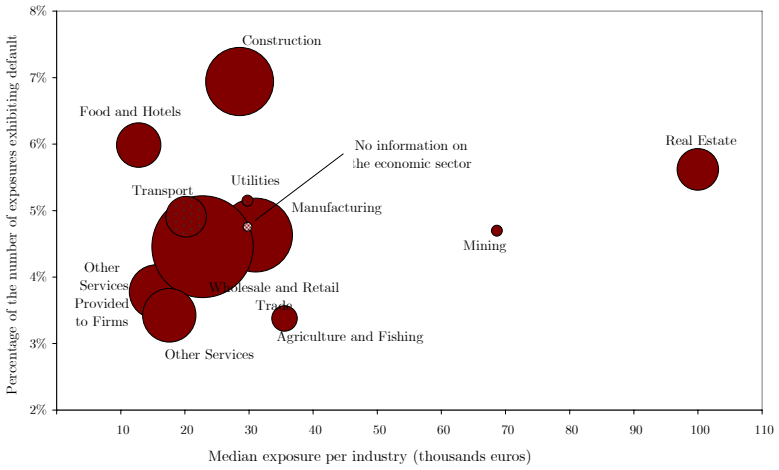
3.2. The rate of default

The following section presents a characterization of the observed rate of default of the Portuguese 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 (loans reported either as overdue loans or loans under litigation) over three consecutive months. For the assessment of the default rate over 2008 only exposures in December 2007 that did not exhibit default over 2007 will be considered.

The heterogeneity of loans among economic sectors motivates a first characterization of the rate of default by economic sector. The highest rate of default is observed in

exposures to firms in the construction sector, while the smallest are in exposures to firms in agriculture and fishing. This information is presented in Figure 8, 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.

Figure 8
Default rates



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

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. This analysis will be performed taking annual sales as proxy for the firm size. 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.[19] This reduction in the sample size creates a bias, as observations not considered correspond to firms with higher default rate. Then, in the sample finally used, 3.6% of the number of exposures exhibited default in 2008. The proportion of amount of loans exhibiting default is also 3.6%.[20]

Table **3** presents a characterization of the rate of default of the financial group exposures for different classes of firms' sales as well as the exposure level. The default rate corresponds to the number of exposures exhibiting default in 2008 over the number

[19] Notice that this number is lower than the one presented in Figure 5, as only loans of firms that did not default during 2007 are considered. The same applies for the remaining analysis.
[20] If all the data was considered, 4.8 % of the exposures reported in December 2007 would exhibit default in 2008, while the proportion of the amount of those loans exhibiting default would only be 4.1% of the total amount of loans.

of exposures in a given combination of firm's sales and exposure size. Moreover, the number of exposures over the total number of exposures as well as the amount of loans over total loans is also reported.

Table 3

The default rate in Portuguese firms in 2008 by firm's sales and exposure size

Firm's sales			Banking group exposure					
			$< 10^4$	10^4 - 10^5	10^5 - 10^6	1M - 10M	> 10M	
	< 5M	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%
	5M - 50M	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%
	> 50M	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%
		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%

Note: The default rate corresponds to the number of exposures exhibiting default in 2008 over the total number of exposures for a given combination of firms' sales and exposure size.

As can be observed, 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 lower rate of default on their loans. This is in line with Dietsch and Petey (2004) and Jacobson, Lindé and Roszbach (2005), among others, who have also reported similar evidence in different countries. In terms of the relationship between the observed rate of default and the size of the exposure, for the adopted classes of exposure, the highest default rate is observed for exposures between one and ten million euros. The smallest default rates are observed for exposures smaller than ten thousand euros and higher than ten million euros. Credit exposures higher than ten million euros, although caused by only 0.3% of the total number of exposures, correspond to 34.1% of total credit. The relationship between the observed rate of default and the size of the exposure still holds if the overall sample is 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 4 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 retail class, as

already shown in Figure 7 for all firms. In fact, the 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

Table 4
The default rate in Portuguese firms in 2008 by credit class

	SME_retail	SME_1	SME_2	Corporate
Exposure	<1M	>1M	>1M	
Sales	< 50M	< 5M	5M - 50M	> 50M
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%

Note: The default rate corresponds to the number of exposures exhibiting default in 2008 over the total number of exposures belonging to a given credit class.

