Support for the supporting factor - Multi-Country empirical evidence on systematic risk factor for SME loans[1][2]

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Abstract

Using a unique and comprehensive data set on the two largest economies of the Eurozone – France and Germany- this paper firstly proceeds to a computation of the Gordy formula relaxing the ad hoc size-dependent constraints of the Basel formulas. Our study contributes to the Article 501 of the Capital Requirements Regulation (CRR) requesting to analyze the consistency of own funds requirements with the riskiness of SMEs. Either in the French or the German sample, results suggest that the relative differences between the capital requirements for large corporates and those for SMEs (in other words the capital relief for SMEs) are lower in the Basel III framework than implied by empirically estimated asset correlations. Results show that the SME Supporting factor in the CRR/CRDIV is able to compensate the difference between estimated and CRR/CRDIV capital requirements for loans in the corporate portfolio.

Keywords: SME Supporting Factor, Asset correlation, Basel II, Minimum Capital requirements, Asymptotic Single Risk factor Model, Multifactor credit risk modeling, SME finance

JEL-Classification: G21, G33, C13

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1. Motivation

The level of banks capital requirement for corporate credit risk in the regulatory Basel framework relies on the standard asymptotic single risk factor model ("ASFR" hereafter) proposed by Gordy (2003). However, the calibration of the requirements by the Basel Committee departs from this theoretical model. In particular, the correlation to the systematic factor is a function of the size and of the probability of default of the firm. However, an empirical application of the theoretical model would call for a direct estimation of the correlation to the systematic factor. Using an unique and comprehensive data set on the two largest economies of the Eurozone –France and Germany- this paper firstly proceeds to a computation of the Gordy formula relaxing the ad hoc constraints of the Basel formulas.

There is a growing concern about SME financing in Europe. As illustrated by recent contributions to the empirical literature[3], banks' lending decisions are sensitive to capital requirements. This paper assess whether the differences implied by the Basel formulas between SME and large corporates capital requirement are empirically justified in the data from a management risk perspective. This question became a salient issue from a policy perspective. One political concern was that Basel III by imposing higher capital requirement indirectly also affects capital requirements for credit exposures to SMEs, what raises the question to know if these regulatory adjustments might not have treated SMEs unfairly given the fact that these firms didn't cause the recent financial crises. The CRR/CRDIV has thus introduced a deduction in the capital requirements for exposures to SMEs, which will be reduced through the application of a supporting factor equal to 0.7619 (SME Supporting Factor) . This reduction is subject to a review by the EBA which might lead the Commission mid- 2016 (CRR Art. 501 (4)) to a potential revision of the SF.

Article 501 of the Capital Requirements Regulation (CRR) requests to analyze the consistency of own funds requirements with the riskiness of SMEs. Our study exactly contributes to this task and provides significant results. For this purpose, comprehensive data sets were built to cover a significant part of the German and French SME and large corporate sector. For Germany, data from more than 1500 banks in Germany were collected For France

[3] See for instance Behn et al. (2015) or Fraisse et al. (2013) respectively in the case of Germany and France.

the national credit register and Banque de France rating system were used. Given the size of the sample, the length of the time series and the application of a fully consistent methodology, this analysis significantly improves the previous ones in this area (see the next section).

Against this background, our paper addresses the consistency of own funds requirements by assessing firm size as a driver of systematic credit risk in loans to SMEs and compares the size of this effect with the capital relief granted to SME lending relative to large corporates in the regulatory minimum capital requirements of Basel III and the CRR/CRDIV. As it is standard in the academic and regulatory literature, the asset correlation is used as the key measure of systematic risk. It also drives the systematic risk in the Asymptotic Single Risk Factor (ASRF) model of Gordy (2003) that is the basis of the regulatory minimum capital requirements in the Internal Rating-Based Approach (IRBA) of Basel III. Large corporates (that is corporates with a turnover of more than EUR 50 million) are used as a benchmark, which means that they are assumed to be correctly calibrated in level.

For the analysis of the own funds requirements, it is important to separate a potentially higher firm-specific (idiosyncratic) risk of SMEs—that is typically reflected in higher default probabilities—from a potentially lower systematic risk of SMEs. Since capital requirements in the ASRF model refer by construction to systematic risk, only, lower asset correlations (and therefore lower systematic risk) compared to large firms would ceteris paribus also suggest lower capital requirements for SMEs. However, the capital requirements for an SME loan in the Basel III IRBA and the ASRF depend on both the default probability and the risk weight function in general, which in turn depends on the asset correlation value. As a consequence, lower systematic risk for SMEs can well be in line with higher capital requirements for SMEs if SMEs have higher default probabilities, i.e., higher firm-specific risk, than large firms.

