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November 2007

The views expressed here are those of the authors and do not necessarily reflect the official view of the central bank of Hungary (Magyar Nemzeti Bank).

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Basel II and financial stability:
An investigation of sensitivity and cyclicality of capital requirements based on QIS 5

(Bázel II és a pénzügyi stabilitás:
A tőkekövetelmények érzékenységének és ciklikusságának vizsgálata a QIS 5 alapján)

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Abstract

This study aims to analyse the sensitivity of capital requirements to changes in risk parameters (PD, LGD and M) by creating a 'model bank' with a portfolio mirroring the average asset composition of internationally active large banks, as well as locally oriented smaller institutions participating in the QIS 5 exercise. Using historical data on corporate default rates, the dynamics of risk weights and capital requirements over a whole business cycle are also examined, with special emphasis on financial stability implications. The purpose of this paper is to contribute to a better understanding of the mechanism of Basel II and to explore the possible impacts of prudential regulation on cyclical swings in capital requirements.

JEL: G21, G28, G32.
Keywords: Basel II, credit risk, capital requirement, regulation, cyclicality, financial stability.

Összefoglaló

A tanulmány célja, hogy a QIS 5-ben részt vevő nemzetközileg aktív nagybankok, valamint a helyi orientációjú kisebb intézmények mérlegszerkezetét visszatükröző „modellbankon" keresztül megvizsgálja a tőkekövetelmények érzékenységét a kockázati paraméterek (PD, LGD és M) változására. A vállalati csődráták historikus adatait felhasználva elemzi a kockázati súlyok és a tőkekövetelmények gazdasági cikluson belüli alakulását, különös tekintettel a pénzügyi stabilitási következményekre. A tanulmány hozzá kíván járulni Bázel II hatásmechanizmusának jobb megértéséhez, továbbá fel kívánja tárni a prudenciális szabályozásnak a tőkekövetelmények ciklikus ingadozásaira gyakorolt hatásait.

JEL: G21, G28, G32.
Kulcsszavak: Bázel II, hitelkockázat, tőkekövetelmény, szabályozás, ciklikusság, pénzügyi stabilitás.

1. Introduction*

In June 2004 the Basel Committee on Banking Supervision (BCBS) adopted the revised version of its Capital Accord, commonly referred to as Basel II among market participants. Two years later, on 14 June 2006, the Basel II rules became transposed into European law by Directive 2006/48/EC of the European Parliament and of the Council (Capital Requirements Directive, or CRD). The directive aims at contributing to the achievement of the single market for financial services by creating unified prudential rules for credit institutions and investment firms.[1] Enhanced financial regulation is considered an important prerequisite for the creation of a more efficient and integrated financial market, which can spur economic growth across Europe.[2,3] The directive had to be implemented in all EU countries by the end of 2006. Besides a compulsory implementation of CRD in the EU, the Basel II framework agreement is planned to be transposed into national law by almost 100 countries all over the world, which will have a substantial effect on the global banking community (FSI, 2006).

It is assumed that readers are familiar with the Basel II (CRD) framework; therefore, the basic features of the accord will not be discussed in great detail. Nevertheless, it is considered necessary to draw attention to certain specific aspects of the Basel II framework, with special emphasis on the incentive structure of the new capital rules, as well as the mechanics of the risk weight functions used for the calculation of the capital requirements in the internal rating based (IRB) approaches.

Compared to Basel I, one of the main features of Basel II is that the calculation of capital requirements became much more risk sensitive, i.e. different risk weights are assigned to different exposures included in the same portfolio but having different risk characteristics. In the advanced internal rating based approach (AIRB) risk parameters, such as probability of default (PD), loss given default (LGD) and maturity (M), are estimated by banks themselves. These estimations are then used as inputs in the risk weight functions to transform them into capital requirements.

It is very important to emphasise that, while measuring the relative riskiness of different exposures (e.g. on a cross sectional basis), these very same risk weight functions are used to determine the changing capital requirement of the exposures over time, originating from the time dimension of risk. As parameter estimations of an exposure change as time elapses, so do capital requirements as well. This characteristic of the new Basel accord has been widely criticised in the academic literature on the basis of the inaccuracy of risk measurement over time and its adverse impact on banks' behaviour (Borio et al., 2001; Danielsson et al., 2001) .

One of the major topics in this field is the issue of pro-cyclicality, i.e. the tendency of banks' lending conditions becoming looser and credit growth becoming more vivid in boom years, and conditions becoming tighter and credit growth slower in times of recession. The importance of the careful analysis of the issue of pro-cyclicality is justified by the fact that this phenomenon may increase the amplitude of real economic cycles by alternating periods of credit expansion and shortages (or even credit crunches).[4,5] Part of this pro-cyclical behaviour is a natural by-product of changing macroeconomic conditions (demand or supply shocks, shifting expectations, etc.) being reflected in banking activity, with no direct connection to banking regulation. However, there are increasing fears that prudential regulation in general, and Basel II in particular, can contribute to these lending cycles by creating an environment characterised by volatile capital requirements, which may add an additional

* The author is indebted to Júlia Király, Magdolna Szőke and Balázs Janecskó for their valuable comments on an earlier draft of this paper. The author would like to thank colleagues at the Financial Stability Department of the Magyar Nemzeti Bank for their insightful suggestions and remarks. Any remaining errors are the sole responsibility of the author.

[1] Prudential regulation is only part of a wider set of regulatory measures adopted under the aegis of the Financial Services Action Plan (FSAP) in the past decade in the EU. The major regulatory steps taken to promote financial integration in Europe are discussed, for example, in ECB (2004, 2005).

[2] Despite being a priority, the creation of a single market for financial services is moving ahead rather slowly. The level of financial integration is very uneven across market segments in Europe. For a more detailed discussion of the development and current issues of financial integration, see Cabral et al. (2002), Baele et al. (2004), Walkner–Raes (2005), Cappiello et al. (2006), Trichet (2006) and ECB (2007).

[3] There is a wide range of literature analysing the impacts of regulation on financial development and economic growth. Empirical evidence is quite straightforward on this issue, showing that a properly designed regulatory framework can contribute to the development of the financial system, which, by increased efficiency in allocating resources, can support economic development as well. For a detailed review of the relevant literature, see Gianetti et al. (2002), Levine (2004) and Serres et al. (2007), while for an analysis with relevance to transition economies, see Kruk (2006).

[4] For a recent study on the relationship between credit market developments and macroeconomic volatility, see Mendicino (2007)

[5] An illustrative example of the effects of regulatory changes on banks' lending behaviour is provided by Watanabe (2007), who demonstrates that the 'capital crunch' and the associated 'credit crunch' were mainly regulatory driven in Japan in the late 1990s.

impetus to the already present pro-cyclicality of bank lending (Resti, 2002; Zsámboki, 2002; Mérő–Zsámboki, 2003; Kashyap–Stein, 2004; Catarineu-Rabell et al., 2005; Fabi et al., 2005; Gordy–Howells, 2006).

This analysis focuses on the results of the fifth quantitative impact study (QIS 5) undertaken by the Basel Committee in the second half of 2005. The results were published in 2006, providing a point-in-time estimation about the relative capital needs of different portfolios on a sample of nearly 400 banks from all over the world (BCBS, 2006a). Although the exercise was intended to serve as a basis for the (re)calibration of the accord, it doesn't say anything about the dynamics of capital requirements over time. Therefore, despite being called an impact study, it gives only a 'flash picture' about the incentive structure of Basel II. The results are critically dependent on the macroeconomic conditions prevailing at the time of the exercise, which, as the Basel Committee admitted, were rather favourable in 2005. This distortion in risk measurement means that, in spite of having a broad picture about the expected risk weights in times of economic expansion, we do not know anything about the sensitivity of risk parameters and, consequently, capital requirements to changing economic conditions.

The aim of this study is twofold. First, the sensitivity of risk weights to changes in PD, LGD and M are analysed by creating a 'model bank' with a portfolio mirroring the average portfolio composition of internationally active large banks (Group 1, or G1) and locally oriented smaller institutions (Group 2, or G2), which participated in the QIS 5 exercise. Second, using historical data on corporate default rates, the dynamics of risk weights and capital requirements over the business cycle are investigated. Several assumptions will be made in this study which should be kept in mind when interpreting the results. Nevertheless, it is believed that this paper contributes to a better understanding of the mechanism of Basel II and to the exploration of the possible impacts of regulation on swings in capital requirements, as they may create additional incentives for banks to modify their lending activity in different phases of the business cycle.

To the best of my knowledge, the results of the QIS 5 exercise have not yet been used for analysing the issue of cyclicality of capital requirements. The novelty of the paper is that it interconnects two databases (QIS 5 as well as Moody's rating and corporate default data) to give a broad view about the possible cyclical swings in minimum capital requirements.

2. Some basic characteristics of the Basel II risk weight functions

2.1. THE ECONOMIC RATIONALE BEHIND THE RISK WEIGHT FUNCTIONS

The risk weight functions of Basel II are based on a so-called Asymptotic Single Risk Factor model developed by the BCBS.[6] An important characteristic of this model is that it is portfolio invariant, i.e. the composition of a portfolio to which an exposure is added does not influence the capital requirement. There is, however, a basic assumption behind the model, namely that the portfolio of the bank is perfectly granular, i.e. it contains a large number of exposures, each of them being small relative to the whole portfolio. This assumption, which is based on the law of large numbers, makes portfolio invariance work. Should a bank not be able to meet this assumption on granularity, its capital requirement calculated by the Basel II functions could be substantially lower than actually needed to cover unexpected losses (BCBS, 2006b). This distortion in the calculation of capital requirements must be dealt with in Pillar 2 by the competent supervisory authorities.

Another important characteristic of the ASRF function is that a single systemic risk factor is used to model system-wide risks that may have an impact on the banks' clients. In that respect Basel II assumes that it is the global economy that affects borrowers and, consequently, local or industry-specific risks are not accounted for in this framework. In an open economy this assumption may prove to be reasonable; however, should a bank's customers be mainly exposed to local economic conditions, this assumption may not give accurate results in capital calculations. The relationship between the systemic risk factor and the banks' exposures are expressed by asset correlation, which differs from one asset class to another.

For the purpose of our analysis, the main characteristics of the AIRB functions are presented shortly, which, as mentioned before, use risk parameters (PD, LGD, M) estimated by banks themselves.[7] The risk weight function for corporate exposures looks as follows, including the size adjustment for SMEs in the correlation function:

Risk weight (RW):	K * 12,5 * 1,06
Capital requirement (K):	[LGD*N[(1-R)^-0.5 * G(PD) + (R/1-R))^0.5 * G(0.999)] - PD * LGD] * (1-1.5 * b(PD))^-1 * (1 + (M - 2.5) * b (PD))
Correlation (R):	0.12 * (1 - EXP(-50 * PD)) / (1 - EXP(-50)) + 0.24 * [1 - (1 - EXP(-50 * PD)) / (1 - EXP (-50))] - 0.04 * (1 - (S - 5) / 45)
Maturity factor b(PD):	(0.11852 - 0.05478 * log (PD))^2

where N(x) denotes the cumulative distribution function for a standard normal random variable (i.e. the probability that a normal random variable with mean zero and variance of one is less than or equal to x). G(z) denotes the inverse cumulative distribution function for a standard normal random variable (i.e. the value x such that N(x)=z). S represents the total annual sales of a corporation, expressed in millions of euros, and falls within the rage of EUR 5-50 million.[8] The scaling factor of 1.06 in the risk weight function aims at (partly) compensating the expected overall decline in capital requirement caused by the introduction of the new capital regime.[9]

[6] For a detailed explanation of the risk weight functions, see BCBS (2005a) and Tarashev-Zhu (2007). The economic rationale behind the risk weight functions, as well as the various incentives created by Basel II, is also discussed by Zsámboki (2007).

[7] Although the present form and the parameterisation of the risk weight functions are the results of several compromises between Basel Committee countries, and thus are subject to debate, for the purpose of the analysis these functional forms are taken as given, and the controversies associated with the functions are hereby not dealt with.

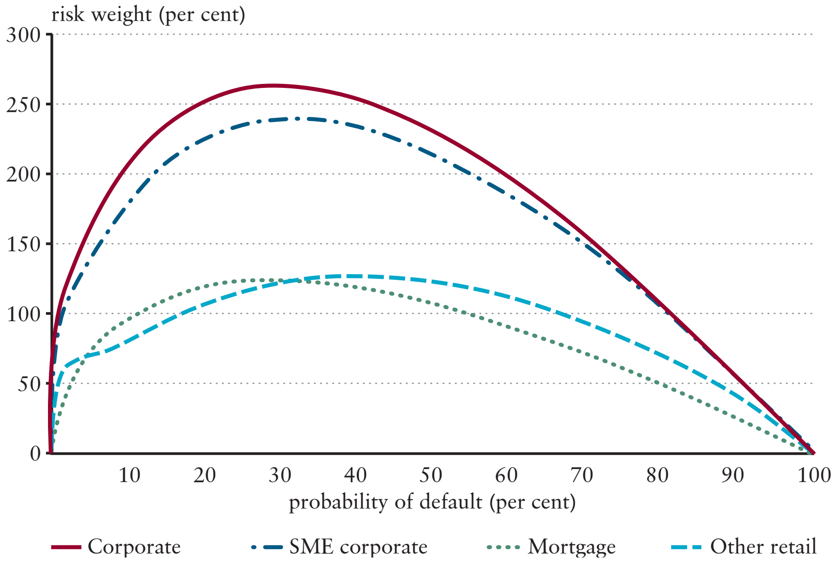
[8] Hereby the definition provided by CAD is used, which expresses the thresholds for size adjustment in euros, instead of dollars as defined by Basel II.