4. Capital requirements for the Portuguese banking system

This section assesses the implications on capital requirements driven by firms' credit risk for Portuguese banks, if the IRB methodology had been adopted in 2007. We begin by presenting the results on capital requirements for the Portuguese banking system concerning firms' credit risk. Robustness tests on this analysis are also performed. This is then followed by a comparison between the results on capital requirements at December 2007 and similar estimates at December 2006.

4.1 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 section, 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,[21] in line with the fact that in 2008 the rates of default exhibit heterogeneous behavior across these two dimensions. Capital requirements are then aggregated using as weights the proportion of the amount of loans in the total portfolio.

[21] For some economic activity sectors and some classes of credit the observed default rate in 2008 is 0%. In these cases, and following Basel II, we take the probability of default to be 0.03%.

As described in section 2 (see equations (1) and (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 two years and a half for the long term is used. At a later stage, simulations with different maturities are also performed.[22] In reference to the loss given default, we first take as benchmark the values 45% and 75%, as discussed in Section 2. These bounds for the LGD are in line with the results of Fernandes (2006), where data from a Portuguese commercial bank gives an average recovery rate of 48.6%. However, using data over the period 1995-2000 from a different Portuguese commercial bank, Dermine and Neto de Carvalho (2006) concluded the mean cumulative recovery rate to be 71%. 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%. Finally, the results of the fifth quantitative impact study (Basel Committee on Banking Supervision (2006a)) show that LGDs in the corporate portfolio range between 29.1% and 56.3% (the average being 39.8%), while for the SME corporate portfolio, the average LGD for G10 largest banks is 35.0%, but values range from 16.3% to 54.5%. Given the previously mentioned studies, the Basel II Accord benchmarks and the absence of information on risk mitigation, several simulations for different values of LGD were carried out.

Capital requirements for each financial group are computed as a weighted average of the capital requirements of each credit exposure, where the weights are the ratio of each exposure at default over the total exposure at default in the financial group. The exposure at default includes short-term loans, medium and long-term loans as well as loans labeled as other. As a conservative scenario, these other loans, where there is no information on maturity, were considered as long-term.

The characterization of capital requirements for the Portuguese banking system begins by analyzing the heterogeneity across financial groups operating in Portugal.[23] This

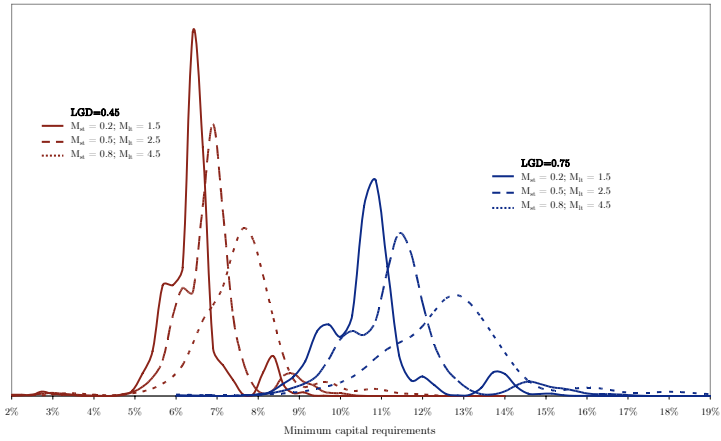
[22] The simulated values for the long-term maturity are restricted as Basel II defines the maximum maturity to be 5 years.

[23] Capital requirements for each financial group are calculated as a weighted average of capital requirements of each exposure, where the weights are the ratio of the amount of each exposure to the total amount of loans of that financial group. Note that capital requirements of each

analysis is carried out using empirical distributions obtained by recourse to a Gaussian kernel that weights financial groups by their total loans to firms, with results being reported in Figure 9. This analysis is performed for different values of LGD and maturity of exposures. Regarding the LGD, the values 45% and 75% were considered. For maturity three different scenarios were used: a short-term maturity of 0.2 years and a long-term maturity of 1.5 years; a short-term maturity of 0.5 years and a long-term maturity of 2.5 years; and a short-term maturity of 0.8 years and a long-term maturity of 4.5 years.

Figure 9

Empirical distribution of capital requirements for different maturities of the exposures and LGD, across financial groups



Note: Empirical distribution obtained by recourse to a Gaussian kernel that weights institutions by loans to firms.

