“Asset Correlations and Capital Requirements for SME in the Revised Basel II Framework”

AUTHORS	Jan Henneke Stefan Trück

ARTICLE INFO	Jan Henneke and Stefan Trück (2006). Asset Correlations and Capital Requirements for SME in the Revised Basel II Framework. *Banks and Bank Systems*, *1*(1)
RELEASED ON	Tuesday, 18 April 2006
JOURNAL	"Banks and Bank Systems"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
0	0	0

© The author(s) 2026. This publication is an open access article.

BUSINESS PERSPECTIVES

businessperspectives.org

ASSET CORRELATIONS AND CAPITAL REQUIREMENTS FOR SME IN THE REVISED BASEL II FRAMEWORK

Jan Henneke, Stefan Trück

Abstract

This article reviews the final changes in the Benchmark Risk Weight Function of the Basel II proposal as of June 2004. A special focus is directed to the impact of the proposed changes to the segment of Small and Mid-Sized Enterprises (SME). One of the main objectives of the recalibration of the IRB approach was to relieve capital requirements for these institutions. We review the changes in the revised Basel II framework and compare the regulatory approach to empirical results on the relationship between asset correlations, probability of default (PD) and firm size. Empirical findings suggest asset correlations in the market to be lower than those assumed in the capital accord. In a final case study we investigate the implications of changes in regulatory capital on credit spreads for SME. Our findings suggest that as a result of the new capital accord credit spreads will decrease for companies with higher ratings while there will be an increase in interest rate and spread for companies with non-investment grade ratings.

Key words: Basel Capital Accord, SME, Capital Requirements, Asset Correlations.

Introduction

The upcoming new capital accord (Basel II) encourages banks to base their capital requirement for credit risk on internal or external rating systems (BIS, 2001). The accord under the Bank of International Settlements (BIS) becoming effective by year-end of 2007 aims to strengthen the risk management systems of international financial institutions. For credit risk, according to a study by Deutsche Bundesbank (2004) most internationally operating banks will choose the so-called internal ratings based (IRB) approach. Under this approach the amount of capital a bank is required to hold in order to cover potential future losses from a loan, is dependent on the creditworthiness of the obligor. To cite the third consultative document of the Basel capital accord (BIS, 2003):

> *"The IRB approach is based on measures of unexpected losses (UL) and expected losses (EL). The risk-weight functions produce capital requirements for the UL portion whereas the Expected losses are treated separately".*

The measure of UL is in its turn a measure of risk. The most prominent risk measure in the industry is Value-at-Risk (VaR) which was introduced by JP Morgan in the 1990s. One can loosely speak of Value-at-Risk as the amount of capital which can be lost within the next year, if the next year is a *really bad* one. Value-at-Risk is the 95% quantile of the loss distribution and can therefore be quantified as the amount of capital that is lost, if an even worse outcome only had less than a 5% chance (Figure 1). To calculate VaR, a model for the determination of the loss distribution of a bank's portfolio is needed. The Basel committee has adopted the concept of VaR as the main risk measure. However, its measure for UL is not a pure implementation of VaR but relies on VaR as its foundation. The functions in the IRB approach were developed on the basis of survey and model-based evidence and are in that sense an interpolation of empirical and mathematical research. In this paper we review the final changes in the benchmark risk weight (BRW) Function of the Basel II proposal as of June 2004. Our focus is set on the impact of the proposed changes to the segment of SME. We will therefore investigate the regulatory approach to asset correlation and capital requirements for these institutions.

© Jan Henneke, Stefan Trück, 2006

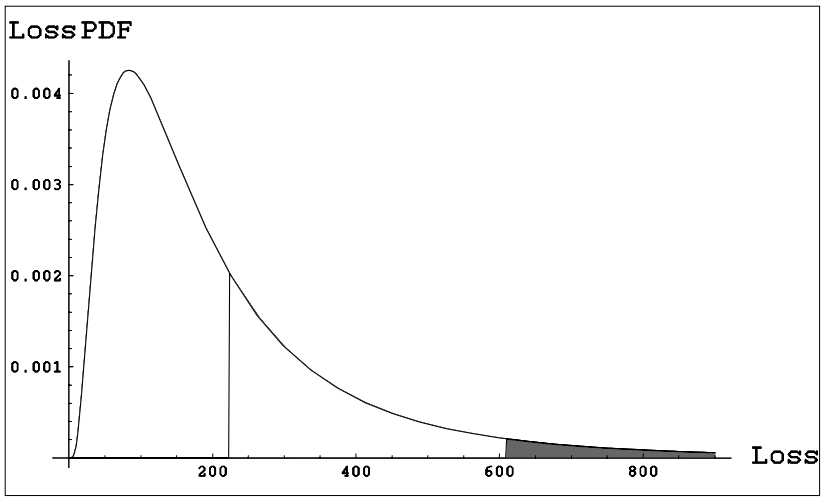

Fig. 1. VaR(95%) and EL. A worse outcome than the VaR(95%) is a loss in the shaded region

The paper is set up as follows. In the next section we present the main input variables and the derivation of the benchmark risk weight function that is used for calculation of the required capital for a loan portfolio in the Basel approach. Then we review the calibration and the changes in the final version of the BRW function from the perspective of capital requirements for SME. Concentrating on the assumed relationship between probability of default (PD), firm size and asset correlation, the regulatory approach will be compared to empirical studies on the issue in the next section. Finally, we provide a case study about the impact of the IRB proposal on the credit conditions for German SME and summarize the results.

The IRB approach – Risk Components, Key Elements and the Benchmark Risk weight function

In this section we give a brief overview of the main ideas and input parameters of the IRB approach for corporate exposures in the new Basel Capital Accord. We further illustrate the one-factor model that is used for derivation of the so-called benchmark risk weight (BRW) function in the IRB approach. This approach relies – in opposite to Basel I or the basic Standardised Approach of Basel II – heavily upon a bank's internal assessment of its counterparty's risk and exposures.

Key elements and Risk Components

According to the consultative document (BIS, 2001), the IRB approach has five key elements:

- A classification of the exposures by broad exposure type.
- For each exposure class, certain risk components which a bank must provide, using standardized parameters or its internal estimates.
- A risk-weight function which provides risk weights (and hence capital requirements) for given sets of these components.
- A set of minimum requirements that a bank must meet in order to be eligible for IRB treatment for that exposure.
- Across all exposure classes, supervisory review of compliance with the minimum requirements.

The capital charge for the exposures then depends on a set of four risk components (inputs) which are provided either through the application of standardised supervisory rules in the foundation methodology, or internal assessments in the advanced methodology:

Probability of Default (PD): All banks – whether using the IRB foundation or the advanced methodology – have to provide an internal estimate of the PD associated with the borrowers in each borrower grade. Each estimate of PD has to represent a conservative view of a long-run average PD for the grade in question and has to be grounded in historical experience and empirical evidence. The preparation of the estimates, the risk management processes, and the rating assignments that lay behind them have to reflect full compliance with supervisory minimum requirements to qualify for the IRB recognition.