[9] Though this requirement on overall capital level is theoretically not grounded, as the Basel I capital accord, which is admittedly an inadequate measure of the risks assumed, is set as a benchmark.

The risk weight functions for other asset classes differ from the one above in the correlation function and maturity adjustment. For the sake of illustration, the risk weight curves are presented in the chart below as a function of PD. In our illustration an LGD of 45% is assumed for corporate, SME corporate and other retail exposures, and an LGD of 20% for mortgage exposures. Naturally, as LGD changes, the steepness of the curves changes as well.[10]

Chart 1

Risk weights of different asset classes as a function of PD

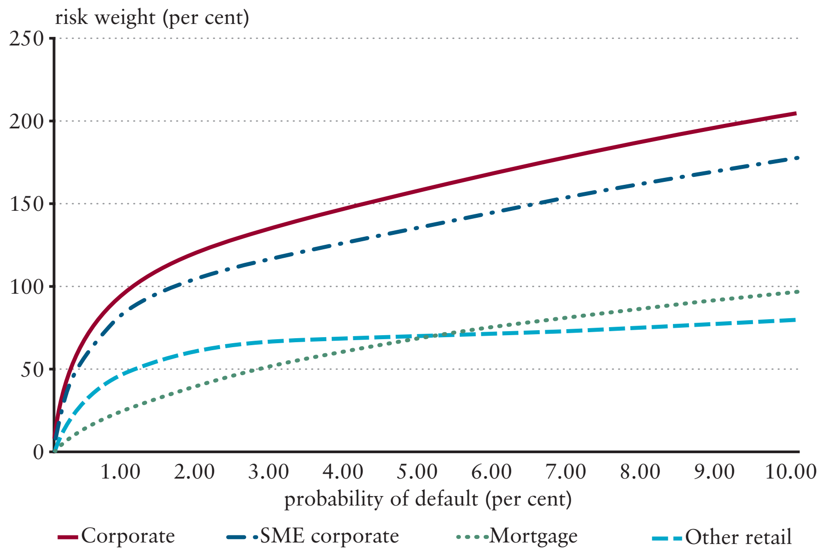


Note: The risk weight function for SME corporate exposures are calculated by assuming total annual sales of EUR 25 million for the size adjustment.

As banks usually have a clientele characterised by PD below 10%, we should concentrate our analysis on that part of the risk weight functions. Having the same assumptions as before, the functions look as follows in the PD interval of 0-10%.

Chart 2

Risk weights of different asset classes an a function of PD (0-10%)



[10] The main characteristics of the functions would be more comparable by assuming identical LGDs for all asset classes. However, for mortgage exposures an LGD of 45% would be unrealistically high; therefore, assumptions about LGD are determined on the basis of the QIS 5 exercise. For more details see section 3.2.

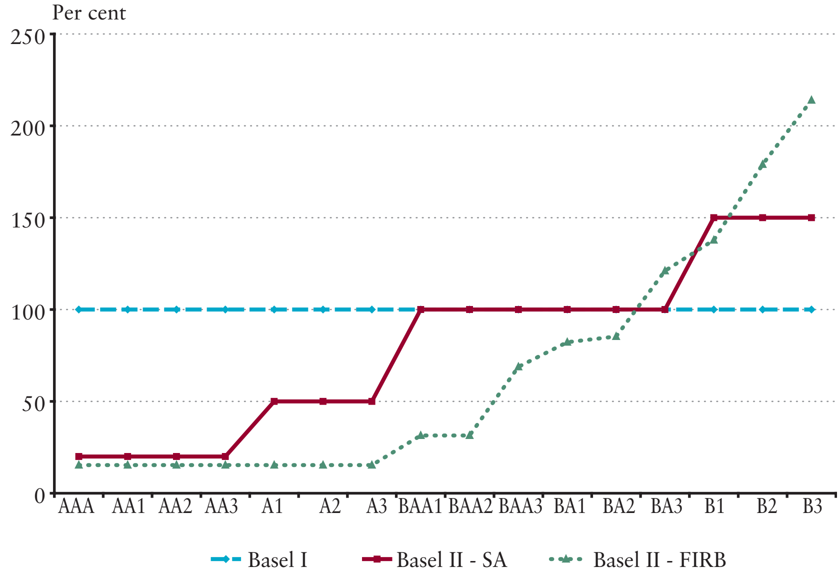
2.2. THE INCENTIVE STRUCTURE OF THE RISK WEIGHT FUNCTIONS

The incentives provided by the Basel II risk weight functions for banks relative to the Basel I regulatory regime are worth a thorough examination. Here attention is focussed on corporate exposures only, as there are no publicly available databases for retail exposures. In order to explore the nature of the risk weight function, Moody's corporate default rate database is used from 1983-2006 (Hamilton et al., 2007). The current regime of Basel I assigns a 100% risk weight to all corporate exposures, irrespective of differences in their riskiness. This regime is replaced by a revised standardised (SA) method and two internal rating based (IRB) approaches, from which banks can choose, according to their risk management policies. This choice, however, is subject to supervisory approval.

As the chart below illustrates, the risk sensitivity of the standardised (SA) method increases substantially in the new regime, allowing banks to free up capital in the high quality segment of their portfolio, and requiring them to allocate additional capital for exposures in the low quality segment. The risk sensitivity of the IRB function is even higher. Using Moody's average default rates for corporate bonds in the period 1983-2006 as a proxy for PDs in different rating categories, we can see that the incentives are even stronger for IRB banks to extend their lending activity toward high quality (low PD) clients, as they can substantially reduce the amount of regulatory capital that has to be set aside to cover unexpected losses. Higher risk sensitivity also means that financing low quality (high PD) borrowers would be less attractive for IRB banks, should they not be able to shift the higher cost of capital through pricing upon borrowers having higher default probability.[11]

Chart 3

Risk weights assigned to different rating classes



Source: own calculations based on Hamilton et al. (2007).

As is clearly shown on the chart, in the case of financing less creditworthy clients, the increase in capital requirements can be quite substantial for IRB banks. Therefore, it is very important from a financial stability perspective to have an idea about the portfolio distribution of banks according to (internal) rating categories and to explore the dynamics of rating transitions, as well as changes of PDs within each rating category over time.

An illustrative example concerning the incentive structure of Basel II is provided by QIS 5. The table below shows the expected changes in minimum regulatory capital (MRC) for banks choosing the AIRB method, in comparison with the current regulatory regime in each portfolio segment. It is quite striking to realise that, even when taking the 1.06 scaling factor into account (as the QIS 5 exercise did), the expected decline in MRC is rather substantial in the retail segment.

[11] It should also be noted that under the revised SA method banks have to assign a 100% risk weight to unrated clients, which can save capital for SA banks relative to IRB banks in the low quality segment of the corporate portfolio. This issue is particularly relevant in countries where external ratings are uncommon. Moreover, in countries with a sovereign rating below investment grade, which serves as a ceiling for the rating of individual exposures, reduction of capital requirement under the SA method is not possible.

Table 1

Changes in minimum required capital relative to current regime for banks using AIRB approach (per cent)

Portfolio	Group 1			Group 2		
	% of current MRC	% change in MRC	Contribution	% of current MRC	% change in MRC	Contribution
Wholesale						
-Corporate	25.2	-17.6	-4.4	11.8	-44.5	-5.3
-Sovereign	0.4	178.1	0.8	0.1	687.1	0.5
-Bank	3.0	1.8	0.1	3.0	8.6	0.3
SME Corporate	7.2	-23.6	-1.7	11.1	-45.2	-5.3
SL	4.9	-24.6	-1.2	2.6	-17.7	-0.6
Retail: (total)						
-Mortgage	12.9	-65.4	-8.5	7.9	-64.6	-5.1
-Other retail	4.4	-23.2	-1.0	32.5	-44.0	-15.0
-Revolving	1.5	71.1	1.1	1.2	-62.2	-1.0
SME retail	4.1	-48.5	-2.0	12.2	-57.0	-7.3
Equity	1.3	67.3	0.8	0.9	175.4	1.9
Purchased receivables	0.0	75.3	0.1	0.0		
Other exposures	2.8	0.0	0.0	4.8	0.0	0.0
Securitisation	2.3	19.4	0.4	0.4	20.3	0.2
Trading book CP	3.5	5.9	0.2	0.2	15.0	0.0
Specific risk	1.3	0.5	0.0	1.4	-0.2	0.0
General market risk	2.3	-0.6	0.0	1.3	-0.2	0.0
Related entities	8.3	12.2	1.0	4.2	29.7	1.3
Large exposures	0.0	0.0	0.0	0.1	0.0	0.0
Deductions	10.9	0.0	0.0	2.5	-0.1	0.0
Partial use	3.8	-7.3	-0.3	1.9	9.1	0.2
Operational risk			6.3			7.5
Overall change	100.0		-8.3	100.0		-26.6

Source: CEBS (2006a).

Given that the QIS 5 was performed in a relatively favourable macroeconomic environment, characterised by low average PDs, the results are not particularly surprising. However, it should be emphasised that the deviations from the average figures presented in the table are rather significant, depending on the portfolio composition of the individual banks and the quality distribution of exposures within each portfolio segment. It also means that analysing the systemic consequences of Basel II critically depends on these characteristics of banking portfolios and their sensitivity to changes in risk parameters.

3. The analytical framework

In order to analyse the possible effects of the new capital accord, a 'model bank' has been created by using information published in QIS 5 about large, internationally active banks and locally oriented, smaller credit institutions. Throughout the analysis the results of the 'CEBS' group will be used, containing data about banks from EU member states and two accession countries (BL, RO). A basic assumption of the paper is that the portfolio of this 'model bank' corresponds to the average portfolio of CEBS banks. To simplify the analysis, attention will be focussed only on the three asset categories having the highest share within the portfolio: corporate, mortgage and other retail. Moreover, as private sector credit has the strongest direct impact on the real economy, analysing the possible effects of regulatory changes on developments in these categories is of utmost importance from the perspective of financial stability.[12]

3.1. ESTIMATING PD

First, each of these three portfolios is divided further into three additional sub-categories, according to the quality distribution, represented by different PD bands of QIS 5 (see Table 2). In that respect distinctions are made between a 'good' (or high quality), an 'average' (or medium quality) and a 'bad' (or low quality) part of the portfolio. The PD bands provided by QIS 5 and the results of the MRC calculations are then used to determine the average PD for each of these quality bands. The analysis rests on two basic assumptions:

1. In the case of the 'good' and 'medium' categories, the average PD of each asset class is assumed to be the arithmetic average of the PDs at the lower and higher ends of the rather narrow quality bands. Therefore, in the 0%<PD<0.2% band an average PD of 0.1% is assumed for that part of the portfolio. Similarly, in the 0.2%<PD<0.8% band the average PD is assumed to be 0.5%.

2. In the 'bad' category, which is much wider, ranging from 0.8%<PD<99.9%, this averaging method would result in highly unrealistic assumptions. Therefore alternative sources of information provided by QIS 5 are used to generate a more reliable estimate of PD. As the expected change in MRC is known from the QIS exercise, an average PD is estimated for the 'bad' category, which, when used for the calculation of minimum regulatory capital (and taking into account the assumptions above) gives the result for MRC presented in QIS 5.

As an illustrative example, the calculation of PDs for the mortgage portfolio of Group 2 banks is presented in Table 3.

The distribution of the mortgage portfolio within PD bands is known and we also have assumptions about average PDs in the first two quality bands (see Table 2). We also know from QIS 5 that the change in MRC compared to the current regime is -64.6% (see Table 1), i.e. MRC is expected to decline from 4% (8% multiplied by 50% risk weight of Basel I for the mortgage portfolio) to about 1.4%. It is, therefore, possible to make an estimation for the average PD in the 'bad' portfolio segment. As the table below shows, setting the PD for the 'bad' portfolio at 1.85% gives a result of an overall MRC of 1.42%. This figure is 64.5% below the level defined by Basel I and is in line with the results of the QIS 5 exercise.[13]

Naturally, dividing a portfolio only into three quality bands is a substantial simplification of Basel II, which requires banks to establish at least seven rating categories within each asset class for non-defaulted obligors and estimate the associated PDs accordingly. Therefore, robustness checks are necessary to have an idea about the distortion that is most probably caused by these simplifying assumptions. Re-calculating the MRC by using alternative PDs being 20% below or above the original assumptions in the 'bad' category resulted in very similar figures for MRC. The robustness of MRC against alternative assumptions on PDs is mainly a consequence of the relative flatness of the risk weight curves in the high PD area.

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[12] As a further simplification of the analysis, exposure-at-default (EAD) is assumed to be independent of PD. Although this assumption may not necessarily hold in reality, academic research is inconclusive in this field. For more details see Allen–Saunders (2004).

[13] This assumption of PD for the 'bad' portfolio should, however, be considered as a rough estimation only, as in this exercise many relevant factors in capital calculation (e.g. risk mitigation techniques) cannot be controlled for.

Table 2

PD quality distributions

PD bucket	<0.2%	0.2 to 0.8%	0.8 to 99.99%	Defaulted
Group 1				
Corporate	38.5	31.8	27.8	1.9
Bank	86.2	9.1	4.5	0.2
Sovereign	93.4	3.3	3.2	0.1
Retail Mortgage	30.8	34.6	32.7	1.9
Retail QRE	15.6	28.9	51.1	4.4
Other Retail	13.3	21.6	59.5	5.7
SME Corporate	14.1	31.5	50.2	4.3
SME Retail	11.7	24.8	58.4	5.0
Group 2				
Corporate	41.9	32.6	23.0	2.5
Bank	85.3	13.4	1.1	0.1
Sovereign	98.1	1.0	0.6	0.4
Retail Mortgage	35.0	33.4	29.2	1.3
Retail QRE	47.0	23.8	25.8	3.3
Other Retail	23.4	29.4	42.1	5.1
SME Corporate	16.8	27.7	47.8	7.7
SME Retail	10.3	26.2	58.2	5.2

Source: CEBS (2006a).