An evaluation of regulatory capital requirements should distinguish between the level of capital and the relative difference against other asset classes. In the development of Basel II, the second aspect—often referred to as relative calibration—was addressed first. It ensures that banks ceteris paribus have to hold more (less) capital for a more (less) risky asset, while the level calibration aims at determining the overall level of capital requirements.

Since the regulatory minimum capital requirements are internationally harmonized today, a key contribution of this paper lies in its international coverage. We use unique data samples of SME lending for France and Germany, two European countries where SMEs stand as a

backbone of the economy. In France, data come from the National Credit Registers, while in Germany, they were provided by over 1500 German banks. The samples stand apart due to their comprehensive coverage of the particularly rich and well developed credit market for SMEs, the availability of banks' internal ratings, and the capture of the recent financial crisis in the time series. Our results show relatively large similarities of the credit risk structure in SME loans portfolios in the two countries.

The asset correlations (and the PDs) are estimated from historical default rates. To estimate the asset correlation, meaning the factor sensitivity towards the unobservable latent systematic risk factor that represents the state of the economy in the ASRF framework, two different estimation techniques are used. The first is the Generalized Linear Mixed Model (GLMM) single factor-estimator of Frey and McNeil (2003). In this framework, the rating information is treated as a fixed effect, while the latent systematic risk factor corresponds to the random effect that is estimated. This estimation technique is relatively robust against low populations of rating classes and allows obtaining one single AC estimate per size class. The second estimator is the Maximum Likelihood estimator of Gordy and Heitfield (2010) which can be used to estimate asset correlations and PDs for each rating/size bucket. As a robustness check, we also compute the asset correlations for a multifactor variant of the GLMM estimator. As this study focusses on the relative calibration of the risk weights, the dependence of systematic risk on firm size is explored in a second step and compares the size of this effect with the capital relief granted to SME lending in the regulatory minimum capital requirements of Basel III and CRR/CRDIV. We use large corporates (that is corporates with a turnover of more than EUR 50 million) as a benchmark, our research question being on the existence of a regulatory distortion between small and large firms.. This is also motivated by the fact that the BCBS has spent substantial effort on calibrating these portfolios due to their immense economic importance. For each size class we therefore compare the relative difference (difference in capital requirements for this size class of SMEs relative to capital requirements for the benchmark, i.e. for large corporates) of both (1) capital requirements based on estimated asset correlations and (2) the current IRBA capital requirements. Comparing these two relative differences can provide useful information for an evaluation of the capital relief for SMEs granted in Basel III and the effectiveness of the SME SF of the

CRR/CRDIV[4]. If the relative differences of the capital requirements is larger for the capital requirements based on empirical asset correlations than for the IRBA capital requirements, there is potential for a capital relief for SME loans. This framework is applied in the same manner to a comparison with the revised standardized approach (RSA).

Our empirical results confirm previous findings that asset correlations increase with firm size conditional on the rating category. More precisely, large corporates face a considerable higher systematic risk than SMEs and a structural difference between loans to large corporates and SME loans is identified. This result is consistent for France and Germany. Furthermore, the empirical results suggest that the relative differences between the capital requirements for large corporates and those for SMEs (in other words the capital relief for SMEs) are in two countries lower under the Basel III framework than implied by our empirically estimated asset correlations referring to the corporate portfolio under the IRBA and the RSA. These results can be transferred to the current regulatory capital requirements under the CRR/CRDIV. Our results reveal for France and Germany that under CRR/CRDIV the SME SF is consistent with the lower systematic risk of SMEs for all exposure classes in RSA, and for corporate SMEs in Internal-Rating-Based Approach (IRBA). However, for retail loans IRBA, the capital reductions associated with the SME SF leads to relative capital requirements that are lower than those suggested by the systematic risk. As a result, after the application of the SME SF the relative regulatory risk weights are in line with the empirical ones in IRBA Corporate exposure class and SA. Furthermore, the study does not find empirical evidence supporting the limit of EUR 1.5 million for the amount owed currently used for the application of the SME SF in accordance with Article 501 CRR.