Loss Given Default (LGD): While the PD associated with a given borrower does not depend on the features of the specific transaction, LGD is facility-specific. Losses are generally understood to be influenced by key transaction characteristics such as the presence of collateral and the degree of subordination. The LGD value can be determined in two ways: In the first way – respectively under the foundation methodology – LGD is estimated through the application of standard supervisory rules. The differentiated levels of LGD are based upon the characteristics of the underlying transaction, including the presence and the type of collateral. The starting point is a value of 50% for most unsecured transactions whereas a higher value of 70% is applied to subordinated exposures, but the percentage can be scaled to the degree to which the transaction is secured. If there is a transaction with financial collateral, a so-called haircut methodology is used (BIS, 2003). In the advanced methodology LGD – which is applied to each exposure – is determined by the banks themselves. Thus, banks using internal LGD estimates for capital purposes are able to differentiate LGD values on the basis of a wider set of transaction and borrower characteristics.

Exposure at Default (EAD): As with LGD, EAD is also facility-specific. Under the foundation methodology, EAD is estimated through the use of standard supervisory rules and is determined by the banks themselves in the advanced methodology. In most cases, EAD is equal to the nominal amount of the exposure but for certain exposures – e.g. those with undrawn commitments – it includes an estimate of future lending prior to default.

Maturity (M): Where maturity is treated as an explicit risk component, like in the advanced approach, banks are expected to provide supervisors with the effective contractual maturity of their exposures. Where there is no explicit adjustment for maturity, a standard supervisory approach is presented for linking effective contractual maturity to capital requirements.

After introducing the input parameters of the IRB approach we will now briefly describe, how the benchmark risk weight function in the new accord can be derived based on a so-called one-factor credit risk model.

Derivation of the Benchmark Risk Weight Function

In credit risk models the discrete event of default is often modelled with a random variable Y which follows a Bernoulli law. This means that Y can take on either 0 or 1 where we assume that $Y = 1$ indicates the default of the firm. Since the seminal work of Merton in 1972, the so-called structural models using the value of the firm as input variable for determining default probabilities are very popular in credit risk management. In a Merton-style model a firm is said to default if the value of the total assets V drops below a certain threshold D, the contractual value of its obligations. The probability of default thus becomes:

$$P(Y = 1) = P(V < D).$$

The idea of a company defaulting if the value of its assets falls below a threshold c_i is also used in the derivation of the credit Value-at-Risk model of the Basel committee. Let therefore $Z_{i,t}$ be the asset change of company i within a time interval of length t. In the so-called one-

factor models, e.g. (Belkin et al., 1998), $Z_{i,t}$ is considered to have a Gaussian distribution with 0 mean and variance 1. This variable can be decomposed into

$$Z_{i,t} = \sqrt{\rho}\, X_t + \sqrt{1-\rho} \cdot \varepsilon_{i,t}$$

with $X_t \sim N(0,1)$ and $\varepsilon_{i,t} \sim N(0,1)$. The interpretation is that the random effect of the asset value of borrower i is a combination of a systematic risk factor X_t which affects all borrowers, and an idiosyncratic risk factor $\varepsilon_{i,t}$ affecting only borrower i. Then $\sqrt{\rho}$ is often called the factor loading of the systematic risk factor and is interpreted as the sensitivity to systematic risk. Put mathematically it is simply the square root of the correlation coefficient of the asset value process with the systematic risk factor. The probability of default can then be denoted as:

$$P(Y_{i,t} = 1) = P(Z_{i,t} < c_i) = \Phi(c_i).$$

This is the unconditional default probability. If the outcome of the systematic risk factor was known, we could also calculate the conditional probability of default:

$$P(Y_{i,t} = 1 \mid X_t = x) = P(Z_{i,t} \le c_i \mid X_t = x) =$$
$$P(\sqrt{\rho} X_t + \sqrt{1-\rho} \cdot \varepsilon_{i,t} \le c_i \mid X_t = x) =$$
$$P(\varepsilon_{i,t} < \frac{c_i - \sqrt{\rho} X_t}{\sqrt{1-\rho}} \mid X_t = x) = \Phi(\frac{c_i - \sqrt{\rho} X_t}{\sqrt{1-\rho}}).$$

Hereby, Φ denotes the cumulative standard normal distribution function. Having modelled the probability of default for an individual loan, we now have to establish a model for a whole loan portfolio. Consider a Portfolio consisting of n loans to different borrowers where each borrower's probability of default is modelled as described above. We further assume that all borrowers have the same default threshold $c_i = c$. Then conditional on the state of the economy $X_t = x$, the probability of having k defaults in the portfolio is binomially distributed:

$$P\left(\sum_{i=1}^{n} Y_{i,t} = k \mid X_t = x\right) = \binom{n}{k} (p(x))^k (1 - p(x))^{n-k},$$

where

$$p(x) = \Phi(\frac{c - \sqrt{\rho} x}{\sqrt{1-\rho}}).$$

Using the law of iterated expectations the probability of k defaults is the expected value of the conditional probability of k defaults:

$$P\left(\sum_{i=1}^{n} Y_{i,t} = k\right) = \int_{-\infty}^{\infty} P\left(\sum_{i=1}^{n} Y_{i,t} = k \mid X_t = x\right) \Phi(x) dx =$$
$$\int_{-\infty}^{\infty} \binom{n}{k} (\Phi(\frac{c - \sqrt{\rho} x}{\sqrt{1-\rho}}))^k (1 - \Phi(\frac{c - \sqrt{\rho} x}{\sqrt{1-\rho}}))^{n-k} \Phi(x) dx.$$

Having described the theoretical model of defaults, we will now investigate how these equations are linked to the Basel IRB framework. As it was mentioned above the IRB functions are based on the VaR measure. Given the probability of k defaults in a homogenous portfolio of size n, the cumulative loss distribution function of the portfolio is:

$$P\left(\sum_{i=1}^{n} Y_{i,t} \le m\right) = \sum_{k=0}^{m} \int_{-\infty}^{\infty} \binom{n}{k} (p(x))^k (1-p(x))^{n-k}\, \Phi(x)dx .$$

Thus, to determine for example the VaR at the 99.9% level one would need to compute $P^{-1}(0.999)$. This is tedious work and has to be done numerically. Fortunately, VaR can be approximated efficiently in one-factor models. The most prominent article is due to Gordy (2002) and provides a portfolio-invariant rule for capital charges at the level of a single loan and thus the foundation of the Basel IRB function. Let $\alpha_{0.999}$ denote the adverse 99.9% quantile of the state of the economy X_t, meaning that a worse outcome of the systematic risk factor only has a 0.01% chance. Since X_t is standard normally distributed with small values of X_t being unfavourable to a firm, $VaR(99.9\%) = \Phi^{-1}(0.001)$. Conditional on this *bad* state of the economy, the probability of default for an individual loan is:

$$P\left(\sum_{i=1}^{n} Y_{i,t} = 1 \mid X_t = \alpha_{0.999}\right) = \Phi\left(\frac{c_i - \sqrt{\rho}\,\Phi^{-1}(0.001)}{\sqrt{1-\rho}}\right)$$

and the expected loss on the loan is:

$$E\left[L_i \mid X_t = \alpha_{0.999}\right] = LGD \cdot \Phi\left(\frac{c_i - \sqrt{\rho}\,\Phi^{-1}(0.001)}{\sqrt{1-\rho}}\right).$$