Table 3

Calculating the average PD for the 'bad' mortgage portfolio of a Group 2 'model bank'

PD band	Share (%) (1)	Average PD (%) (2)	Risk weight (%) (3)	Capital requirements (%) (4)=(1)*(3)*8%	Change in MRC (5)=(4)/4%-1
<0.2%	35	0.1	5.04	0.13	
0.2-0.8%	33.4	0.5	16.53	0.42	
0.8-99.99%	29.2	**1.85**	39.48	0.87	
Defaulted	1.3	100	0.00	0.00	
SUM				**1.42**	**-64.5%**

Note: The 1.06 scaling factor is not taken into account in the calculation.

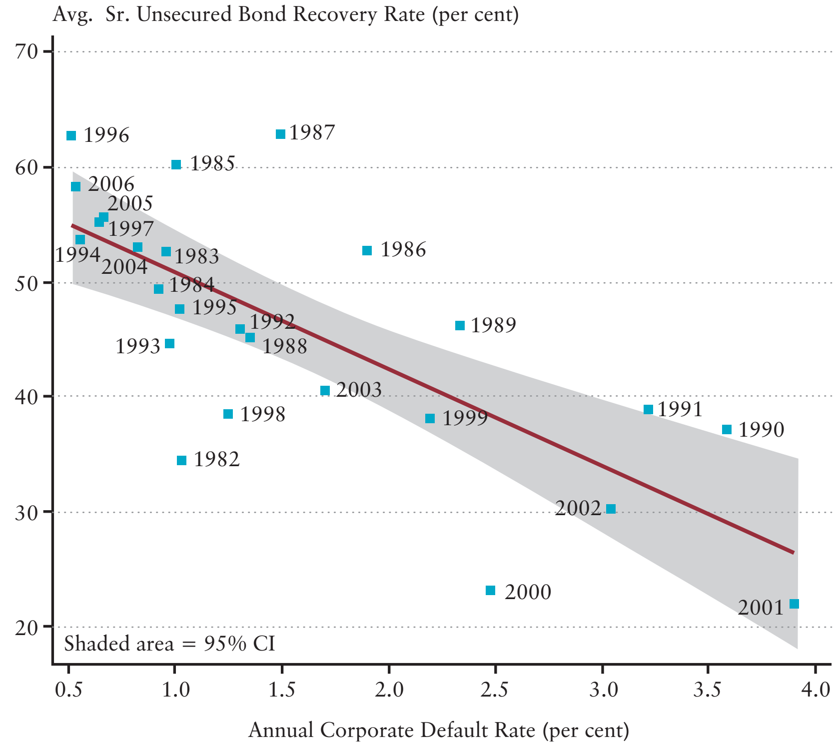
3.2. ESTIMATING LGD

Estimating average PDs for the three quality bands is only a first step in the direction of analysing the sensitivity of a 'model portfolio' to changes in risk parameters. As a second step, we have to estimate LGDs for the different portfolios as well. Moreover, the correlation between PD and LGD should also be taken into account when calculating capital requirements. There is a wide range of literature analysing the relationship between these two parameters, generally drawing the conclusion that a positive correlation is observable between PD and LGD, or in other words, there is a negative correlation between default and recovery rates (Allen–Saunders, 2002; Hu–Perraudin, 2002; Altman et al., 2002, 2005; Bruche–González-Aguado, 2006; Emery et al., 2007).

In an illustrative example, based on Moody's corporate default and recovery rate database, a clear tendency of falling recoveries is detectable when default rates increase. In stress years, such as 1990-1991 and 2001-2002, when the global

Chart 4

Illustrative example about the correlation between default and recovery rates



Source: Hamilton et al. (2007).

economy slowed down substantially, recovery rates were particularly low, indicating that this relationship between risk parameters should not be overlooked when analysing the possible effects of Basel II on financial stability.

As regards LGD, two alternative scenarios are analysed in the paper. First a fixed LGD is assumed, and then the results are compared to an alternative scenario based on variable LGDs as a function of PD. As regards corporate exposures, the fixed LGD is assumed to be 45%, as defined in the FIRB approach. The variable LGD is defined such that a 10% increase in PD leads to a one percentage point increase in LGD. Consequently, the doubling of the default rate (i.e. a 100% increase) is assumed to lead to a 10 percentage point increase in LGD, to 55%, which largely corresponds to the empirical findings of the literature (Allen–Saunders, 2002; Altman et al., 2002, 2005).[14]

As there is no FIRB method defined for the retail portfolio, we should choose an alternative method to make an estimation for average LGD in the mortgage and other retail portfolio. For this purpose the results of the QIS 5 AIRB methods are used. The average LGD of mortgage exposures for G1 and G2 banks using AIRB is 16% and 21%, respectively. Therefore, for the sake of simplicity, a 20% fixed LGD is assumed for the mortgage portfolio. Similarly, the average LGD for the other retail portfolio according to the QIS 5 AIRB method for G1 banks is 48%, and for G2 is 42%, therefore a 45% fixed LGD is assumed in the case of the other retail portfolio. The variable LGD is assumed to behave the same way as in the corporate portfolio: a 10% increase in PD is assumed to raise LGD by one percentage point. Although these assumptions are purely arbitrary, they may help us to better understand the mechanics of the risk weight functions and the incentives created by changes in risk parameters. Naturally, when banks use their own estimates for PD and LGD, the correlation assumed above may turn out to be an overestimation or underestimation of the actual relationship between risk parameters. Nevertheless, this analysis may serve as a benchmark, which corresponds to findings of previous studies on the relationship between PD and LGD, as referred to above.

[14] It should be noted, however, that the relative sensitivity of LGD to changes in PD is not necessarily the same across the whole PD spectrum. Therefore, the results based on the assumptions above should be interpreted with caution.

3.3. ESTIMATING MATURITY

Although maturity adjustment is an important element of the Basel II risk weight function for corporate exposures, less attention has been devoted in the literature to the investigation of this risk parameter and its sensitivity to changes in macro-economic conditions. The FIRB approach assumes a fixed 2.5 years maturity, which is also used in this paper for analytical purposes. However, in order to have a more realistic picture about the possible effects of Basel II, it should also be taken into account that in recession years banks tend to refrain from extending longer term credits, while in boom years long-term lending usually gains ground. These tendencies are partly supported by shifts in borrowers' demand, as they usually claim more short-term liquidity in recession years and increase their demand for long-term (investment) loans in boom years. An important consequence of this phenomenon is that risk weights and capital requirements are also altering, in parallel with changes in maturity. However, given that these changes in maturity affect only new extensions, which make up only a small part of total corporate exposures, it would be unrealistic to assume large swings in the average maturity of a corporate portfolio.

As an alternative hypothesis, the effects of variable average maturity between 2.3-2.7 years are examined in this paper. Depending on the average PD of a quality band, shifts in average maturity are estimated to have minor effects on capital requirements, as the table below reveals. Since these changes are not material from a financial stability perspective, the assumption of variable maturity is omitted from the rest of the analysis.

Nevertheless, from the point of view of a borrower applying for credit, these changes in maturity can have substantial effects on monthly instalments. At any given amount of credit and interest rate, shorter maturity is naturally accompanied by higher instalments, which may screen out some of the less creditworthy borrowers from the banks' portfolio. Alternatively, if borrowers are optimising on instalments, shortening maturities can contribute to slower credit growth in recession years.

Table 4

Risk weights of different quality bands assuming variable maturity

	Good quality		Medium quality		Bad quality	
Maturity (years)	PD=0.1%	PD=0.2%	PD=0.5%	PD=1%	PD=5%	PD=10%
2.3	29.9%	54.5%	71.3%	116.3%	156.3%	247.2%
2.5	31.4%	56.9%	73.8%	119.6%	158.8%	250.2%
2.7	33.0%	59.3%	76.3%	122.9%	161.4%	253.2%

Note: The 1.06 scaling factor is not taken into account in the calculation.

4. Sensitivity of capital requirements to changes in PD and LGD

In this section some basic calculations on the sensitivity of the Basel II risk weights are presented, in order to provide a background for the analysis in the following sections. The logical framework of the paper is illustrated in the chart below. The sequence of analytical steps is as follows:

1. First, the sensitivity of capital requirements to identical relative changes of PDs in different quality bands is investigated, assuming a fixed LGD. This is illustrated on the chart as a move from point A to A' as well as from B to B'. In this illustrative example 'identical relative changes' are interpreted as doubling of the default rates (i.e. from 0.1% to 0.2% and from 0.5% to 1%).

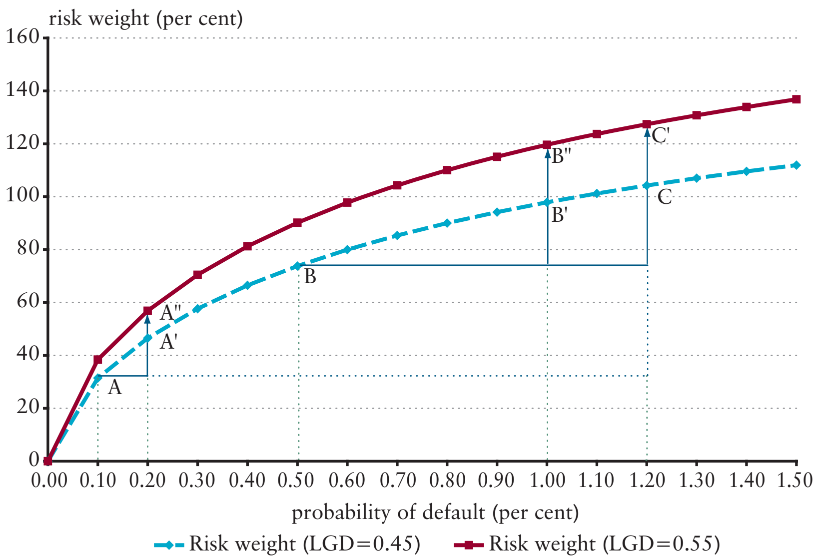
2. Second, changes in LGD are also taken into account. Doubling of the PD is assumed to be accompanied by a 10 percentage point change in LGD, i.e. from 45% to 55% in this example. This is illustrated on the chart as a shift from one risk weight function to another, i.e. from point A to A'' as well as from point B to B''.

3. Third, the assumption about identical relative changes of PDs in different quality bands is relaxed by using historical default data provided by Moody's for corporate exposures. Relative changes in PDs in different rating categories can be different from each other, depending on the state of the economy; therefore, cyclical swings may have various impacts on the PDs of each quality bands. This phenomenon is illustrated as a move from A to A'' for high quality exposures and a move from B to C' for lower quality assets, where a more substantial relative change in PD is assumed.

4. Fourth, the impacts of rating transitions are also investigated during recession and boom years. A certain proportion of assets is down- or upgraded year by year, resulting in changes in the composition of portfolio quality. The effect of this rating drift (downgrade in this example) is illustrated as a move from point A to C' on the chart.

Chart 5

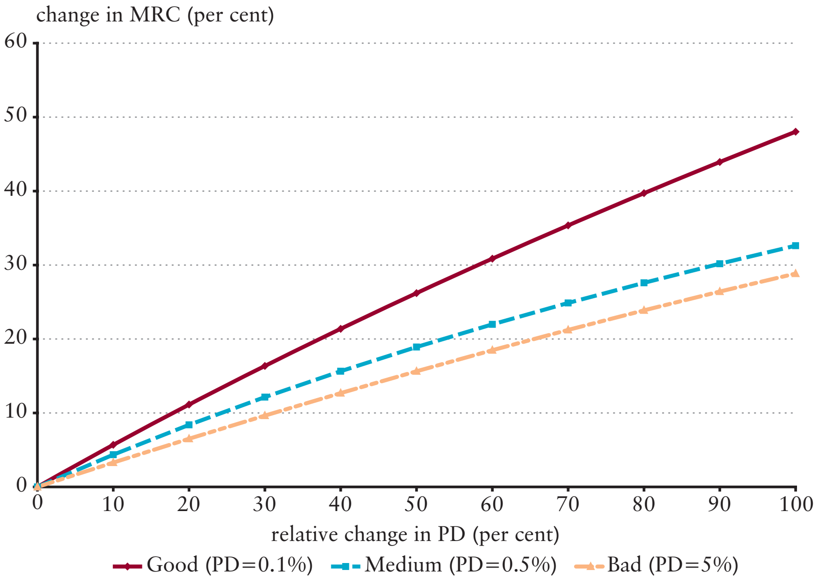
An illustration about changes in risk weight as a function of PD and LGD



The sensitivity analysis, which can be considered as a kind of stress test, can be performed on the basis of alternative assumptions about the extent of relative changes in PD. If a bank has a corporate portfolio, which is divided into 'good', 'medium' and 'bad' quality exposures with original estimated PDs of 0.1%, 0.5% and 5%, respectively, rather diverse responses to changes in PD are observable in different quality classes, as presented in the chart below.

Chart 6

Sensitivity of corporate exposures with different original default probabilities to changes in PD



Note: LGD is assumed to be 0.45.

A 100% increase in PD in case of the 'good' part of the portfolio (i.e. from 0.1% to 0.2%) raises capital requirements set aside to cover unexpected losses of 'good' exposures by nearly 50%. In the meantime, doubling of the average PD from 5% to 10% in the 'bad' portfolio (i.e. a 100% increase of PD) raises capital requirement for that asset class by less than 30%. To put it in another perspective, 0.1 of a percentage point change in average PD of the 'good' portfolio has a substantially stronger effect on relative capital requirements than a change of 5 percentage points in the 'bad' portfolio.