The remainder of the paper is as follows: Section 2 presents the relation of our paper to the literature. Section 3 describes the data sample of the two countries. Section 4 presents the methodology and Section 5 the empirical results given by the GLMM estimator. The paper concludes with a summary of the key results.

[4] Note that the SF might be alternatively presented as a tool for supporting credit distribution to the SMEs and/or as a tool for taking into account the underlying lower risk of the SMEs at the portfolio level. Our paper assesses the effectiveness of the SF with respect to this second presentation.

2. Relation to the literature

There exists a by now well-established strand of empirical work on the systematic risk in SME loans. Although its findings on the level of asset correlations in the ASRF model vary substantially, they overall tend to indicate rather lower than higher asset correlations compared to the values used in the IRBA capital requirements. A comprehensive overview of asset correlation studies can be found in Berg, Gehra and Kunisch (2011) and Düllmann and Koziol (2013). In general, asset correlations can be computed in two different ways, or rather by using different types of data sources. These two strands of the empirical literature find quite different results in terms of the level of asset correlations.The first possibility is the use of historical default rates.[5] Among these studies there are Roesch (2003), Dietsch and Petey (2004), Düllmann and Scheule (2006), Palombini (2009), Haddad (2013), Bams, Pisan, and Wolff (2014) and Düllmann and Koziol (2014). These authors generally estimate lower values than the ones used in the IRBA. Finally, another common method is the estimation of asset correlations based on equity prices, which cannot truly form a comprehensive data set for SME loans. In the second strand, Düllmann, Kunisch, and Kuell (2010) have shown that asset correlation estimates based on equity prices tend to be somewhat higher than those based on default rates. In line with their results are, for instance, studies by Hahnenstein (2004), Lopez (2004) or Chernih, Henrard and Vanduffel (2010).

Several studies assess the dependence of asset correlations on size and creditor quality (i.e., rating) which is also incorporated in the Basel II/III IRB corporate risk-weights formula. Table A.1 in the Appendix A provides a comprehensive overview of the existing empirical studies on the relationship between asset correlations and firm size. Lopez (2004) finds a positive size dependence of asset correlations estimated from equity prices for multiple regions (World, Japan, US, Europe). A study in this respect is Düllmann and Scheule (2006) that is based on default rates. Using Deutsche Bundesbank data they construct a time series of default rates of German firms for the years 1991 to 2000. The objective of the paper is to estimate the asset correlation of German corporate borrowers and its dependency on the firm size. For this purpose, both the Asymptotic Methods-of-Moments (AMM) and Maximum

[5] As default events are scarce, asset correlations estimates based on default rates are sometimes supplemented by using credit rating transition data. Examples for this approach can be found in van Landschoot (2007) and Kalkbrener and Onwunta (2009). Studies that rely on the joint direction of rating changes to estimate asset correlations include Fu et al. (2004), Akhavein, Kocagil and Neugebauer (2005) and Cassart, Castro, Langendries and Alderweireld (2007).

Likelihood (ML)-estimators are used. Under both estimation methods and for all considered rating classes, asset correlation increases with firm size. In contrast, Dietsch and Petey (2004) find that for French and German SMEs "asset correlations decrease significantly on average with the SME size", while a comparison between SMEs and large corporates points towards higher asset correlations for large corporates as compared to SMEs.

In recent years the analysis of firm size as a driver of asset correlations has been extended to further regions (Japan, US, UK, Italy and Canada) and more refined data sets (e.g. Düllmann and Koziol,2014; Dietsch and Fraisse, 2013). The majority of studies suggest a positive relationship between asset correlations and firm size. In an empirical study of default data for Japanese companies Hashimoto (2009) shows that asset correlation varies with industry, size, credit rating and region. When grouped by size, the results exhibit higher asset correlations for large and medium-sized companies (about 4.5%) and lower asset correlations for small companies (about 1.5%). Gabbi and Vozzella (2013) use balance sheet data for small and medium-sized Italian firms for 1994 to 2008 to estimate confidence sets for asset correlations. Their results for different size clusters of small firms suggest a J-shaped relationship between asset correlation and company size, i.e. for the smallest companies, asset correlations and size are negatively interconnected, while for medium companies, the relationship shows a positive pattern. Bams, Pisa and Wolf (2015) use a multi-factor model to estimate asset correlations for a data set of US SMEs. They find that asset correlations of SMEs are negatively related to credit quality and tend to be much lower than their asset correlation estimates for corporates (based on publicly available S&P data). For UK Lee et al. (2013) also find a positive relationship between firm size and asset correlarions estimated from asset prices (Datastream).