As expected, capital requirements increase with the LGD and the effective maturity of the exposures. The LGD assumption proves to be crucial to the determination of capital requirements. For an LGD of 45%, capital requirements for firms' credit risk is lower than 8% for most institutions while the opposite happens for an LGD of 75%. It is observed that the heterogeneity across banks increases with the LGD value and with the maturity of exposures. As LGD increases, capital requirements exhibit higher dispersion as its level is more sensitive to the composition of each financial group's loans across credit classes. An analogous conclusion can be made concerning the average maturities.

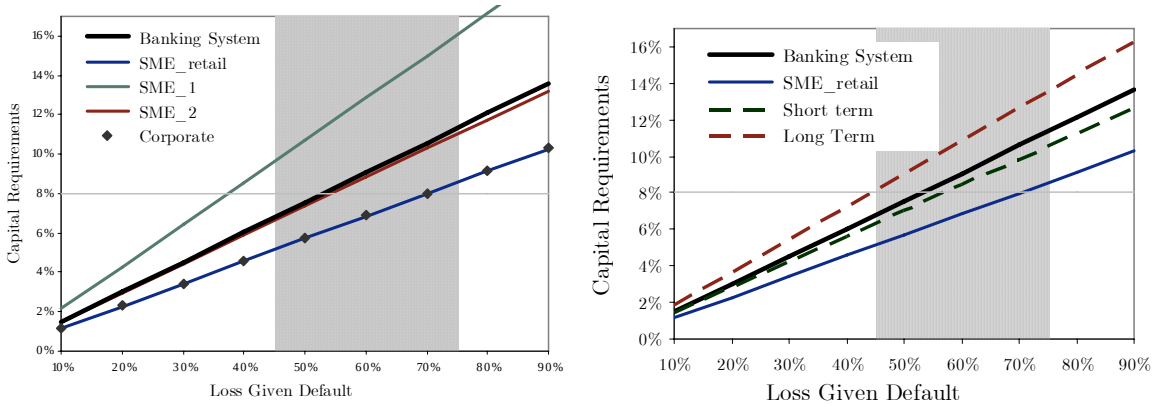
We now proceed with the analysis of capital requirements for the Portuguese banking system, weighting each financial group by its total amount of loans to non financial

exposure depends 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.

firms. The analysis is carried out by decomposing total loans into the credit classes previously defined and according to the maturity of exposures. Results show that capital requirements driven by firms' credit risk for the banking system will be lower than the ones under Basel I as long as the LGD is assumed to be lower than 52% (see Figure 10). The corporate and retail classes are those that have smaller capital requirements, for any level of LGD. In the case of the 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. On the subject of exposures to SMEs, it should be stressed that capital requirements for exposures higher than 1M euros and sales smaller than 5M are above those of the overall banking system, while capital requirements for the other two SME classes 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, the fact that capital requirements are smaller for the retail results from the fact that the risk weight function is less demanding and the probability of default is lower. This corroborates the results presented in Section 2 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. However, as presented in Figure 10, this is not observed because of the heterogeneous probabilities of default. 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. Figure 10 also illustrates the fact that errors due to incorrect classification increase with higher levels of LGD. In terms of the decomposition of capital requirements according to the maturity of exposure, which is not a relevant risk driver for capital requirements of retail exposures, longer-term maturities result in higher capital requirements, as expected (right panel of Figure 10).