However, taking the combined effects into account as well, a somewhat different picture emerges. Given the relatively low share of capital which has to be set aside to cover unexpected losses of the 'good' portfolio, large swings in default probabilities in the low PD segment have a milder effect on the overall level of minimum regulatory capital. The table below demonstrates how capital requirements change with alternative assumptions on PDs in different quality bands.[15]

It is already clear at this stage of the analysis that the overall sensitivity of a bank's portfolio critically depends on the quality distribution of the assets, as well as the relative changes of PDs within different quality bands. It is, therefore, necessary to analyse how PDs are changing in different asset classes and how the asset composition evolves during the economic cycle, in order to get a view about the dynamic impacts of Basel II on banks' capital levels. This issue will be discussed in chapter VI.

Table 5

Capital requirements calculated with alternative assumptions on changes in PD in different quality bands

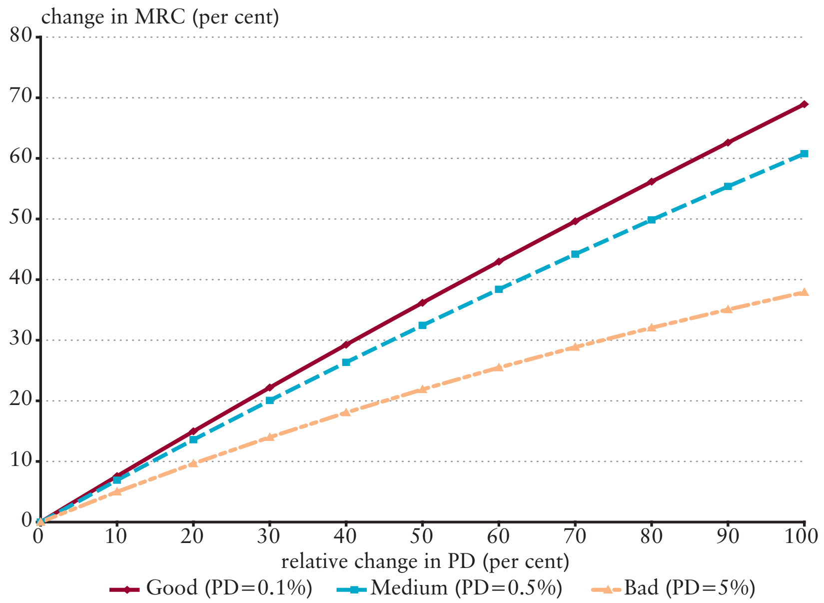
Quality band	Share	PD	PD*	PD**	PD***	PD****
Good	38.5%	0.10%	**0.20%**	0.10%	0.10%	**0.20%**
Medium	31.8%	0.50%	0.50%	**1.00%**	0.50%	**1.00%**
Bad	27.8%	5.00%	5.00%	5.00%	**10.00%**	**10.00%**
Defaulted	1.9%	100.00%	100.00%	100.00%	100.00%	100.00%
Regulatory capital ratio		6.38%	6.84%	6.99%	7.40%	8.47%
Change in capital requirements			**7.29%**	**9.60%**	**15.98%**	**32.87%**

[15] These combined effects will be analysed in more detail in the following chapters, assuming identical relative changes, as well as diverse relative variations in PDs in different quality bands. This latter analysis will rely on Moody's database.

Assuming the same quality distribution of exposures (i.e. an average PD of 0.1%, 0.5% and 5% in different asset classes) for mortgage or other retail portfolio gives similar results, as shown in the charts below. Although low PD assets are more sensitive, the extent of variation differs from the one above. It is also observable that the sensitivity of the other retail portfolio to changes in PD is much lower than that of mortgage exposures in the high PD segment. Consequently, banks focusing on consumer lending and having a significant exposure towards low quality (high PD) retail borrowers do not have to face material changes in capital requirements, even in the case of substantial variations in the average default rate. Naturally, the other side of the coin is that these banks have to make significant provisions or write-offs to cover larger expected losses originating from high PDs and LGDs. This issue will also be analysed in detail in the following chapters.

Chart 7

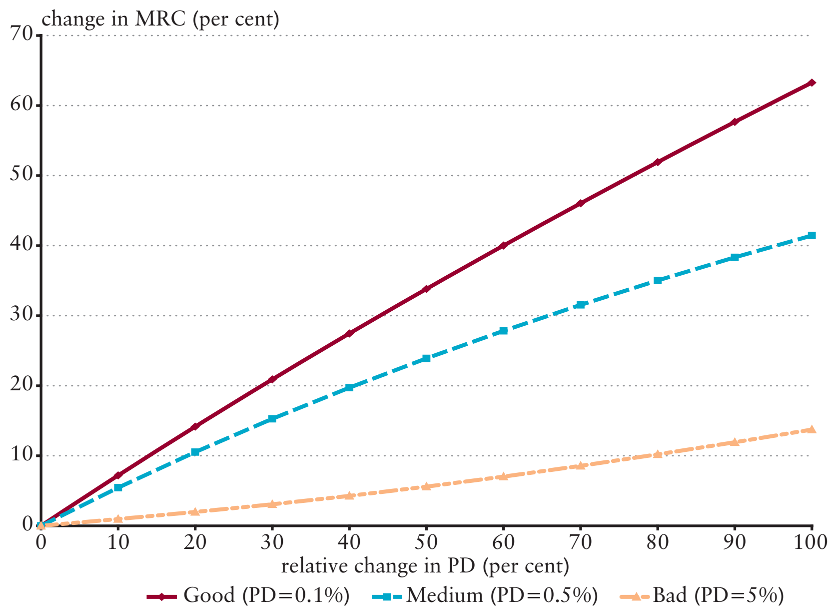
Sensitivity of mortgage exposures with different original default probabilities to changes in PD



Note: LGD is assumed to be 0.2.

Chart 8

Sensitivity of other retail exposures with different original default probabilities to changes in PD

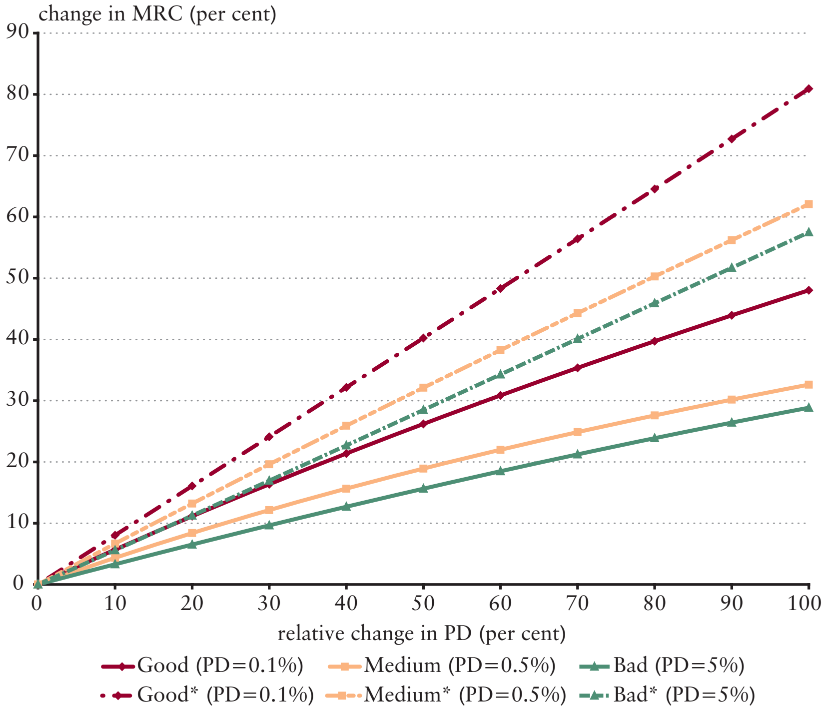


Note: LGD is assumed to be 0.45.

So far we have assumed a fixed LGD for exposures in different asset classes. However, as mentioned before, a positive correlation is detectable between PD and LGD, which may also have an effect on expected and unexpected losses. Re-calculating the variations in capital requirements with changing LGDs gives an even more striking picture about the sensitivity of the portfolio to changes in risk parameters. As we can see from the dotted lines in the charts below, the assumption of positive correlation (i.e. a 10% change in PD accompanied by a one percentage point change in LGD in the same direction) can increase capital requirement quite substantially.

Chart 9

Sensitivity of corporate portfolio to changes in PD and LGD

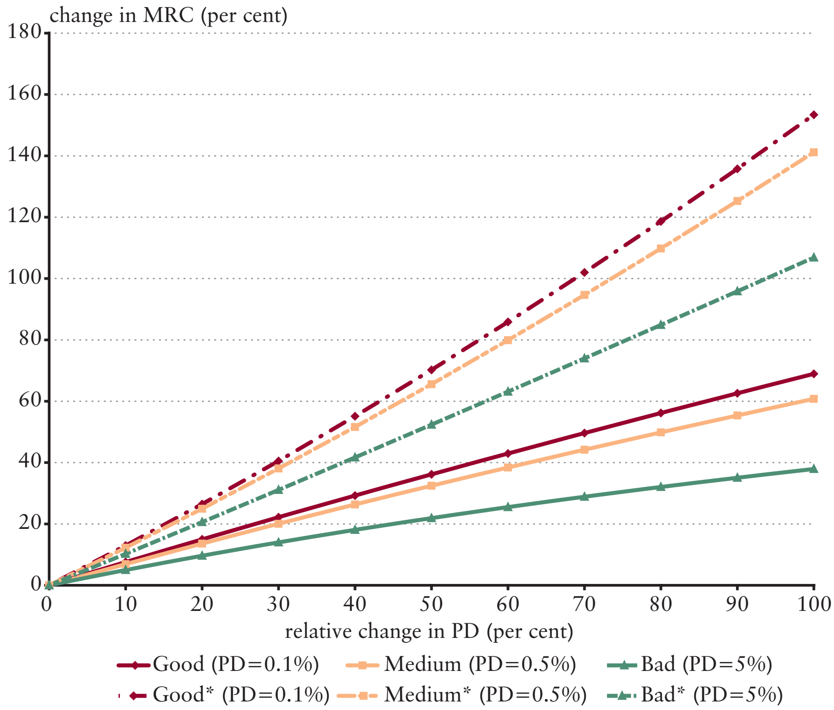


Notes: A 10% increase in PD is assumed to be accompanied by a one percentage point increase in LGD.
The sensitivity of asset classes marked by an asterisk (depicted on the chart with dotted lines) is calculated by assuming variable LGD.

The mortgage portfolio is even more sensitive to changes in LGD, as assumed above. The reason for this behaviour is that average LGD is much lower in the mortgage portfolio (in our case 20%), resulting in a higher relative effect of a one percentage point increase in LGD. For example, a doubling (100% increase) of the default rate in the high quality (low PD) band of the mortgage portfolio (i.e. from 0.1% to 0.2%) accompanied by a 10 percentage point increase in LGD (i.e. from 20% to 30%) results in a 150% increase in capital requirement. Therefore, banks focusing their activity on high quality mortgage lending may face dramatic growth of regulatory capital, should they be exposed to material changes in LGD as well. A possible reason for increasing LGD may be a fall in asset prices during recession years, which is generally accompanied by higher default rates as well.

Chart 10

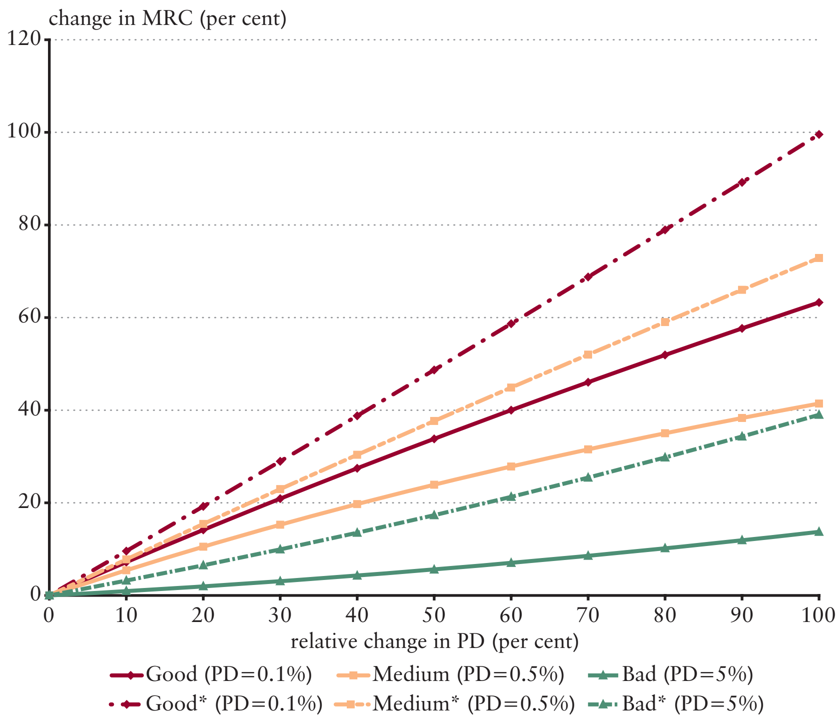
Sensitivity of mortgage portfolio to changes in PD and LGD



Notes: A 10% increase in PD is assumed to be accompanied by a one percentage point increase in LGD.
The sensitivity of asset classes marked by an asterisk (depicted on the chart with dotted lines) is calculated by assuming variable LGD.