Our study extends Düllmann and Koziol (2014) who estimate asset correlations from a time series of default rates of SME and large corporates bank lending (2005-2011) by using the ML estimator of Gordy and Heitfield (2010). They use their asset correlation estimates for various size classes for a comparison with the minimum capital requirements in Basel II and find that the relative differences between the capital requirements for large corporates and those for SMEs (in other words, the capital relief for SMEs in Basel II) are in two cases lower in the current regulatory framework than implied by the empirically estimated asset

correlations: (1) In the Internal Ratings-Based (IRB) Approach this difference amounts to up to 24 percentage points on average across rating categories. This concerns only SME loans in the corporate portfolio. (2) For all loans assigned to the SME portfolio in the Revised Standardized Approach (RSA), this effect is considerably stronger.

Several studies have considered the size dependence of asset correlations by extending the ASRF-framework to capture additional factors. Dietsch and Petey (2007) focus on French SMEs again using a database of French SME rating and defaults provided by COFACE Services -a large French credit insurance company- for the time period of 1995 to 2005. The method chosen for estimation purposes consists of a Generalized Linear Mixed Model multi-factor framework taking into account sector, location, or size specific factors additionally to a single systematic factor. Their results suggest that higher default rates do not imply higher asset correlation, but that asset correlations increase with firm size. Recently, applying a multifactor extension of the ASRF framework to a French business loans sample, Dietsch and Fraisse (2013) show that regulatory IRB capital requirement could overestimate the business cycle effect and underestimate diversification benefits when adding size or industry risk factors in the credit risk parameters estimation.

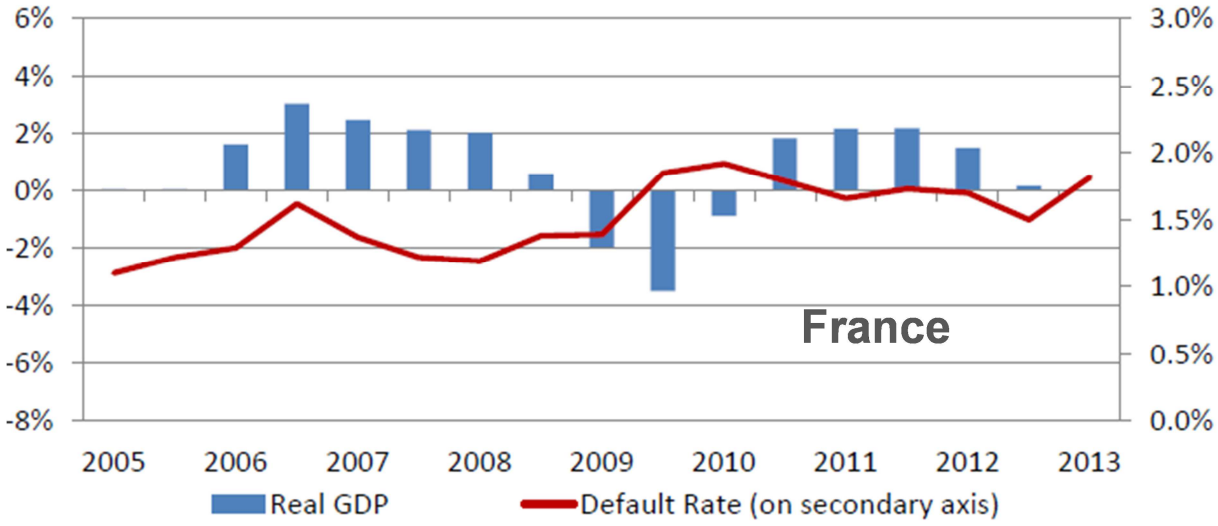
There is almost no evidence on the impact of exposure on the level of asset correlation. A notable exemption is Haddad (2013) who for a portfolio of Canadian high-risk SME loans fails to find a clear pattern for the behavior of asset correlations in relation to credit exposure. Thus their paper is one of the first to explore the dependence of asset correlation on outstanding obligors.