Figure 10

Capital requirements of the banking system: by credit class and maturity

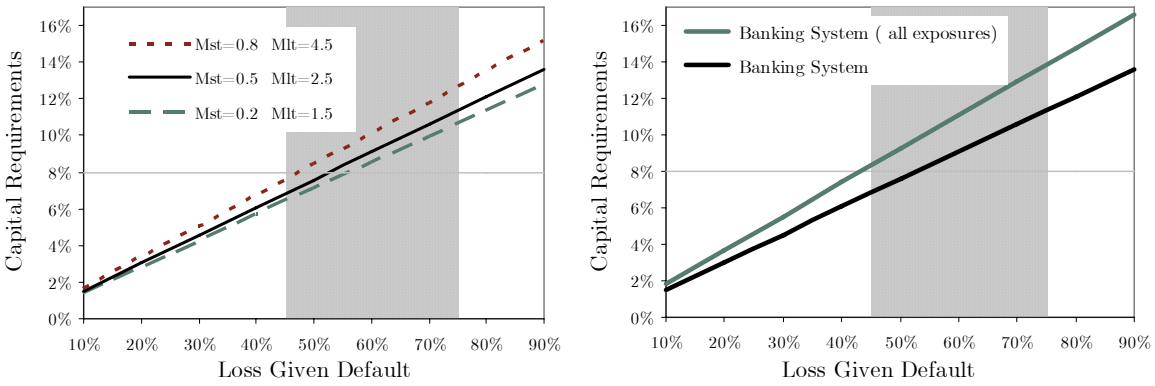


Notes: The maturity of short-term loans was assumed to be 0.5 years while the maturity of long-term loans was assumed to be 2.5 years.

4.2 Robustness analysis

As a robustness test of the Portuguese banking system capital requirements for firms' credit risk, we assess the implications of the postulated maturities of the exposures, the exclusion of the exposures for which there is no available information on annual sales and the use of different probabilities of default. Hence, the first robustness check concerns the maturity of exposures. If the short-term maturity is assumed to be 0.2 years and the long-term maturity is assumed to be 1.5 years, the recovery rate higher than 44% assures that capital requirements under Basel II are lower than those under Basel I (see left panel of Figure 11). On the other hand, assuming a short-term maturity of 0.8 years and a long-term maturity of 4.5 years, capital requirements under Basel II are lower than those under Basel I if the recovery rate is higher than 53%. As previously mentioned, this value for the recovery rate is in line with previous studies on Portuguese banks.

Figure 11
Robustness analysis of capital requirements of the banking system



Note: 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 for the right hand side panel.

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 "retail" [24] (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 1M euros. The probability of default assigned to these exposures was, once again, the observed rate of default over 2008. For exposures smaller than 1M euros, the observed rate of default is 13.6%. For exposures higher than 1M euros the observed rate is 9.7%, which is much higher than the rate observed for exposures initially classified as corporate. In this scenario, capital requirements for firms' credit risk in the banking system remain below those under Basel I only if the recovery rate is assumed to be around or higher than 60% (see right panel of Figure 11). Moreover, the consideration of these exposures causes a higher sensitivity of capital requirements with respect to the LGD.

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 the whole system. The reason

[24] This classification is not the most conservative as firms with sales higher than 50M euros may have exposures lower than 1M euros. In such cases, exposures lower than 1M euros would be wrongly categorized as retail. However, this situation was not contemplated as for firms that did not exhibit default over 2007 and with information available on sales for the year 2007, only 1.3% of the loans lower than 1M euros was caused by firms with sales higher than 50M. Hence, given the impossibility of classifying as retail or corporate the exposures smaller than 1M euros, the classification of the whole group as corporate would lead to a less precise evaluation of capital requirements.

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 concave on the probability of default (see Figure 4). In this context, using as proxy for the probability of default the observed rate of default calculated for different homogeneous groups, the impact on the minimum capital requirements is assessed. The homogeneous groups considered are: i) per economic sector and exposure size; ii) per sales level and exposure size and iii) per economic sector. The exposure size classes, as well as the level of sales classes, are as defined in Table 3**.** Comparing with the baseline case presented in section 4.1, the highest difference in capital requirements is observed if default rates are uniform for exposures in the same economic sector. An increase of 1.33 p.p. in the level of capital requirements is observed if an LGD of 50% is considered. The use of a single rate of default per sales level and exposure size results in the lowest change of around 0.7 p.p. in capital requirements (for an LGD of 50%). These results stress the importance of stratifying adequately the portfolio of loans to non-financial firms into homogeneous groups for the purpose of computing capital requirements.