Chart 11

Sensitivity of other retail portfolio to changes in PD and LGD



Notes: A 10% increase in PD is assumed to be accompanied by a one percentage point increase in LGD.
The sensitivity of asset classes marked by an asterisk (depicted on the chart with dotted lines) is calculated by assuming variable LGD.

Again, it is important to keep in mind that banks' risk management processes, as well as the level of their risk aversion, may differ substantially. Therefore, on an individual level, the sensitivity of their portfolios to risk parameters may vary accordingly. Throughout the calculation, average PDs and LGDs provided by the QIS 5 exercise and a rather arbitrary assumption on the relationship between them were used, which, even if being in accordance with many empirical findings, may not be valid on the level of individual credit institutions. However, the aim of this part of the study was nothing more than to give an insight into the main characteristics of the risk weight functions and to present some basic calculations that may illustrate the sensitivity of capital requirements in different asset classes and on changes in parameters.

5. Sensitivity of different portfolios of G1 and G2 banks

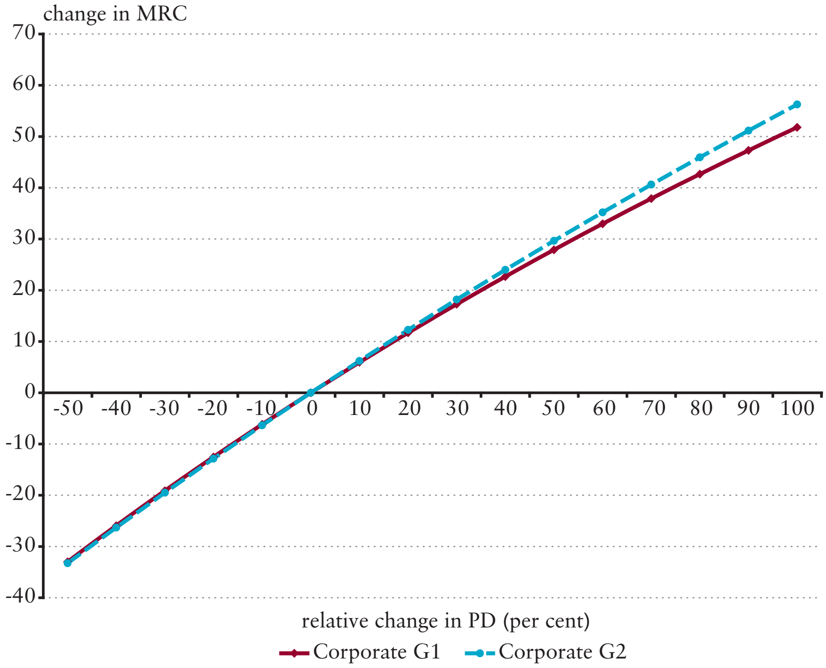
Having a first picture about the mechanics of Basel II risk weight functions, we can now turn towards the analysis of sensitivity of G1 and G2 banks' typical portfolios, taking into account, as a starting point, the estimated PDs in each quality band and the distribution of assets between different quality bands. In this section the estimated effects of changes in PDs is discussed, assuming identical relative movements in PDs in all quality bands. A more differentiated view about relative changes in PDs in corporate assets will be presented in the following section.

As regards corporate portfolio, the quality distribution of assets of G1 and G2 banks are very similar to each other, i.e. the shares of 'good', 'average' and 'bad' portfolios are almost identical (see Table 2). However, the expected changes in minimum required capital according to QIS 5 differ somewhat between G1 and G2 banks. Given that identical PDs are assumed for the 'good' and 'average' portfolio (0.1% and 0.5%, respectively), this divergence in MRCs may result from differences in average PDs in the low quality segment of the portfolio. Calculating the average PD for the 'bad' portfolio in accordance with the method described in the previous sections gives an estimate of 11.7% for G1 banks and a 9.5% G2 banks.[16]

Calculating the combined effect of identical relative changes in all asset classes produces a result illustrated on the chart below. The chart also reveals that halving PDs in every quality band would decrease capital requirement by about a third.

Chart 12

Sensitivity of corporate portfolio of G1 and G2 banks to changes in PD and LGD



Note: A 10% increase in PD is assumed to be accompanied by a one percentage point increase in LGD.

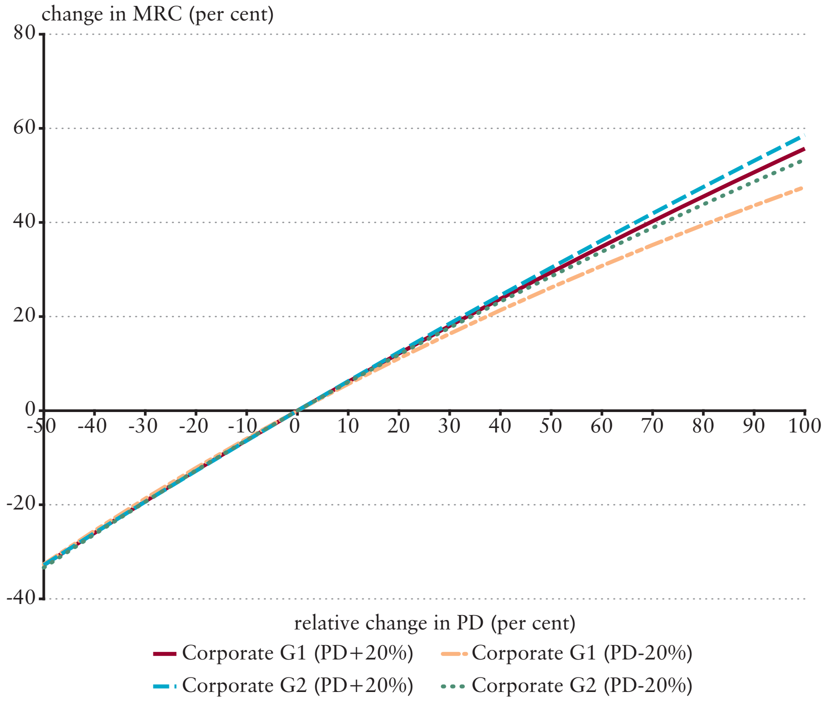
[16] Although these PD figures may seem rather high, it should not be forgotten that this quality band overarches the PD spectrum of 0.8-99.9%, including assets with high PDs, having minor impact on capital but exerting a significant effect on averages.

Despite being rather high, alternative assumptions on average PDs for the 'bad' portfolio do not modify the results of sensitivity calculations significantly, given the relative flatness of the risk weight curve in the high PD segment, as already presented in the previous section.

In order to check the robustness of the results of alternative assumptions on PDs, the figures were recalculated, assuming a 20% lower and 20% higher PD in the 'bad' segment. As the chart below demonstrates, these alternative assumptions do not make the results deviate materially from the original.

Chart 13

Sensitivity of corporate portfolio of G1 and G2 banks to changes in PD and LGD, with different assumptions on the average PD of the 'bad' quality band.

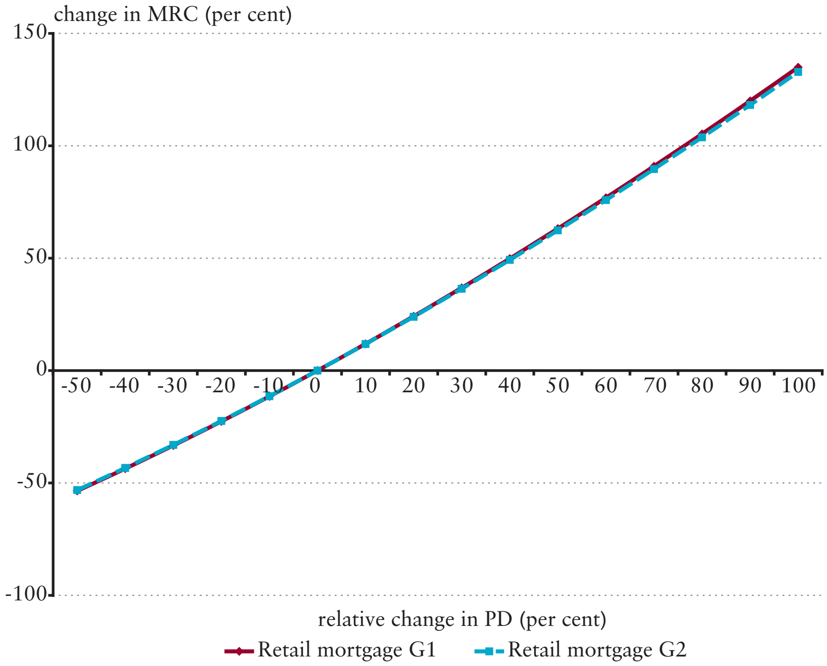


Note: A 10% increase in PD is assumed to be accompanied by a one percentage point increase in LGD.

As regards mortgage portfolio, differences between G1 and G2 banks in portfolio composition and average estimated PDs for each quality band are even smaller than in the case of corporate exposures. Therefore, their overall sensitivity to changes in PD and LGD is practically indistinguishable from the point of view of financial stability.

Chart 14

Sensitivity of mortgage portfolio of G1 and G2 banks to changes in PD and LGD

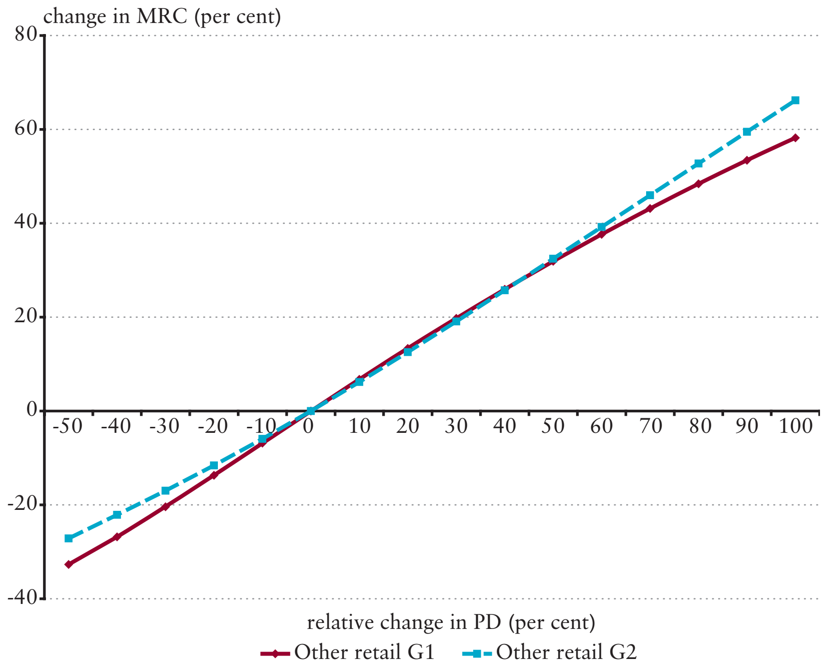


Note: A 10% increase in PD is assumed to be accompanied by a one percentage point increase in LGD.

However, in the case of other retail portfolio, differences in portfolio composition result in measurable deviations in their sensitivity to changes in risk parameters. Nevertheless, this sensitivity is substantially lower than that observed in the mortgage portfolio.

Chart 15

Sensitivity of other retail portfolio of G1 and G2 banks to changes in PD and LGD



Note: A 10% increase in PD is assumed to be accompanied by a one percentage point increase in LGD.

As a general conclusion, both portfolio composition between different market segments (corporate, mortgage, other retail) and quality distribution within each market segment ('good', 'medium', 'bad') have substantial effects on variations in capital requirements. Sensitivity increases as the share of 'low-capital-need' market segments grows within the portfolio (i.e. a shift from corporate to mortgage markets) and as we move from low quality assets to better rated ones (i.e. from 'bad' to 'medium' or 'good'). However, it should be kept in mind that relative changes in PDs are not necessarily identical in all rating classes, therefore the impact of dissimilar shifts in PDs should also be investigated.

6. Cyclicality of corporate capital requirements

In the previous section the effects of variations in PD on capital requirements have been presented, assuming that the default probability changes identically (in relative terms) in all quality classes (e.g. duplicates in every quality band). However, this assumption is rather strict and may not hold in reality. Economic downturns may hit low quality clients more adversely than better rated ones, or vice-versa. Therefore, it is of utmost importance to have a clear view about the behaviour of PDs in different quality bands during a business cycle.

The publicly available database of rating agencies on historical default rates and rating transitions can reveal the behaviour of risk parameters over time in different rating classes. In my paper I use the dataset published by Moody's, currently including data about 5000 companies worldwide and covering the period 1983-2006. This period covers one and a half business cycles, with two recessions, in 1990-91 and 2001-2002. The database contains information about the mean, median, standard deviation as well as minimum and maximum levels of default rates in each alphanumeric rating class. Relying on this dataset, changes of default rates can be investigated over the business cycle in different quality bands.[17] Therefore, our assumptions about the behaviour of this risk parameter can be refined accordingly. However, as regards LGD, our simplifying assumptions should be kept, as no functional relationship can be estimated on the basis of the publicly available data.

6.1. ASSUMPTIONS ABOUT PD

Both the new Basel Capital Accord and the CRD prescribe that banks should use long-term averages when estimating PD for their exposures in each quality band.[18] However, the meaning of 'long-term average' is not defined exactly. Throughout the rest of the paper our 'model bank' is assumed to use 5-year moving averages of historical default rates to calculate its estimations of PD in different asset classes (i.e. the PD estimate for 1987 equals the average default rate between 1983 and 1987). This assumption smoothes out the cyclical swings in PD and therefore could be considered as a step towards a 'through-the-cycle' estimation of PD.