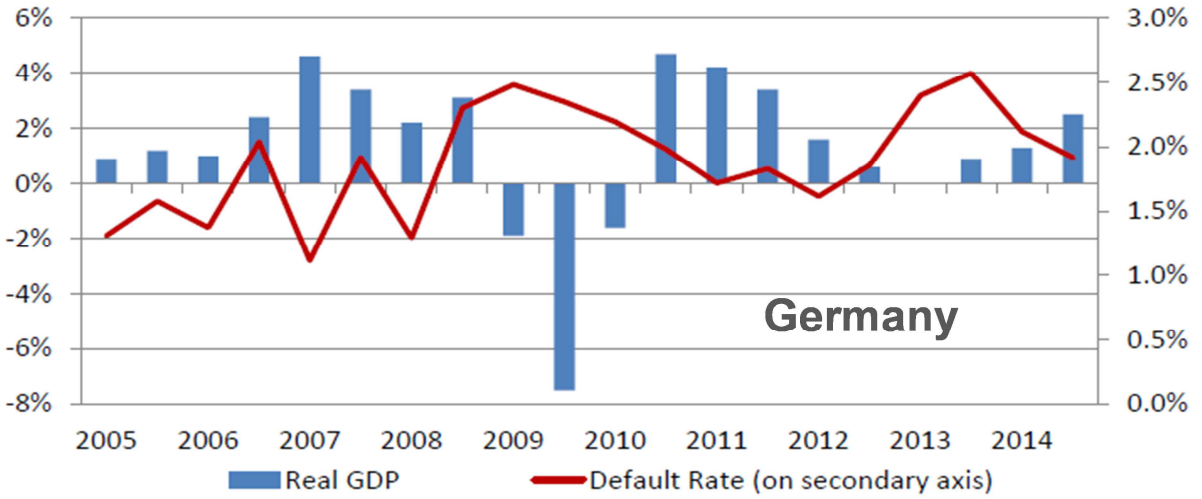
3. Data Samples

The study applies a unique data set of SME lending for France and Germany. The two samples cover a significant proportion of loans to SMEs, as well as large corporates in the respective countries. We exploit time series of default data to estimate the asset correlation. As systematic risk is driven by the evolution of the credit cycle over time, the time series should capture at least a full economic cycle. The German database covers observations from 2005 to 2014, whereas French data range from 2005 to 2013. As graphically depicted in

Figure 1 each of the sample for the two countries encompasses both periods of economic growth and decline, including the financial crisis.

Figure 1: Default Rates over time (all size and rating classes) and change in real GDP





Following the specifics of each of the national data sets, different definitions of default are used.[6].The German data is based on the Basel II/III definition[7]. This definition is not only wider than the insolvency legal criterion that has often been used in previous studies, it is also

[6] Any aggregation of the two data sets is therefore not applicable.

[7] "A default is considered to have occurred with regard to a particular obligor when either or both of the two following events have taken place. (1) The bank considers that the obligor is unlikely to pay its credit obligations to the banking group in full, without recourse by the bank to actions such as realising security (if held). (2) The obligor is past due more than 90 days on any material credit obligation to the banking group. Overdrafts will be considered as being past due once the customer has breached an advised limit or been advised of a limit smaller than current outstandings." (See Basel Committee on Banking Supervision (2006))

to the consistent with the aim of our study to assess the appropriateness of the size dependence of asset correlations incorporated in the regulatory capital requirements of Basel II/III.[8] In the French database, a combination of judiciary definition and banking definition of default is used. Even if the number of defaults is expected to be on average higher when using the Basel II/III definition of default, and, consequently, the results expected to be more robust to small sample noise in buckets of low default rates, works in progress tend to show that the difference in the definition do not impact the measures of credit risk too strongly. What is more important for the robustness of asset correlation estimates is the fact that the default definitions in both countries are consistent over time. Thus any bias resulting from a structural break in the definition of default can be avoided.

Our analysis is based on the widely known ASRF model of Gordy (2003) that is also the foundation of the IRB risk weight functions for credit exposures in the banking book. The IRB risk weights for corporate SMEs are driven by the PD and the firm size. It is therefore important to capture not only the size dependence but also the effect of diverging credit quality. This is done by clustering the two samples into size buckets and into rating buckets.

The French sample contains the population of French firms which fulfill four conditions (Table 1): i) they have exposures in the French Credit Register, ii) the BDF rating department gives them a rating (including default grades), iii) they get loans from at least one large banking group operating in the French loans to businesses market, and iv) their annual turnover is over 0.75 M€. The population contains more than 170,000 firms on average each year. The sample is very representative of the French businesses population and especially SMEs population.