Gordy (2002) shows how the sum of these expected conditional losses approaches the true VaR(99.9%) of the whole loan portfolio. For regularity conditions and the exact type of convergence we refer to Gordy (2002). The threshold c_i can be determined from the PD of the respective loan in the following way:

$$PD_i = P(Y_{i,t} = 1) = P(Z_{i,t} < c_i).$$

With $Z_{i,t} \sim N(0,1)$ we get

$$PD_i = \Phi(c_i) \quad \Leftrightarrow \quad \Phi^{-1}(PD_i) = c_i .$$

This leads us to the core of the Basel IRB function to determine the regulatory capital charge on a single loan. With the fact that the standard normal distribution is symmetric around the origin we get the core of the benchmark risk weight function in the new Basel capital accord:

$$E\left[L_i \mid X_t = \alpha_{0.999}\right] = LGD \cdot \Phi\left(\frac{\Phi^{-1}(PD) + \sqrt{\rho} \cdot \Phi^{-1}(0.999)}{\sqrt{1-\rho}}\right).$$

In the following we will take a look at the calibration of this function with focus on its effect on capital requirements for SME.

Calibration of the Benchmark Risk Weight Function

The January 2001 Consultative Document

In the previous section we introduced the key risk factors according to the Basel committee and illustrated the derivation of the benchmark risk weight function. According to the second consultative document (CP2) the risk weighted assets (RWA) should be calculated using the formula (BIS, 2001):

$$RWA = \min\left[\frac{LGD}{50} \cdot K(PD) \cdot (1 + b(PD) \cdot (M - 3); 12.5 \cdot LGD\right].$$

Obviously next to the probability of default PD also the factors Loss Given Default LGD and maturity M enter the calculation of risk weighted assets. The factor $b(PD)$ is a maturity adjustment and $K(PD)$ the calibrated benchmark risk weight function. Especially in the advanced IRB approach, maturity is treated as an explicit risk component. The sensitivity of a loan's end-of-horizon value to credit quality deterioration short of default is dependent on its maturity. As a consequence, maturity has a substantial influence on economic capital within so-called mark-to-market (MTM) models, with longer-maturity loans requiring greater economic capital. The schedule of maturity adjustment factors was based on an underlying MTM calibration approach. The calibration of $b(PD)$ according to the committee was a smooth functional relationship between PD and $b(PD)$ according to:

$$b(PD) = \frac{0.023 \cdot (1 - PD)}{PD^{0.44} + 0.047 \cdot (1 - PD)}.$$

Further, the calibrated benchmark risk function was of the form:

$$K(PD) = 976.5 \cdot \Phi\left(\frac{\Phi^{-1}(PD) + \sqrt{0.20} \cdot \Phi^{-1}(0.995)}{\sqrt{1 - 0.20}}\right) \cdot \left(1 + 0.047 \cdot \frac{1 - PD}{PD^{0.44}}\right).$$

It is easy to see that the parameter for the asset correlation in the 2001 proposal was set to $\rho = 0.20$ for all loans while the quantile for Value-at-Risk calculation was set to the 99.5% level. Further the above expression consisted of three separate factors. The first term 976.5 was a constant scaling factor to calibrate the $K(PD)$ to 100% for PD = 0.7% and LGD = 50%. The second term $\Phi\left(1.118 \cdot \Phi^{-1}(PD) + 1.288\right)$ represented the sum of EL and UL and was associated with a hypothetical, infinitely-granular portfolio of a one-year loan having a LGD of 50%, based on the idea of the one-factor model as it was decribed in the previous section. The last factor $\left(1 + 0.047 \cdot (1 - PD) / PD^{0.44})\right)$ was an adjustment due to the fact that the benchmark risk weights for loans were calibrated to a three-year average maturity. Some exemplary risk weights for given PDs according to the second consultative document are presented in Table 1. It should be noted that there is a minimum risk weight of 14.1 based on a 0.03%-floor which was imposed for PD values by the committee. The floor is due to the committee's evaluation of banks difficulties in measuring PDs adequately. Further the risk weights were capped at 625% which corresponds to a PD of exactly17.15%.

Table 1

Exemplary Benchmark Risk Weights for Corporate Exposures according to the second consultative document of January 2001

PD (in %)	BRW (in %)	PD (in %)	BRW (in %)
0.03	14.1	1.0	125.0
0.05	19.1	2.0	192.4
0.1	29.3	3.0	246.0
0.2	45.1	5.0	331.4
0.4	69.9	10.0	482.4
0.5	80.6	15.0	588.0
0.7	99.8	20.0	625.0

Criticism of the CP2 IRB Approach

The suggestions of the IRB approach of the second consultative document (BIS, 2001) were subject to extensive discussions. Especially SME were afraid of higher capital costs for banks that would lead to worse credit conditions for these companies. Also the desired incentive character of the IRB approach for banks was very questionable, since risk weights in many cases were rather higher for the IRB approach than for the STD approach. There was a clear tendency in the IRB approach of assigning lower risk weights to companies with a very good rating and much higher risk weights to such companies with a rating worse than BB-. Since especially SME could rarely obtain a rating in one of the first three categories, according to CP2 banks would have to hold a higher amount of capital for such companies. Therefore, SME and companies with a rating in the speculative grade area were afraid to suffer from higher capital costs for the banks that would be passed down to the companies.

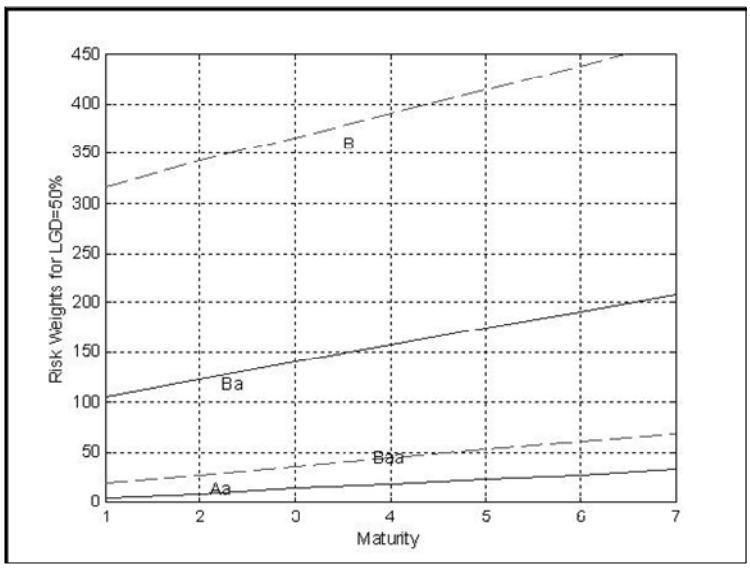

Fig. 2. Assigned Risk Weights in CP2 as a function of Maturity for different ratings