6.2. ASSUMPTIONS ABOUT LGD

As regards the relationship between PD and LGD, two alternative assumptions are investigated. First, a fixed LGD of 45% is assumed, as in the previous sections. Second, besides LGD being 45% around the mean PD, large swings in PD are assumed to affect LGD as well. Should the 5-year average PD be at least 25% higher (or lower) than the long-term (1983-2006, 24 years) average, LGD is assumed to increase (decrease) from 45% to 50% (40%). In the case of a more than 50% increase in 5-year average PD, an LGD of 55% is assumed. Similarly, in years with a 5-year average PD being 50% below the long-term average, LGD is assumed to be 35%.

Table 6

Assumptions relating to LGDs

	$PD5 < PD24 \cdot 0{,}5$	$PD24 \cdot 0{,}5 \leq PD5 < PD24 \cdot 0{,}75$	$PD24 \cdot 0{,}75 \leq PD5 \leq PD24 \cdot 1{,}25$	$PD24 \cdot 1{,}25 < PD5 \leq PD24 \cdot 1{,}5$	$PD24 \cdot 1{,}5 < PD5$
LGD	35%	40%	45%	50%	55%

Note: 'PD5' means the 5-year average PD, while 'PD24' means the long-term (24-year) average PD.

[17] It should be kept in mind that corporations rated by Moody's are acquiring funds from the capital market; therefore, their behaviour in the business cycle is not necessarily the same as those included in banks' portfolios. The rating practices of Moody's as regards corporate exposures and the way ratings should be interpreted is extensively discussed by Hamilton–Cantor (2006).

[18] It is, however, subject to debate as to how historical data should be used for a forward-looking assessment of PD. As Validation Principle 1, issued by CEBS states: 'Validation is fundamentally about assessing the predictive ability of an institution's risk estimates and the use of ratings in credit processes'. In that respect, long-term averages are not necessarily the best estimates of future PDs. For details see CEBS (2006b).

Again, these assumptions are purely arbitrary, serving only as a basis for a better understanding of the mechanics of Basel II and its systemic consequences. Naturally, each and every bank using the AIRB method will have its own estimations of PD and LGD, which may even differ substantially from our assumptions. However, the average of these individual figures cannot be far from the figures used in this analysis, which is based on historical default data of 5000 companies globally and the widely documented positive correlation between PD and LGD.

Table 7 below represents the annual issuer-weighted corporate default rates of selected alphanumeric rating categories, as well as investment grade and speculative grade exposures between 1983 and 2006, provided by Moody's (Hamilton et al., 2007). Rating classes AAA-A are not included in the table, as hardly any defaults occurred in them. The table reveals that rating classes of Baa1 and Baa2 have a long-term mean default rate of 0.105% and 0.107%, respectively, corresponding to our assumption of 0.1% for the 'good' quality band. Therefore, the 'good' part of the portfolio of our model bank is assumed to behave in a cycle

Table 7

Selected Annual Issuer-Weighted Corporate Default Rates by Alphanumeric Rating, 1983-2006

Cohort	Baa1	Baa2	Baa3	Ba1	B1	B2	Investment Grade	Speculative Grade	All Rated
1983	0.000	0.000	0.000	0.000	0.000	10.000	0.000	3.818	0.962
1984	0.000	0.000	1.075	1.156	5.839	18.750	0.095	3.324	0.922
1985	0.000	0.000	0.000	0.000	4.380	7.692	0.000	3.670	1.007
1986	0.000	0.000	4.878	0.870	7.609	16.667	0.318	5.644	1.901
1987	0.000	0.000	0.000	3.731	4.930	4.301	0.000	4.234	1.499
1988	0.000	0.000	0.000	0.000	4.313	7.143	0.000	3.598	1.355
1989	0.000	0.820	1.053	0.794	5.755	9.790	0.286	5.797	2.336
1990	0.000	0.000	0.000	2.667	8.521	22.642	0.000	10.079	3.587
1991	0.730	0.000	0.000	1.064	5.818	13.072	0.064	10.395	3.216
1992	0.000	0.000	0.000	0.000	1.000	1.639	0.000	4.841	1.300
1993	0.000	0.000	0.000	0.820	4.149	5.128	0.000	3.668	0.977
1994	0.000	0.000	0.000	0.000	1.929	3.704	0.000	1.943	0.558
1995	0.000	0.000	0.000	0.000	3.947	7.273	0.000	3.326	1.021
1996	0.000	0.000	0.000	0.000	1.193	0.000	0.000	1.673	0.511
1997	0.000	0.000	0.000	0.000	0.000	1.521	0.000	2.064	0.650
1998	0.000	0.307	0.000	0.000	2.130	7.447	0.037	3.518	1.249
1999	0.000	0.000	0.345	0.485	3.352	6.960	0.035	5.831	2.197
2000	0.288	0.000	0.977	0.950	3.631	3.846	0.131	6.271	2.487
2001	0.274	0.262	0.000	0.533	3.495	10.050	0.126	10.594	3.907
2002	1.238	0.942	1.762	1.657	1.812	6.240	0.513	8.253	3.047
2003	0.000	0.000	0.000	0.548	0.709	2.322	0.000	5.133	1.704
2004	0.000	0.000	0.000	0.000	0.000	0.582	0.000	2.408	0.821
2005	0.000	0.237	0.294	0.000	0.000	0.833	0.059	1.797	0.654
2006	0.000	0.000	0.000	0.000	0.663	0.504	0.000	1.574	0.543
Mean	0.105	0.107	0.433	0.636	3.132	7.004	0.069	4.727	1.601
Median	0.000	0.000	0.000	0.243	3.423	6.600	0.000	3.744	1.275
StDev	0.292	0.256	1.060	0.940	2.489	5.982	0.129	2.730	1.017
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.574	0.511
Max	1.238	0.942	4.878	3.731	8.521	22.642	0.513	10.594	3.907

Source: Hamilton et al. (2007).

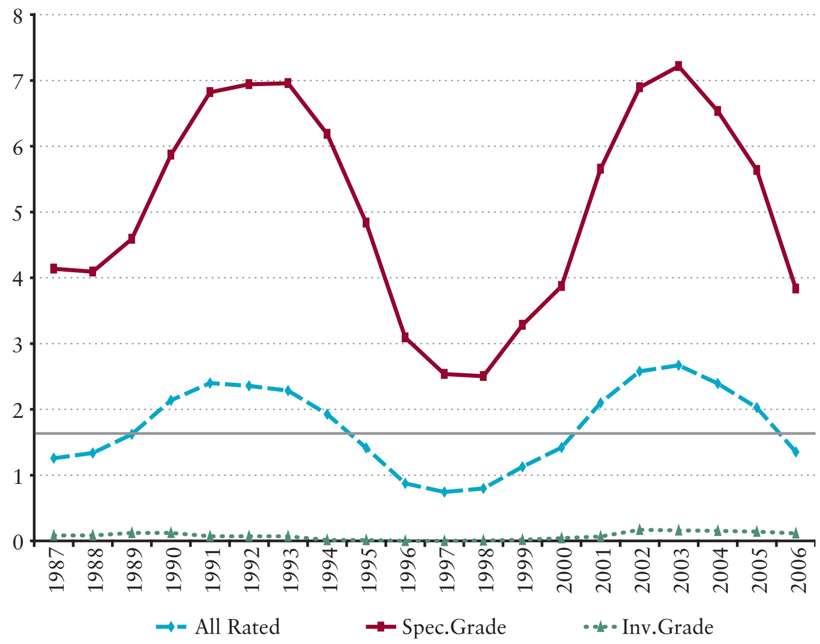
similarly to a Baa1 or Baa2 rated asset class in the Moody's database. Accordingly, Baa3 and Ba1 rating classes with an average default rate of 0.433% and 0.636% correspond to our assumption of 0.5% PD for the 'medium' quality portfolio.

As regards the 'bad' part of the portfolio, it is difficult to assign a single rating to it, as the assumptions about the average PD are rather arbitrary, given the very wide range of 0.8%-99.9% PD for this portfolio segment. Therefore, calculations assuming a B1 rating for this asset class were made with an average PD of 3.132% and, as an alternative scenario, a B2 rating, with an average PD of 7.004%. The distribution of assets among these quality bands is used in accordance with the results of QIS 5 for G1 banks. The reason behind this being that the Moody's database provides a global coverage of corporate exposures, which mainly corresponds to the activity of large, internationally active banks included in Group 1.

The chart below represents the 5-year average default rates for speculative and investment grade assets, as well as the 5-year average default rates for all rated companies. Variations of PD in the investment grade are hardly visible on the chart, as defaults are very infrequent in this asset category. At the same time, however, a clear cyclical pattern is observable in the case of speculative grade assets, having an average PD of around 5%, fluctuating between 2.5% and 7.5%. The amplitude of PD fluctuation in all rated assets is, naturally, much smaller than that of speculative grade exposures.

Chart 16

Five-year average default rates of investment grade and speculative grade assets



Source: own calculations based on Hamilton et al. (2007).

The period 1987-2006 overarches 1.5 business cycles, which is clearly visible on the chart. This phenomenon reveals the importance of the analysis of cyclicality from a financial stability perspective, as substantial cyclical changes in PD are observable, even when using 5-year averages. Consequently, variations in this risk parameter may influence regulatory capital requirements and thus, through changing incentives, banks' behaviour over the cycle as well.

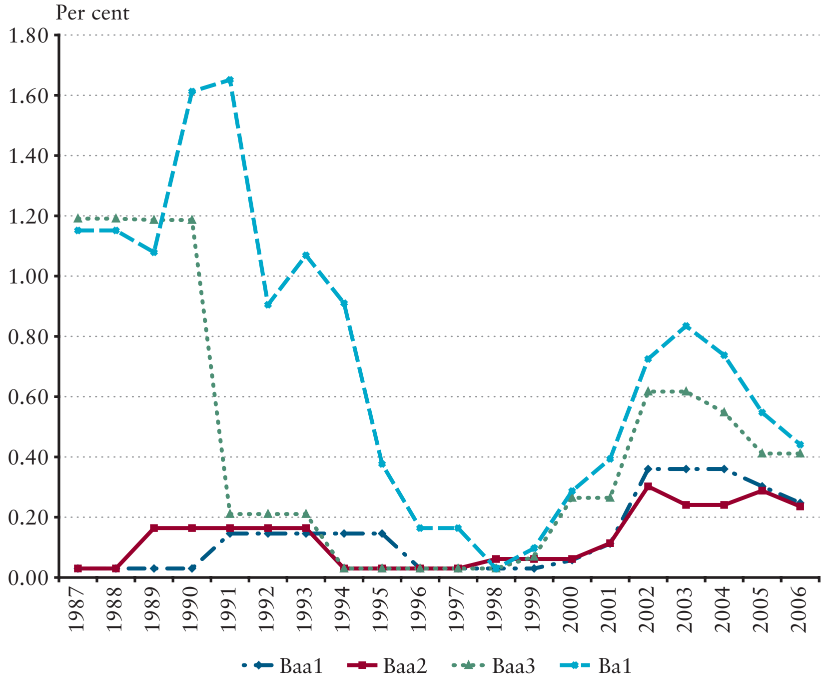
From the point of view of our analysis it is important to emphasise that most of the investment grade assets, with a rating of AAA or AA, have a probability of default well below the floor of 0.03% established by Basel II for the calculation of minimum capital requirements. Therefore, variations below this floor are irrelevant for us, as capital requirement cannot fall below this limit. Moreover, the share of such highly rated companies is usually very small in banks' portfolio, being practically negligible in emerging countries. The focus of our investigation is therefore directed towards the lower end of the investment grade category, having an average PD of about 0.1%.

6.3. CYCLICALITY OF UNEXPECTED LOSSES

Calculating the 5-year average default rates, which are assumed to correspond to the estimated PD for Baa1 and Baa2 ('good'), as well as Baa3 and Ba1 ('medium') rated assets, produces a result shown on Chart 17.

Chart 17

Five-year average default rates of different rating classes mirroring 'good' and 'medium' quality assets



Source: own calculations based on Hamilton et al. (2007).

It is somewhat surprising that the recession periods of the early 1990s and 2000s have had very different relative impacts on high and medium quality assets. The first recession period increased the average PD of the medium quality assets more substantially than the second one. Conversely, highly rated assets were more adversely affected by the burst of the IT bubble in the early 2000s, reaching a close to 0.4% average PD, which is about 4 times as high as the long-term average of 0.1%. This also warns us of the importance of taking into account the relative variations of PD in different asset classes in different periods.

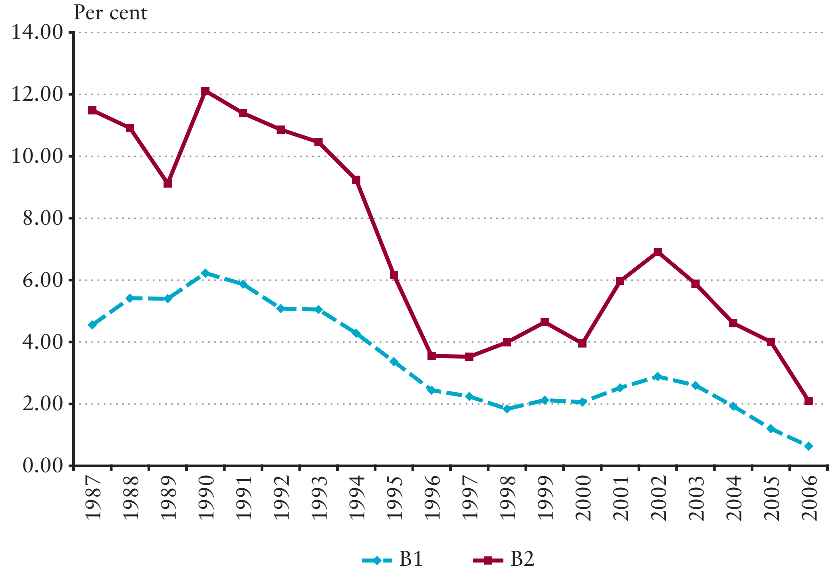
As regards 'bad' quality assets (rated as B1 and B2), a similar pattern is observable as in the case of 'medium' quality exposures. However, due to the multiple numbers of defaults relative to the better rated assets, the evolution of the 5-year average default rate in the B1 and B2 rating classes is illustrated in Chart 18.