Then, we assessed the impact on capital requirements of using a single rate of default for the whole economy. As an example of the potential error which may arise when grouping heterogeneous exposures assigning them the same probability of default, consider an economy with only two exposures. The exposure to firm A has a probability of default PD_A and the exposure to firm B has a probability of default PD_B. The proportion of the exposure at default of firm A is w_A, while the proportion of the exposure at default of firm B is w_B. According to Basel II the probability of default should be computed for each homogeneous group, the minimum capital requirements is given by $K(PD_A,PD_B) = w_A\ K(PD_A) + w_B\ K(PD_B)$. However, if a single probability of default is assigned to both firms (PD), the resulting minimum capital requirements will be K(PD). Hence, the use of a unique probability of default results in an error defined as $K(PD_A,PD_B)$ - K(PD). Considering a unique PD defined as the weighted average of the probability of default of each firm (that is, $PD = w_A\ PD_A + w_B\ PD_B$), results in minimum capital requirements higher than the ones established under Basel II, as the risk weight function is concave on the probability of default. Moreover, different probabilities will result in different errors. If a probability of default higher than the weighted average is assigned, the error would have the same sign and would be even larger. If a lower probability of default is assigned either the error is of the same sign but smaller, or it becomes negative with a magnitude dependent on the probability of

default assigned. The errors on the minimum capital requirements resulting from using a single rate of default within a group are minimized if firms are homogenous in what concerns their probability of default. In this context, instead of using different probabilities of default a single probability of default is used, resulting in higher minimum capital requirements. Using a probability of default of 3.6% (as pointed in section 3.2) the minimum capital requirements for firms' credit risk will exhibit an increase of 1.1 percentage points, for an LGD of 50%. Hence, the use of a single probability of default, which is not in line with Basel II fundamentals, introduces a non negligible error.

4.3 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, 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 p.p. in capital requirements, for an LGD of 50%. This increase can go up to 0.4p.p. if an LGD of 75% is considered.[25] Most of this increase in capital requirements (around 85%) is due to an increase in the probability of default. This effect results from assessing capital requirements for 2006 using, as proxy for the probability of default, the default rate in 2008. The remaining effect (around 15%) can be justified by changes in the portfolio structure.

5. Conclusions

The Basel II Accord, which came into force in 2007, establishes new capital adequacy rules. In contrast to the previous Accord, this new one seeks a better alignment between regulatory capital and economic risk. One of the most important changes is the definition of capital requirements for credit risk based on internal risk ratings. Banks are permitted to develop internal methodologies to quantify the creditworthiness

[25] 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.

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 Basel II rules for the determination of capital requirements for firms' credit risk. It starts by establishing regions of values for the probability of default and the loss given default for which Basel II 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 hand, for credit to firms classified as retail, and for commonly accepted values for PD and LGD, capital requirements are below those under Basel I. Our analysis emphasizes the importance of an exposure's classification as retail or corporate.

In Portugal, as expected, most loans are granted to firms with annual sales smaller than 50M euros (SMEs), from which less than half are classified as retail exposures. The real estate and construction sectors are the economic sectors where loans are more concentrated. The majority of the loans have a maturity higher than one year. The observed firms' rate of default in Portugal over the year 2008 presents a differentiated pattern across different economic sectors. Construction comes in with the highest default rate. Moreover, the observed rate of default decreases with the firms' size, taking the definition of firm size as in the Accord. For the adopted categories of exposure size, the observed rate of default is non monotonic, increasing (roughly) with the exposure size for exposures smaller than 10M euros (which account for 66% of total loans) and decreasing significantly for those higher than that amount (which account for 0.3% of the number of exposures and 34% of total loans).

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, capital requirements for the Portuguese banking system associated with loans to non-financial firms are shown to be lower than the ones under Basel I, for recovery rates higher than 50%. Among the SMEs, the 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. The empirical analysis for Portuguese non-financial firms confirms the importance of the allocation of credits among the credit classes defined under Basel II. As there is no precise information available for the maturity of exposures, different assumptions were made. Under extreme assumptions for maturity if a recovery rate of 53% is assumed, capital requirements for firms' credit risk are still 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. Assuming standard values for maturity and a recovery rate of 50%, capital requirements for firms' credit risk will still be smaller than those under Basel I. Using a different segmentation for the estimation of the probability of default, an increase in capital requirements was observed. In all cases, only a recovery rate of 60% assures that capital requirements are still lower than under Basel I. Finally, comparing capital requirements for 2006 and 2007, an increase was obtained. The main reason for this change was an increase in the probability of default, reflecting the recent deterioration of firms' credit risk.

It should be stressed that our analysis only considers the credit risk of non-financial corporations' loans, 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 non-negligible amount to capital requirements presented in this work.

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