Another questionable issue was the assumed linear relationship between maturity and the assigned risk weights of the second consultative document (Figure 2). Comparing the assigned risk weights to actually observed spreads in the market, one could find that for high rated bonds credit spreads rise with longer maturities. This behavior matches the model of the Basel committee where higher risk weights are assigned to exposures with longer maturities. However, especially

for lower rated bonds market credit spreads do not show a positive correlation with maturity. For *Ba* rated bonds the spreads are constant while for single *B* rated bonds the spreads fall from year one. The reason for the falling credit spreads in lower rating categories can be explained empirically by the fact that as the threat of default recedes, risk neutral investors require a smaller yield spread to compensate them for expected default loss. This market behavior of credit spreads was not incorporated in CP2. Even worse, many SME were afraid that due to higher risk weights for long-term loans, banks could even refuse to make such contracts anymore.

The problems and criticism mentioned above were also confirmed by so-called quantitative impact studies (QIS) conducted by banks for the Basel committee. According to a study for several of the G10 major banks the capital requirements would have been between 6% and 14% higher. Therefore, the goals of the accord to keep the overall capital unchanged were not satisfied. Thus, obviously to match the goals set by the committee there was need for a revision of some features in the accord – especially for the BRW function in the IRB approach that should provide an incentive for banks to refine their risk management procedure.

Changes in the final version of the IRB approach

Due to the severe criticism of the second consultative document there were several changes in the Basel Capital Accord until June 2004, when the final version of the framework (BIS, 2004) was published. In this section we will illustrate the most important changes in the final version with respect to the effect on capital requirements especially for SME.

Treatment of SME

One of the major criticism was the treatment of more risky loans or companies in the new accord. Generally, SME borrowers are defined as companies with less than Euro 50 Million in annual sales, e.g. in Germany more than 90% of the companies will fall into this class. In recognition of the different risks associated with SME borrowers, under the IRB approach for corporate credits, banks will now be permitted to separately distinguish loans to SME borrowers from those to larger firms. Banks that manage small-business-related exposures in a manner similar to retail exposures will be permitted to apply the less capital requiring retail IRB treatment to such exposures, provided that the total exposure of a bank to an individual SME is less than Euro 1 Million. Such exposures are then treated the same way as credits to private customers. The committee assumes that this should result in an average reduction of approximately ten percent across the entire set of SME borrowers in the IRB framework for corporate loans. Furthermore, several changes in the benchmark risk weight function that will be described later were especially designed to reduce regulatory capital for exposures to SME.

Changes in the Maturity Adjustment Term

A second criticised drawback was the assigned maturity adjustment in CP2, especially the linear relationship between maturity horizon and the assigned risk weights for more risky loans. In the IRB foundation approach all exposures will now be assumed to have an average maturity of 2.5 instead of 3 years. Additionally, in the advanced IRB approach in recognition of the unique characteristics of national markets, supervisors will have the option of exempting smaller domestic firms from the maturity framework. In this framework smaller domestic firms are defined as those with consolidated sales and consolidated assets of less than Euro 500 Million. If the exemption is applied, those firms will be assumed to have an average maturity of 2.5 years, as under the foundation IRB approach. For firms with sales greater than Euro 500 Million in the advanced IRB approach the maturity adjustment will be included according to the factor

$$\frac{(1+b(PD)\cdot(M-2.5)}{1-1.5\,b(PD)}$$

with

$$b(PD) = 0.011852 - 0.05478\log(PD))^2 .$$

The denominator in the fraction can be interpreted as an adjustment to the average maturity of 2.5 years while the numerator is the maturity adjustment based on the PD of the exposure and its maturity. Table 2 shows the exemplary maturity adjustments compared to a one-year maturity of an exposure. Obviously for exposures with higher default probabilities the effect of the maturity is much smaller than for higher rated exposures. This indicates the intention of the Basel committee to avoid particularly high benchmark risk weights and thus, capital requirements for exposures to SME with longer maturities.

Table 2

Maturity Adjustments subject to PD in the June 2004 Version of the Basel Capital Accord. Factors in comparison to an exposure with a one-year maturity

PD	M=1	M=2	M=2,5	M=3	M=4	M=5
0,03%	1,000	1,604	1,906	2,208	2,811	3,415
0,05%	1,000	1,501	1,752	2,002	2,504	3,005
0,10%	1,000	1,392	1,588	1,784	2,177	2,569
0,50%	1,000	1,223	1,334	1,446	1,669	1,892
1,00%	1,000	1,173	1,260	1,346	1,520	1,693
5,00%	1,000	1,091	1,136	1,182	1,272	1,363
10,00%	1,000	1,066	1,099	1,132	1,197	1,263
15,00%	1,000	1,053	1,080	1,107	1,160	1,214
20,00%	1,000	1,046	1,068	1,091	1,137	1,183
25,00%	1,000	1,040	1,060	1,080	1,120	1,160
30,00%	1,000	1,036	1,054	1,072	1,108	1,143

The refined BRW function

As a consequence of the fair comment on the risk weight function assigned in the IRB approach the Basel committee imposed a refined version of the function. The modified formula relating probability of default, asset correlation, firm size and maturity to capital requirements differs from the formula proposed in the second consultative document in several ways.

The formula in the second consultative document incorporated an implicit assumption that asset correlations for all exposures are equal to 0.20. The new formula assumes that the asset correlation declines with PD and decreases with the size of the firm according to the following relationship (for $5 \le S \le 50$):

$$\rho(PD;S) = 0.12 \cdot \left(\frac{1-e^{-50*PD}}{1-e^{-50}} \right) + 0.24 \cdot \left(1 - \frac{1-e^{-50*PD}}{1-e^{-50}} \right) - \left(1 - \frac{S-5}{45} \right) \cdot 0{,}04 .$$

Note that for $S > 50$ the last term will take the value of 0, while for $S < 5$ it takes the value of 0.04. Ignoring the adjustment for the size of the company, for the lowest PD value the asset correlation equals 0.24 and for the highest PD value it is equal to 0.12. Additionally, between 0 and 0.04 can be subtracted from the value of the asset correlation according to the size of the company. For companies with a turnover of Euro 5 Million or less the assumed asset correlation is reduced by 0.04 while for companies with a turnover greater than Euro 50 Million there is no reduction of the assumed asset correlation at all. In between there is a linear relationship. Since the topic of asset correlations will be treated more extensively in the next sections we will only present exemplary correlations for several combinations of PD and turnover S in Table 3. Again the intention of the Basel committee to reduce benchmark risk weights for exposures to SME with higher PDs is obvious.