As was presented in the previous sections, capital requirements are more sensitive to variations of PD in the high quality segment of the portfolio. The recession period of the early 1990s had relatively modest effects on this asset class, and defaults mainly occurred in the lower quality segments. However, in the early 2000s, when average default rates of the 'medium' and 'bad' quality band were substantially lower than ten years previously, a somewhat higher average default rate in the high quality band was observable. Therefore, taking the combined effects of changing PDs in 'good', 'medium' and 'bad' quality assets into consideration may provide us with a more accurate picture about the evolution of capital requirements, had Basel II been in force during this period.

Chart 19 shows the risk weighted assets as calculated by the Basel II IRB functions for corporate exposures of G1 banks, assuming a 5-year average PD in every quality band, a fixed LGD of 45%, and constant quality distribution over the whole period. For the sake of simplicity and prudence, the 'good' and the 'medium' part of the portfolio of our model bank are assumed to have a rating of Baa2 and Ba1, respectively, and are assumed to behave in the cycle accordingly. As regards the low quality part of the portfolio, two separate calculations were made, assuming a B1 and, alternatively, a B2 rating of this asset

Chart 18

Five-year average default rates of different rating classes mirroring 'bad' quality assets

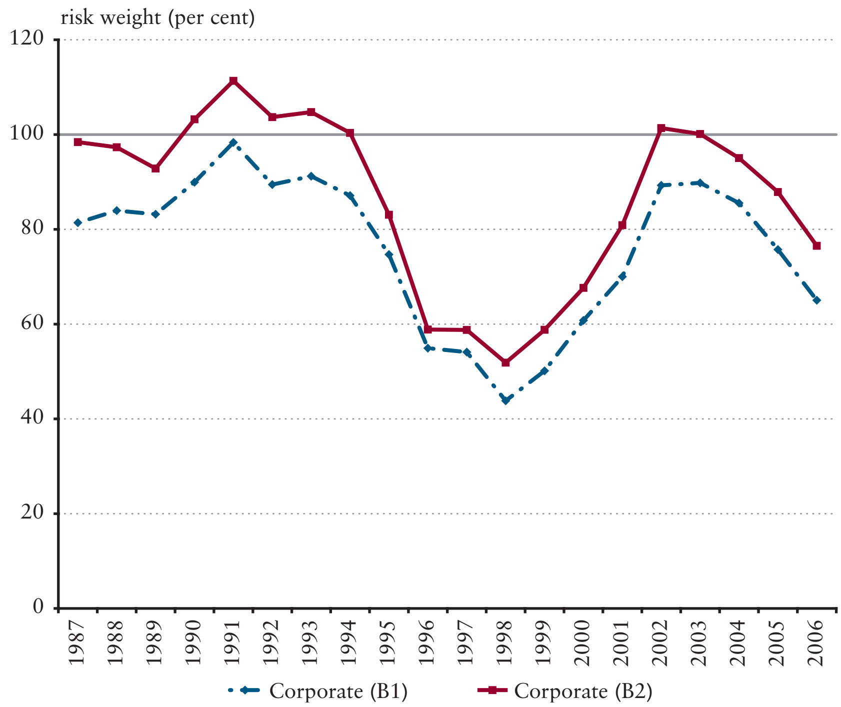


Source: own calculations based on Hamilton et al. (2007).

class, and using the 5-year average PDs calculated from Moody's database. The chart reveals that, on average, the risk weights would have been well below the mandatory 100% of Basel I, irrespective of the assumptions made about the low quality band. It is also observable that, assuming different ratings and, therefore, significantly different average PDs on the 'bad' portfolio (about 3% for B1 and 7% for B2 rated assets, as presented above) doesn't change the shape of the chart materially.

Chart 19

Changes in risk weighted assets over the business cycle assuming fixed LGD

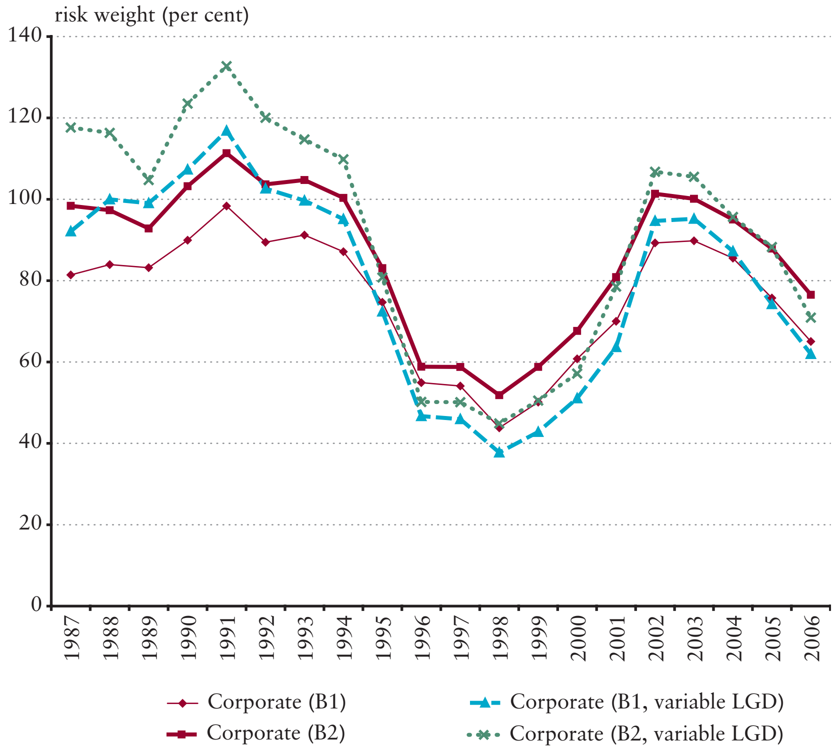


Note: LGD is assumed to be 0.45. The two lines represent different assumptions about the rating of the 'bad' portfolio (B1 and B2).

Refining our calculations by assuming variable LGDs may give us a more realistic view about the expected effects of Basel II on risk weights. As Chart 20 below reveals, changes in LGD result in higher risk weights in recession years (early 1990s and 2000s) and lower weights in boom periods (mid 1990s). Although the shape of the charts remain similar to that calculated assuming fixed LGD, the amplitude of variation of risk weights increases quite substantially in accordance with changes in LGD. In the case of a portfolio composed of assets with rating Baa2, Ba1 and B1, risk weights oscillate between 40% and 120%, and in the case of an assumed rating of B2 for the 'bad' portfolio, risk weighs move between 45% and 130% in the period under investigation.

Chart 20

Changes in risk weighted assets over the business cycle assuming variable LGD



Note: The two solid lines represent different assumptions about the rating of the 'bad' portfolio (B1 and B2). The dotted lines show the effect of variable LGD.

In order to transform risk weights into capital requirements, the results above have to be multiplied by 8%. The chart below shows that, depending on the assumptions concerning the 'bad' portfolio and LGD, the period 1987-2006 would have experienced a capital requirement changing between 3.5% and 10.5% for the corporate portfolio, had Basel II already been in place and had the portfolio composition of banks remained the same during these years.

We can conclude from the exercise that, taking the variation of PD and LGD as well as the correlation between them into account, regulatory capital requirements could multiply within a couple of years, even if using 5-year averages for the calculation.[19] However, this is only one side of the coin. Banks should cover not only unexpected, but also expected losses by reserves (provisions) and current earnings. In the Basel II framework, banks have to calculate their expected losses (EL) by multiplying average PDs, downturn LGD[20] and EAD, and then they should compare this figure with the amount of provisions that are supposed to cover EL.[21] Any shortage in provisions has to be deducted from the capital. Therefore, it is of utmost

[19] The spectacular fall of the hypothetical (Basel II) capital requirements in the mid 1990s also reveals that the banks, operating more advanced internal risk measurement and capital allocation systems, had very strong incentives in these years to free up capital by selling high quality corporate assets, being 'penalized' by the overly strict regulations of Basel I, which required an 8% CAR over the whole period. Not surprisingly, this period was characterised by a massive upsurge of securitization in the developed countries.

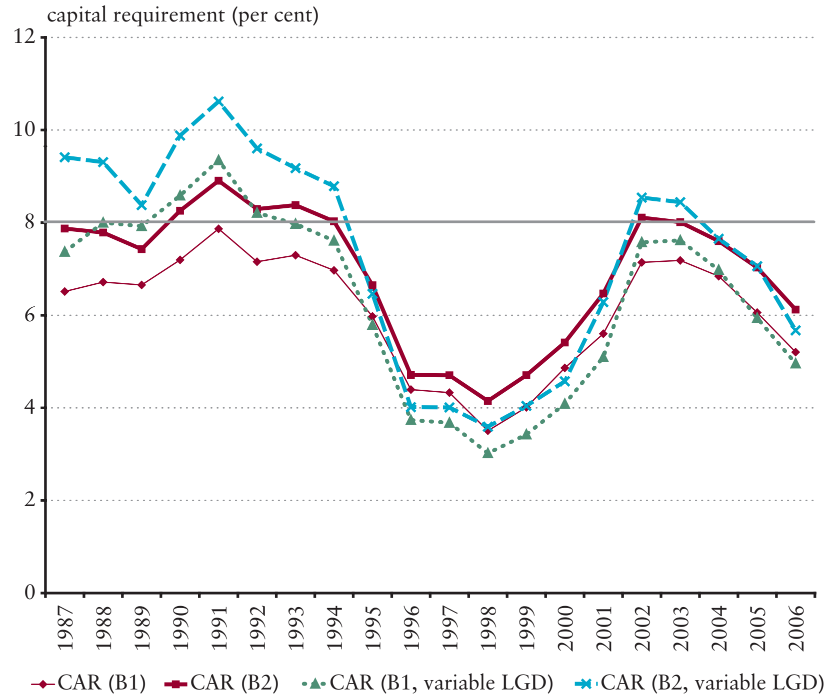
[20] For a discussion about the methods of estimating downturn LGD, see BCBS (2005b).

[21] Due to differences in accounting standards the terms provisions, write-offs, allowances and value adjustments are often used interchangeably in the international literature. I use the term provisions for all of these categories.

importance to have the necessary reserves generated for EL, otherwise it will involve the capital, which serves as a cushion to absorb these types of losses as well.

Chart 21

Changes in capital requirements over the business cycle



6.4. CYCLICALITY OF EXPECTED LOSSES

Using the same assumptions for PD, LGD, correlation and the distribution of assets among quality bands as in the case of UL calculation, we can get a picture about the simultaneous developments in EL as well. The chart below shows the hypothetical evolvement of EL in the period 1987-2006. Here we can see that, contrary to the calculations for UL, the assumptions about the rating (and thus about average PD) of the 'bad' portfolio significantly influence the results. Expected losses would have been much higher in the early 1990s than ten years later, if Basel II had already been in place. Moreover, the difference between EL figures in the same period may be twofold, depending on whether we assume a B1 or B2 rating for the 'bad' part of the portfolio.

As an illustrative example, let us suppose that a bank had a corporate portfolio of EUR 100 million in 1998, which is considered as a year with a low default ratio. Of this portfolio, let 38.5 million be rated as Baa2, 31.8 million as Ba1 and 27.8 million as B1, which mirrors the average quality distribution of G1 banks according to QIS 5 (see Table 2). With the assumptions concerning PD and LGD discussed above, our model bank would have to generate provisions of EUR 212,000 for non-defaulted assets and its capital requirement would have been EUR 3 million in the Basel II framework. Four years later, in 2002, which was a recession year, the provisioning and capital requirement would have increased to EUR 541,000 and EUR 7.5 million, respectively. It should be noted, however, that an unchanged portfolio composition was supposed during these four years, i.e. maturing or defaulting loans dropping out from the portfolio were replaced by loans with the same original rating.

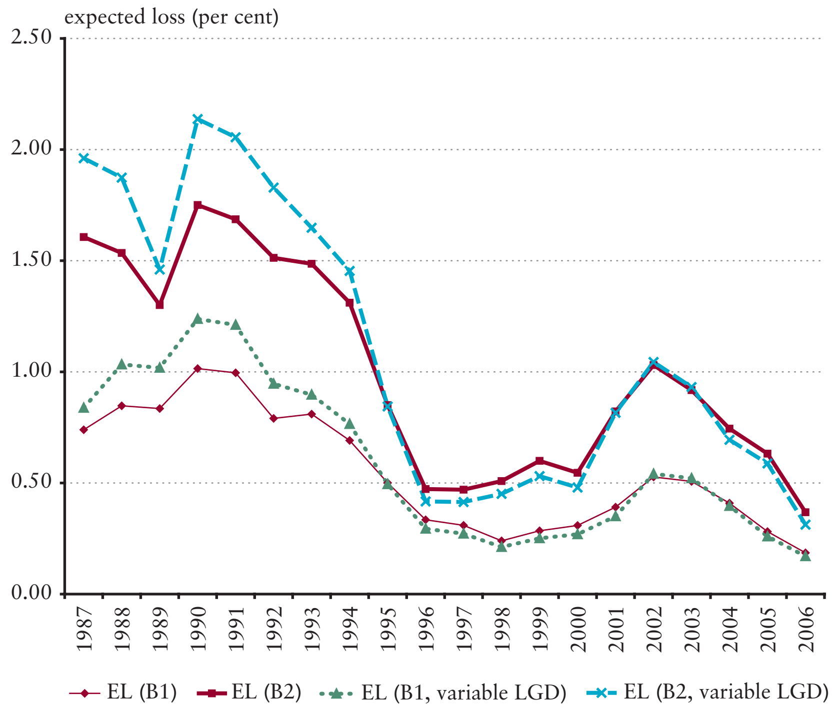
From a financial stability perspective it is important to emphasise that provisions are usually generated from pre-tax earnings, whereas capital is accumulated from earnings after tax.[22] Assuming a tax rate of 20% means that our bank, after generating its additional provisions of EUR 329,000, should accumulate profit before tax of EUR 5,625,000 during these four years. After deducting a 20% tax payment (EUR 1.125 million) these earnings can be used to build up capital reserves by EUR 4.5 million to meet the minimum requirements for regulatory capital (which increased from EUR 3 million to EUR 7.5 million).[23]

[22] For an extensive discussion about the issue of different provisioning practices and their effects on capital, see Laeven–Majnoni (2002).