Table 3

Model Asset Correlations for different combinations of PD and company size S measured in turnover, compared to the CP2 formula

PD	CP2	S = 5	S = 15	S = 25	S = 50
0,03%	0.2	0.20	0.21	0.22	0.24
0,05%	0.2	0.20	0.21	0.21	0.24
0,10%	0.2	0.19	0.20	0.21	0.23
0,50%	0.2	0.17	0.18	0.19	0.21
1,00%	0.2	0.15	0.16	0.17	0.19
5,00%	0.2	0.09	0.10	0.11	0.13
10,00%	0.2	0.08	0.09	0.10	0.12
15,00%	0.2	0.08	0.09	0.10	0.12
20,00%	0.2	0.08	0.09	0.10	0.12
25,00%	0.2	0.08	0.09	0.10	0.12
30,00%	0.2	0.08	0.09	0.10	0.12

Another major change is that there is no explicit scaling factor in the formula anymore. Also the confidence level that was implicit in the formula has been increased from 0.995 to 0.999 to cover some of the elements previously dealt with by the scaling factor. This value enters the main formula for the capital requirement and risk-weighted assets. With the given confidence level and $\Phi^{-1}(0.999)$, the resulting formula is the following:

$$RWA_i = K(PD, \rho) \cdot 12.5 \cdot EAD$$

with

$$K = LGD\left[\Phi\left(\frac{\Phi^{-1}(PD) + \sqrt{\rho} \cdot \Phi^{-1}(0.999)}{\sqrt{1-\rho}}\right) - PD\right] \cdot \frac{(1 + b(PD) \cdot (M - 2.5)}{1 - 1.5\, b(PD)}.$$

Again Φ denotes the cumulative standard normal distribution function. The total risk weighted assets are simply the sum over all individual values.

The effects of the changes in the benchmark risk weight function are illustrated in Figure 3. Recall that one objective of the changes was to reduce the burdens of the IRB approach to the sector of SME. Firms in this segment usually have lower ratings. Moving from a fixed capital charge of 8% to the IRB approach from the January proposal yielded a steep risk weight curve. It resulted in heavy capital charges, especially for borrowers in lower rating categories. The new version of the BRW function shows, how the risk weights have been reduced significantly for borrowers with PDs above 1.0% (at this PD level one usually refers to loans as being in the non-investment grade, i.e. BB and below).

Expected, Unexpected Losses and the Required Capital

Finally, a novelty in Basel II is the calibration of the risk weights only to unexpected losses. Therefore, the expected loss is subtracted from the total loss:

$$UL = LGD \cdot \Phi\left(\frac{\Phi^{-1}(PD) + \sqrt{\rho} \cdot \Phi^{-1}(0.999)}{\sqrt{1-\rho}}\right) - LGD \cdot PD.$$

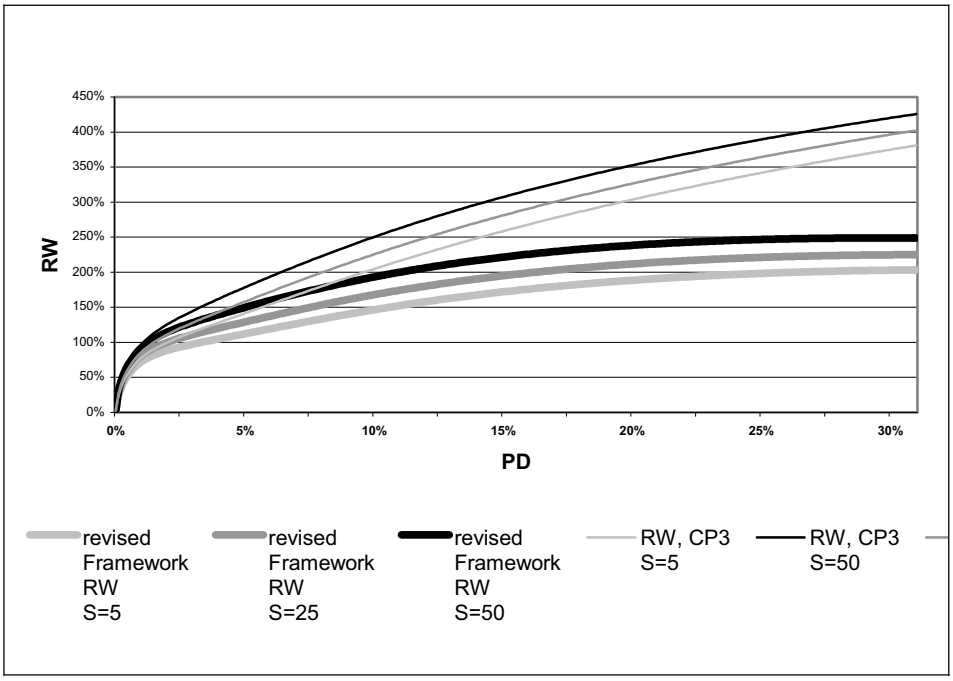

Fig. 3. Risk Weights for the different turnover S=5, S=25 and S=50 in the final version of the accord (BIS, 2004) and in CP3 (BIS, 2001)

Thus, for the first time the required capital is based only on unexpected losses and not the sum of expected plus unexpected losses. This also leads to a reduction of the regulatory capital. One concern that has been identified in the committee's prior impact surveys has been the potential gap between the capital required under the Basel I approach, the standardized and IRB foundation or advanced approaches. To overcome this gap, the committee decided to alter the structure of the minimum floor capital requirements in the revised accord. Under the new approach, there will be a single capital floor for 2007-2009 following implementation of the new accord. This floor will be based on calculations using the rules of the existing accord. Beginning year-end 2006 and during the first years following implementation, IRB capital requirements for credit risk together with operational risk capital charges cannot fall below 95% of the current level required in 2007, 90% in 2008 and 80% in 2009 of the capital requirements based on the old regulations.

We conclude that the capital requirements for the various exposures in the final document have been designed to be consistent with the committee's goal of neither significantly decreasing nor increasing the aggregate level of regulatory capital in the banking system. The main focus in the final changes of the benchmark risk weight function of the IRB approach was the treatment of small and medium sized enterprises. From this angle one can conclude that the final version of the capital accord gives banks dealing with such companies a much better position than in earlier versions. In the following section we will have a special focus on the calibration of the asset correlation parameters.

Model Parameters and their Impact

This section investigates the adequacy of the new Basel capital accord from the perspective of asset correlation. Again, a special focus is set on SME, where the results of empirical studies are compared to the relationship suggested by the regulatory approach. Further, the implications on capital requirements for banks dealing mainly with SME will be analysed. As we summarized in the previous sections, the BRW function for corporates is based on a one-factor model imposing strong restrictions on the parameters. The asset correlation is not to be estimated by the banks but is hardwired

as a function of the PD and the size of the borrower. The issue of how to define firm size is nontrivial; in the accord the total turnover of a borrower serves as a proxy for this quantity.

Asset Correlation and the Firm Size

We will now discuss economic arguments that support the assumption that asset correlation is dependent on size and probability of default. At first we address the influence of firm size. The interpretation of the one factor model is that the value of the total assets is controlled by a systematic factor and an idiosyncratic one. A higher correlation of certain assets then implies a higher correlation with the systematic risk factor. The Basel II approach suggests that smaller companies exhibit lower asset correlations. This is supported by the argument that large firms can be thought of as being a portfolio of small ones. This means that large firms are usually better diversified, so their idiosyncratic risk would be smaller compared to their systematic risk. A second argument is the so called "business sector argument". Business sectors that are known to be very cyclical and thus more dependent on the systematic risk usually show a higher percentage of large companies. Considering size unconditional of the business sector can therefore lead to the conclusion that firm size is a strong indicator of asset correlation even though it is merely a proxy for a business sector. This would be consistent with data from Institut für Mittelstandsforschung (2004) which is presented in Table 4. The sectors “manufacturing”, “construction” and “automotive” are all known to be cyclical and do indeed possess a smaller amount of SME. The other three sectors “transport & communication”, “health & financial services” and “other public & personal services” consist to a higher degree of small and medium sized enterprises.

Table 4

Distribution of German SME over business sectors

Business sector	Fraction of SME
Manufacturing	15.6%
Construction	17.6%
Automotive	15.4 %
Transport & Communication	31.7%
Health & Financial Services	27.4%
Other Public & Personal Services	42.1%

Thirdly, according to Bernanke et al. (1996) there is an effect known as the “financial accelerator”. In their framework endogenous developments in credit markets work to propagate and amplify shocks to the macro economy. While larger firms have better access to capital markets, SME will be very vulnerable to a change in the business cycle. This means that due to the financial accelerator SME could be more exposed to macroeconomic shocks and will have a higher asset correlation in the one-factor model. Von Kalckreuth (2001) suggests that the credit channel (capital markets, banks or other) plays a subordinated role in Germany due to a strong house-bank relationship (especially for SME). Therefore the effect of the financial accelerator could be significantly smaller in Germany.

In summary, the two first arguments support the hypothesis of a decreasing relationship of ρ with firm size, whereas the financial accelerator opposes this.

Asset Correlation and PD

Concerning the dependence of asset correlation on PD there seems to be little literature that has dealt with this issue on a theoretical basis. First empirical evidence on a relationship between PD and the asset correlation parameter emerged after the second quantitative impact study (QIS-2), which was initiated in April 2001. Meanwhile, several authors have addressed this issue for various credit markets. The first major change in the current accord to risk-weight functions

came in reaction to QIS-2. The January 2001 proposal had the asset correlation set to a fixed 20%. In the light of the results they initiated a more targeted study which is known as QIS-2.5. In this study (often referred to as the November proposal), the asset correlation was modified to make ρ a function of the PD. As it was described above, in the final version of the accord (BIS, 2004), the asset correlation is now dependent on both the PD and the turnover S of a company and the possible range for ρ is now between 0.08 and 0.24. The reasons for this change were manifold. Partly the changes are motivated model-theoretically, as described for the dependence of the asset correlation on size, others are due to macroeconomic and political reasoning.

One objective was to mitigate pro-cyclical effects induced by the new accord. Changing the asset correlation in this way should help to achieve that goal. To see this, we suppose that a downturn in the business cycle took place resulting therein that the non-defaulted borrowers of a bank will be downgraded by the internal rating system. This forces the bank to keep more capital against its current loan portfolio. Since raising new capital is more expensive in these adverse conditions, a bank will be forced to cut back on its lending activities. Thereby it is contributing to a worsening of the situation. This effect was more severe in the CP2 January 2001 proposal, because firms that are moved to higher PD values are still assigned the same asset correlation parameter. In the CP3 proposal from November 2001 the asset correlation would decline and thus alleviate this effect.

Empirical Evidence on the Asset Correlation

Before we review empirical results for various markets, we briefly discuss the relationship between equity and asset correlations. Since the introduction of the CreditMetrics model, it has been industry practice to use equity correlations as a proxy for asset correlations. Servigny and Renault (2002) question the accuracy of this approach. Comparing empirical default correlations and the inferred default correlations from equity, they find a prohibiting low dependency between these quantities. They attribute this to the fact that equity prices and their returns reflect many factors such as changes in risk aversion in the equity markets and liquidity effects. Besides, most firms are not traded on the stock market, so the concept has to be refined to be applicable also to SME. Hahnenstein (2004) explores how the book value of total assets can be used instead of the market capitalization. His findings do not suggest the use of this method to determine equity correlations for non-traded firms. Lopez (2002) finds empirical evidence that supports the hypothesis of a decreasing relationship between asset correlation and probability of default. His estimates show that this effect is stronger for larger firms. For firms that fall into the SME category his estimates indicate no significant dependence. Deviant from the Basel II methodology he uses the book value of the total assets as a proxy for the firm size instead of the turnover. These facts could account for the discrepancies to the results of other empirical studies.

Dietsch and Petey (2002, 2004) provide comprehensive results for SME in the German and French market. Their evidence does not suggest a negative relationship between PD and ρ as it is laid out in the Basel II functions. For the relationship with firm size measured in turnover S, they find some support for a decrease of ρ with firm size. Hamerle et al. (2003, 2004) have made strong use of additional explanatory variables within a model. It turns out that the inclusion of these regression variables reduces the estimates for ρ significantly. This could be explained by the fact, that the business cycle is reflected in macroeconomic quantities. Therefore, the inclusion of these figures will increase the fit of the model drastically. The given estimates for ρ are non-monotone in the rating categories and do therefore not support the Basel II assumptions. Another empirical study by Rösch (2002b) examines the effect of the business cycle on correlations in a one factor model. In his work he makes extensive use of explanatory variables in a framework as it is described in the previous sections. He finds that correlations can be significantly diminished through the introduction of proxy variables for the business cycle. Though he does not specifically address the issue of a PD relationship with the asset correlation, his findings are still relevant at this point. This is because in some sectors he includes lagged values of the default rates for the respective sector. As described before, the estimates for the parameters of these variables can be interpreted as explaining parts of the correlation with the common risk factor. When compared to the other included regression variables for a

certain sector, the lagged default rates showed smaller standard errors and were all positive. This strongly contradicts the Basel approach of a decreasing ρ with PD.

Finally, Düllmann and Scheule (2003) provide the most sophisticated empirical study of the effects of PD and firm size on the asset correlation. Their findings reject a clear relationship of ρ on PD, too, and do also support a decreasing relationship of ρ with decreasing firm size. In their model setup they include a macro-economic variable in form of a business climate index and a borrower specific credit score.