[23] Note that no dividend payments are assumed in the calculation. Should a bank pay dividends to its owners, its profitability must be even higher.

Chart 22

Expected losses of G1 banks calculated on the basis of 5-year average default rates and alternative assumptions on LGD and rating (B1 v. B2) of the 'bad' portfolio



In this paper no specific assumptions are made about the behaviour of the rest of the portfolio, as we do not have publicly available data concerning the developments of PD and LGD during the business cycle in the mortgage and other retail portfolio. However, it is highly improbable that capital requirements would change only modestly in these portfolios, especially given the high sensitivity of the mortgage portfolio to changes in risk parameters. Nevertheless, concentrating only on the corporate segment also provides us with some useful information about the necessary level of profitability required for a bank to comfortably meet the capital needs to cover unexpected losses defined by Basel II risk weight functions.

Assuming that our model bank intends to maintain a constant capital adequacy ratio (i.e. it operates with a fixed capital buffer ratio over the regulatory minimum), it should generate enough earnings to set aside provisions of EUR 329,000 and to increase its capital reserves by about 5.6 million before tax, which, when summed up, requires a pre-tax profit of approximately 6 million within four years. Not taking external capital in- or outflows into account (e.g. capital increases from investors or dividend payments to the bank's owners), pre-tax return on equity should be at least 30% for four years in a row to meet the increased capital need for corporate exposures.

6.5. IMPACT OF RATING DRIFT

So far a fixed distribution of assets between different quality bands has been assumed. However, especially in recession years, rating drift may be quite substantial, changing the relative share of each quality band within the total portfolio. Moody's database on rating transitions reveals that downgrades tend to dominate years which are characterised by increased default rates, and this tendency of downgrading often continues for a while even when the recession is over. This phenomenon indicates that, despite the efforts of rating agencies to assign a 'through-the-cycle' rating to their clients, ratings are inherently pro-cyclical (Carty, 1997; Nickell–Perraudin–Varotto, 2001; Amato-Furfine, 2004; Moody's, 2004; Posch, 2006). Moreover, cyclical changes in ratings tend to follow the business cycle, instead of leading it, making their predictive power in the anticipation of a cyclical turn rather weak.[24]

[24] However, putting an exposure on watch list has a good predictive power about future changes in ratings. For details see Hamilton–Cantor (2004, 2005).

Table 8

Estimated impact of rating drift on portfolio composition

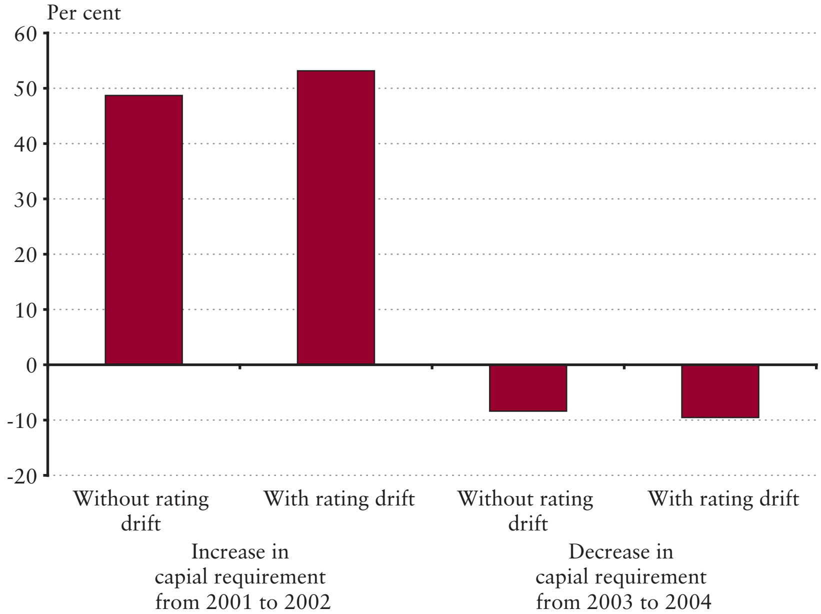
Quality band	Share (QIS 5)	Share 2002	Share 2004
Good	38.5	34	43
Medium	31.8	31	30
Bad	27.8	33	25
Defaulted	1.9	2	2
SUM	100	100	100

As the rating history of every single exposure cannot be followed in the Moody's database, the analysis has to rely on aggregated data in order to have a deeper insight into the cyclical behaviour of ratings. To test the effects of rating drift on capital requirements, a recession year (2002) and a boom year (2004) was chosen, and net shifts between the three asset quality bands of our model bank were calculated. The first class includes assets with ratings Baa1 and Baa2, the second class includes assets rated Baa3 and Ba1, while the rest is classified in the third quality band including assets with rating between Ba2 and B2.

Starting from the QIS 5 quality distribution at the beginning of each year, we can have an estimation about the impact of rating drift of asset quality composition by using transition matrices for 2002 and 2004. These matrices reveal that downgrades by one or two rating classes were suffered by about 11-13% and 3-7% of 'good' quality assets, respectively. Similarly, downgrades from our 'medium' quality band into lower asset classes made up a comparable part of the portfolio, as can be followed in the transition matrix for 2002. Upgrades were quite uncommon in this year. These developments in ratings can help us in creating a new hypothetical distribution for the year end of 2002. Analogously, net upgrades improved the quality composition of the portfolio in 2004, which should also be reckoned with in the analysis. A rough estimation about portfolio compositions after taking rating drifts in 2002 and 2004 into account is represented in the table and the impact on risk weighted assets is depicted in the chart below.

Chart 23

Estimated impact of rating drift on capital requirements



Although the overall effects of rating drift on risk weights and capital requirements are not substantial, for banks operating close to the regulatory minimum these shifts in quality composition may represent additional sources of risk.

7. Conclusions

A wide range of economic literature deals with the problem of exploring the relationship between banks' behaviour and the real economy. There seems to have evolved a consensus among economists that financial development can contribute to macroeconomic development and to the well-being of society; therefore, it is of primary importance to create a stable and smoothly functioning financial system. One of the most important prerequisites of financial stability is a properly designed regulatory framework, which, on the one hand, sets the operational environment and, on the other, creates various incentives for credit institutions. Since these incentives can substantially influence the behaviour of banks, we should devote special attention to the analysis of the incentive structure of any regulatory step and to the careful examination of the potential impact on the financial system.

A major development in financial regulation has been the implementation of Basel II into national law across Europe and in many other countries worldwide. The aim of this paper was to give an insight into some aspects of the incentive structure of Basel II, through the examination of the sensitivity of capital requirements to changes in estimated risk parameters. Having different assumptions about the movements of PD and LGD in the business cycle, as well as about the correlation between them, some estimated effects on minimum regulatory capital were presented. The main conclusions of the paper can be summarised as follows:

1. The QIS 5 exercise has shown that in certain market segments, such as mortgage lending, capital requirements are expected to fall rather substantially. This may free up capital for banks that can be used either for generating capital buffer or for supporting further credit expansion. However, our analysis pointed out that precisely those portfolios are the most sensitive to changes in risk parameters, which experience the largest fall in capital requirements. From a financial stability perspective, careful examination of these 'low-capital-need' portfolios are very important, as in cases of major shifts in risk parameters (such as in recession years), banks concentrating their activities on these markets can become capital constrained, if not having enough buffer to absorb an increase in unexpected losses.

2. It is not only the distribution of portfolio between different market segments (i.e. corporate, mortgage, other retail, etc.) that matters, but also the quality distribution of assets within each part of the portfolio. The very high quality (low PD) segment of the portfolio is rather safe for the banks, as defaults are fairly infrequent among these exposures, even in years of deep recession. However, the lower end of the investment grade category (i.e. rated around Baa), which is still considered to be part of the 'good' portfolio, is substantially more sensitive to relative changes in PD than lower rated exposures. The Basel II risk weight functions were designed to allow a significant decrease in capital requirements for this portfolio segment, which, if used for additional lending instead of creating a capital buffer, may be a source of risk for banks in years with less favourable economic conditions.

3. Capital requirements are very sensitive to changes in LGD, therefore exploring the relationship between PD and LGD is of primary importance from a financial stability perspective. Banking systems across Europe follow fairly diverse practices in collateralization requirements, both in corporate and retail lending, which, in turn, affect LGD ratios. In mortgage lending, for example, differences in LTV ratios, as well as in the extent of using mortgage credit insurance and securitization may be rather substantial, making it practically meaningless to apply an 'average' LGD to the analysis of the possible effects of Basel II on an 'average' mortgage portfolio. Therefore, national authorities responsible for financial stability should pay particular attention to a better understanding of the behaviour of loss rates in mortgage lending, especially if asset price bubbles are supposed to be present in an economy.

4. As regards cyclicality, our analysis focused on the corporate market and found that minimum capital requirements can fluctuate quite substantially in a business cycle, even if long-term (5-year) average default rates are used for estimating PD. The difference between the capital requirement in a recession year and a boom year can easily be twofold, or even more, depending on the quality composition of the corporate portfolio. It is, therefore, inevitable for a bank to build up the necessary reserves in good years to cover expected losses and increased capital requirements in bad years. Both the market (e.g. through pricing of inter-bank funds) and the supervisory authorities (through the supervisory review process in Pillar 2) can and should create the proper incentives for banks to adopt prudent behaviour in boom years, both in provisioning

practices and capital accumulation. According to this analysis, the socially optimal level of capital and reserves are higher than currently required by Basel II in a boom period.

5. Basel II requires that banks have a long-term estimation of PD for the calculation of regulatory capital requirement. However, large internationally active banks often use parameter estimations for measuring their own economic capital needs which is closer to a point-in-time than a through-the-cycle estimation. This may create even more volatility in internal capital requirement calculations, which, in turn, may influence the banks' lending activity even before becoming capital constrained by Basel II. Naturally, banks adjust their business strategies to changes in the macroeconomic environment; therefore, they cut back lending or change their portfolio composition before reaching the regulatory minimum. However, it is precisely this adjustment process which is responsible for increasing the amplitude of lending cycles, being stronger in case of banks operating close to the regulatory minimum.

6. The cyclical behaviour of capital requirements cannot be examined without also taking into account provisioning practices. As presented in my paper, being less sensitive to changes in unexpected loss, low quality segments of the portfolios are particularly exposed to variations in expected loss. However, should a bank's provisioning policy not be able to anticipate the increasing losses, capital buffer would have to be used to absorb (part of) expected losses as well. Therefore, financial stability analysis must focus not only on movements in capital requirements, but also on provisioning practices, the cyclicality of which has to be seriously examined. Moreover, proper pricing of expected losses is also a core issue from the point of view of financial stability.

All the above conclusions should, however, be interpreted with caution. Among the shortcomings of this analysis the following imperfections have to be considered carefully:

1. The quality distribution used in the analysis is based on the results of QIS 5, which, as emphasised before, was conducted in favourable macroeconomic conditions, possibly leading to an over-representation of good quality assets in banks' portfolios. Therefore, the 'through-the-cycle' quality composition of an average portfolio is probably somewhat worse than assumed in my analysis. This may have an effect on sensitivity to changes in risk parameters as well.

2. As the BCBS pointed out (BCBS, 2006a), PD and LGD estimations of banks in the QIS 5 exercise have not always met the requirements of Basel II, i.e. some banks have not used long-term average default rates for estimating PD and downturn loss rates for estimating LGD. Therefore the reliability of PD quality bands as well as LGD estimations presented in QIS 5 tables is somewhat uncertain.

3. Internal models used for estimating risk parameters have not yet been validated by supervisory authorities. Therefore, model misspecifications can, to a certain extent, distort the accuracy of risk parameter estimations.

4. Finally, and probably most importantly, there is no such thing as an 'average bank' in a banking system. This notion can be used for analytical purposes only, modelling the possible impacts of regulatory changes on the system as a whole, where individual differences between banks may cancel each other out. However, should a major bank not be able to meet the regulatory requirements, adverse systemic consequences may arise, even if averages show a favourable picture about the banking sector.

In summary, we can conclude that financial regulation in general, and Basel II in particular, can have significant effects on banks' behaviour by creating various incentives in different phases of the business cycle. Therefore, any institution responsible for promoting financial stability should be particularly cautious when implementing a regulatory measure, and more advanced and sophisticated impact studies are needed in order to estimate their potential effects accurately. An important challenge for researchers is, therefore, to properly determine the effects of changes in risk parameters during the business cycle and to explore the relationship between these parameters in different economic circumstances as precisely as possible. This is a necessary precondition for better understanding banks' behaviour and for detecting the associated risks that may potentially threaten financial stability.

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