Conclusion on the empirical findings

Recent research provides some evidence of a relationship between firm size and asset correlation for a one factor model, as it is specified in the Basel Capital Accord. Here the term "relationship" is chosen intentionally since it has not been clarified whether this relationship stems from the fact that the size adequately represents a firms dependence on the unobserved state of the economy. The inclusion of figures such as the total turnover, credit scores or other firm specific quantities in a regression model provide the methods to test the significance of these parameters against each other. To find out whether firm size is merely a proxy for a business sector, one can use the regression framework as it is outlined here, to statistically test the explanatory power of the *turnover* against sector specific variables. Further the results provide evidence that the asset correlation increases with the probability of default. This contradicts the assumptions imposed by the IRB risk weight functions.

With respect to the macro-economic concerns regarding pro-cyclicality we would like to point out results from Rösch (2002a, 2002b). He identifies two drivers being responsible for the changes in regulatory capital charge. The first one is the actual default risk that changes with the business cycle. This changes the rating grade for a firm in a loan portfolio through the new PD estimates as it was previously described. The second driver is what he calls transition risk. This is the risk that firms in the loan portfolio move to different rating grades from one period to the other. In simulations on historical data with the Standard and Poor's empirical rating transitions, Rösch found that the effect of the transition risk had been reduced through the changes in the asset correlation. But the default risk had a much higher impact on the change in capital charges. Therefore, the decreasing relationship between ρ and PD does counteract pro-cyclicality, but the impact is significantly smaller than the impact of the change in the VaR quantile. Rösch (2002b) suggests that to adequately reduce the cyclical effects of this regulation, the VaR quantile should be determined according to the business cycle. Kashyap and Stein (2004) pursue this idea from a macro-economic perspective and arrive at a similar conclusion.

A Case study

We will finally conduct a case study to investigate possible effects of the new accord on interest rates and credit spreads for obligors of different creditworthiness. Examining a typical German SME portfolio as that of the KfW Mittelstandsbank depicted in Figure 4, we see that approximately 50% of the firms have a rating of BB, BB+ or BB-. To see how credit conditions can change for these firms, we consider companies with different ratings AAA, BB and B. Based on simplified calculations we demonstrate how credit spreads can change due to Basel II.

Assume loans with the properties in Table 5. For simplicity we assume that all loans have an EAD of 100%, a LGD of 50%, a maturity of four years and a turnover of 45 Million Euro. This means we are mainly concerned with the effects of the probability of default on credit spreads due to the new accord.

Table 5

Exemplary properties for the considered loans in the case study

EAD	LGD	Rating Class	PD	Maturity (M)	Firm Size
100	50	AAA	0,01%	4 years	45
100	50	BB	1,20%	4 years	45
100	50	B	7,00%	4 years	45

In the old accord, for all loans a capital charge of 8% is obtained. This means that the *own funds* to be held against this exposure would be 8% of the outstanding debt compared to 92% in *borrowed funds*. This calculation is the same for all three loans, since the riskiness of the debt is not considered in the old accord. Let's now calculate the risk weights based on the new capital accord. For the borrower rated B, the risk weight changes to 201.67% in the IRB approach. Thus, for the B rated loan, the bank has to hold $100 \cdot 0.08 \cdot 2.0167 = 16.133$ of *own funds* against 83.867 of *borrowed funds*.

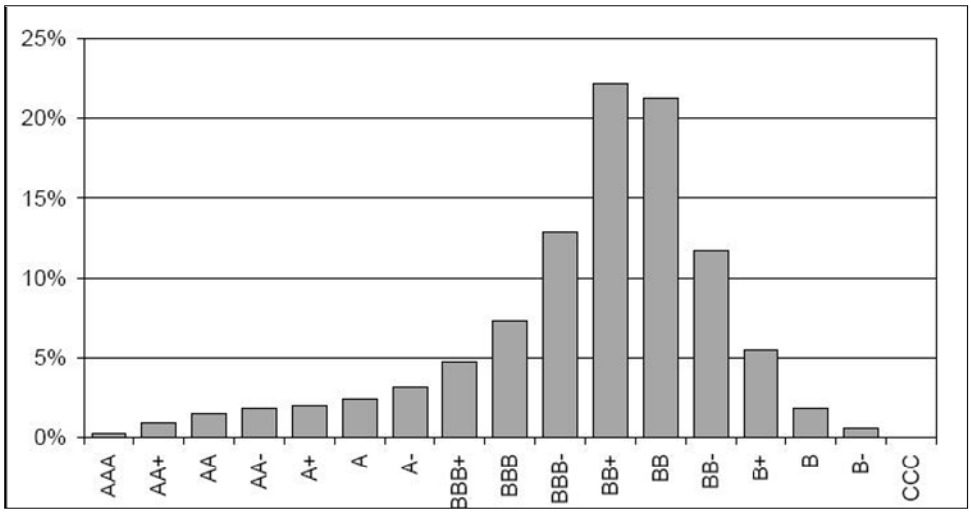

Fig. 4. The benchmark SME portfolio of the KfW Group (Kreditanstalt für Wiederaufbau, 2003)

Further assume a ROE for the bank of 15% and the bank's internal credit cost of 5%, leaving a net ROE of 10%. With the required equity this adds a margin of $10\% \cdot 16.133 = 1.61$. Additionally, we assume a handling charge of 0.25% and a Risk Premium of 3.5%, this yields a credit interest rate of 10.36% for the firm compared to an interest rate of 9.55% under the old accord. Thus, in our case study the interest rate for a customer with rating B is approximately 0.81% higher under the new accord.

The calculations for different rating grades AAA, BB and B are summarized in Table 6. We obtain a decrease in interest from 6.15% to 5.45% for a loan with rating AAA, while for a customer with rating BB there is also a slight decrease in interest from 7.05% to 6.75%. Our findings suggest that as a result of the new capital accord credit spreads will decrease for companies with higher ratings while there will be an increase in interest rate and spread for companies with non-investment grade ratings especially for those with ratings below BB.

This is in line with the aims of the new accord focusing on a more risk-sensitive evaluation of loans and diminishing the subsidization of risky loans by credits to companies with higher ratings. It may also be considered as an incentive for SME to increase their equity fraction and

creditworthiness. Especially in Germany SME often provide a critical capital structure and equity ratios below 10%. A change in capital structure might also lead to a better rating by financial institutions. Otherwise, especially for companies with speculative grade ratings, credit conditions are likely to worsen as a consequence of the new regulatory approach. Further conclusions drawn from these changes are that SME will have to improve their creditworthiness and actively maintain a good house-bank relationship (Kreditanstalt für Wiederaufbau, 2003). They will have to professionalize their management in this respect and improve on the issue of transparency. This could lead to an improved flow of information between banks and SME and reduce their finance premium.

Table 6

Exemplary interest rate calculations for different loans and rating classes

	Basel I Accord			Basel II IRB Ansatz		
Rating Grade	AAA	BB	B	AAA	BB	B
EAD	100	100	100	100	100	100
Risk Weight	100%	100%	100%	12,9%	62,6%	201,7%
Own Funds	8%	8%	8%	1,03%	5,01%	16,13%
Borrowed Funds	92%	92%	92%	98,97%	94,99%	83,87%
ROE	15%	15%	15%	15%	15%	15%
Credit cost	5%	5%	5%	5%	5%	5%
net ROE	10%	10%	10%	10%	10%	10%
net cost of equity	0,8%	0,8%	0,8%	0,103%	0,501%	1,613%
Handling charges	0,25%	0,25%	0,25%	0,25%	0,25%	0,25%
Risk Premium	0,1%	1,0%	3,5%	0,1%	1,0%	3,5%
Interest Rate	6,15%	7,05%	9,55%	5,45%	6,75%	10,36%

Conclusions

In this paper we reviewed the final changes in the BRW function of the IRB approach of the new Basel Capital Accord. A special focus was set on the impact of the proposed changes to the segment of Small and Mid-Sized Enterprises (SME). We found that based on the various changes in the final version of Basel II, especially for SME capital requirements were substantially decreased compared to earlier versions of the accord. We conclude that the Basel committee followed the fair criticism towards the second consultative document that was received from theory and practice.

We further investigated the relationship between asset correlations, probability of default (PD) and firm size in the regulatory approach and compared them to results of several empirical studies. Empirical findings suggest asset correlations in the market to be lower than those assumed in the capital accord. There is also some evidence for the decreasing relationship between firm size and asset correlation it is specified in the regulatory approach. Considering the assumed relationship between probability of default and asset correlation throughout several empirical studies, the estimated correlations have been much lower than those imposed by the Basel II IRB approach. However, this fact does not lead to direct criticisms of the proposed risk weight functions since also macro- and micro-prudential perspectives played an important role in the considerations of the Basel committee.

Finally, we conducted a case study on effects of the new accord for interest rates and credit spreads. Therefore, exemplary obligors with different PDs were considered. Our findings suggest that as a result of the new capital accord credit spreads will decrease for companies with higher ratings while there will be an increase in interest rate and spreads for companies with a rating below BB. This is in line with the aims of the new accord focusing on a more risk-sensitive

evaluation of loans and bonds. We conclude that in order to remain their current credit conditions SME may have to improve their ratings, Thus, SME should increase their capital structure, improve their creditworthiness and actively maintain a good house-bank relationship.

References

1. Basel Committee on Banking Supervision (2001), Consultative Document – The Internal-Ratings-Based Approach to Credit Risk.
2. Basel Committee on Banking Supervision (2003), The new Basel Capital Accord, Third consultative Document, http://www.bis.org/bcbs/bcbscp3.htm.
3. Basel Committee on Banking Supervision (2004), The new Basel Capital Accord, International Convergence of Capital Measurement and Capital Standards: a Revised Framework, June 2004.
4. Belkin, B., Forest, L.R. and Suchower, S. (1998), The effect of systematic credit risk on loan portfolio value-at-risk and loan pricing, *CreditMetrics Monitor*.
5. Benzin, A., Rachev, S.T. and Trück, S. (2003), Approaches to Credit Risk in the New Basel Capital Accord, *Credit Risk: Measurement, Evaluation and Management*, 1-34, Physika.
6. Bernanke, B., Gertler, M. and Gilchrist, S. (1996), The financial accelerator and the flight to quality *Review of Economics and Statistics*, 78(1), 1-15.
7. Dempster, A.P., Laird, N.M. and Rubin, D.B. (1977), Maximum Likelihood from Incomplete Data via the EM Algorithm, *Journal of the Royal Statistical Society*, Series B (Methodological), 39(1), 1-38.
8. Dietsch, M. and Petey, J. (2002), The credit risk in SME loans portfolios: Modeling issues, pricing and capital requirements, *Journal of Banking and Finance*, 26, 303-324.
9. Dietsch, M. and Petey, J. (2004), Should SME exposures be treated as retail or corporate exposures? A comparative analysis of default probabilities and asset correlations in French and German SMEs, *Journal of Banking and Finance*, 28, 773-788.
10. Düllmann, K. and Scheule, H. (2003), Determinants of the Asset Correlations of German Corporations and Implications for Regulatory Capital, Working Paper, University of Regensburg.
11. Frey, R. and McNeil A.J. (2003), Dependent Defaults in Models of Portfolio Credit Risk, *Journal of Risk*, 6(1), 59-92.
12. Gordy, Michael (1998), A Comparative Anatomy of Credit Risk Models, Working Paper, Board of Governors of the Federal Reserve System.
13. Gordy, Michael (2002), A Risk-Factor Model Foundation for Ratings-Based Capital Rules, Working Paper, Board of Governors of the Federal Reserve System.
14. Gupton, G.M., Finger, C.C. and Bhatia, M. (1997), *CreditMetrics – Technical Document* Morgan Guaranty Trust Co, http://creditmetrics.com.
15. Hahnenstein, L. (2004), Calibrating the CreditMetrics Correlation Concept for Non Publicly-Traded Corporations – Empirical Evidence from Germany, Working Paper.
16. Hamerle, A., Liebig, T. and Rösch, R. (2003), Credit Risk Factor Modeling and the Basel II IRB approach, Discussion Paper, Deutsche Bundesbank.
17. Hamerle, A., Liebig, T. and Scheule, H. (2004), Forecasting Credit Portfolio Risk, Deutsche Bundesbank, Discussion Paper.
18. Institut für Mittelstandsforschung (2004), SMEs in Germany, Facts and Figures 2004, IfM-Studie.
19. Kashyap, A.K. and Stein, J.C. (2004), Cyclical Implications of the Basel II Capital Standards, *Economic Perspectives*, Federal Bank of Chicago, 28(1), 2004
20. Kalckreuth, von U. (2001), Monetary transmission in Germany: New perspectives on financial constraints and investment spending, Working Paper, European Central Bank, No. 109.
21. Koyluoglu, H. and Hickman, A. (2002), A Generalized Framework for Credit Risk Portfolio Models, Manuscript, Oliver Wyman & Company.

22. Kreditanstalt für Wiederaufbau (2003), Basel II – aktueller Stand und Auswirkungen auf die Mittelstandsfinanzierung, KfW-Arbeitspaper.
23. Lopez, Jose, A. (2002), The Empirical Relationship between Average Asset Correlation, Firm Probability of Default and Asset Size, FRSBSF, Working Paper.
24. Rösch, D. (2002a), Mitigating Pro-Cyclicality in Basel II, Working Paper, University of Regensburg.
25. Rösch, D. (2002b), Correlations and Business Cycles of Credit Risk: Evidence from Bankruptcies in Germany, Financial Markets and Portfolio Management 17, No. 3.
26. Servigny, A. and Renault, O. (2002), Default Correlation: Empirical Evidence, Working Paper, Standard and Poors.
27. Trück, S., Link, T. and Rachev, S.T. (2001), New tendencies in rating SMEs with respect to Basel II, *Informatica*, 12(4), 593-610.
28. Trück, S. (2001), Basel II and the consequences of the IRB approach for capital requirements, Proceedings of the METU International Conference in Economics, Ankara.