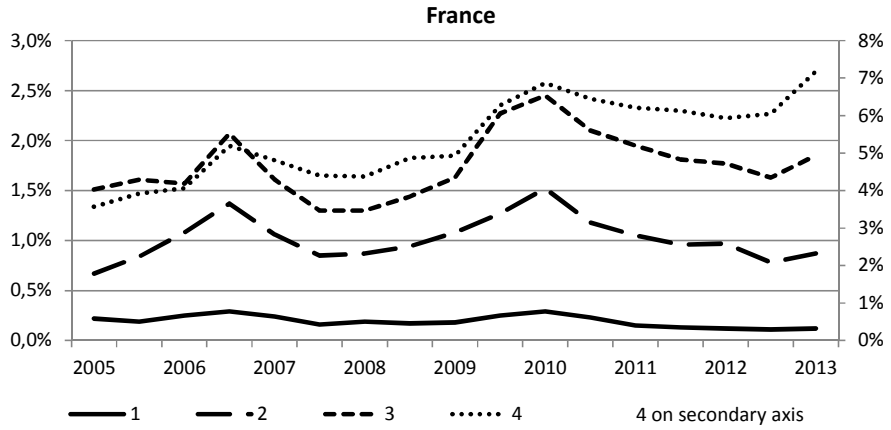
The German data has been provided by a significant proportion of both small and large German banks. This allows us to consider also the smallest borrowers in terms of turnover and amount owed. The dataset is representative for the whole universe of German corporate lending, while minimizing the risk of any potential double-counting. Consistent with the aim of our study the data set also contains information on the amount owed (as defined in Art. 501 CRR) by the borrowers in the sample and extends the data set used in Düllmann and Koziol

[8] The data has been seasonally adjusted to avoid any potential influence from the provisioning practices of the banks.

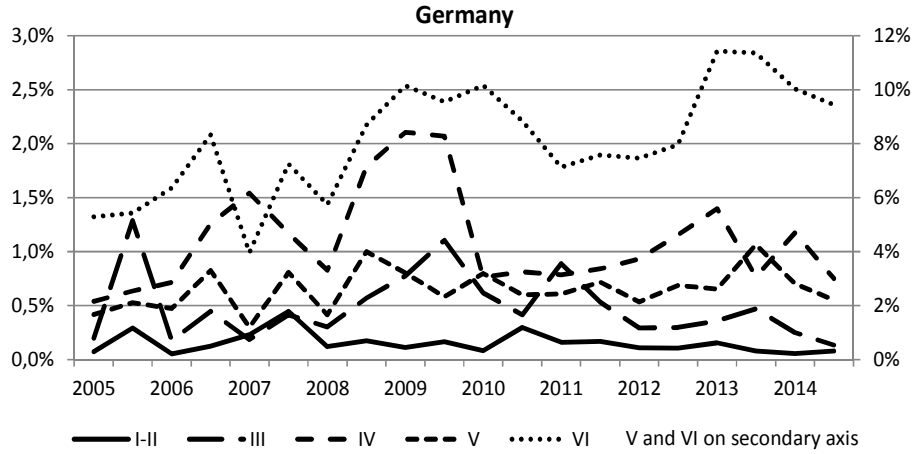
(2014). The sample includes a total of over 5.4 million observations. Credit quality is measured in terms of IRB PDs which are mapped to a consistent master scale[9]. Although the vast majority of banks in the sample have adopted the RSA, their rating system has been designed along the requirements of an IRB rating system.

As for both data sets zero defaults were observed for certain points in time, some rating classes had to be merged to ensure the robustness of the estimations. For Germany we obtain five rating classes (from six in the master scale). For France the original rating scale of ten grades is collapsed to four rating classes for the purposes of this study. As it can be seen from Figures 2 and 3 depict the time series of defaults rates for the different rating or turnover categories in both countries. Low default rates are observed for borrowers of high credit quality rating/larger corporates classes. Lower credit quality rating/smaller SMEs classes are related to higher default rates.

Figure 2: Default Rates over time (all size classes, by rating)



[9] The master scale was set up by the Joint Banking Initiative for the Financial Location of Germany (IFD).



To differentiate between large corporates and SMEs and to explore a potential size dependence of asset correlation we cluster firms according to their annual turnover. We follow Art. 501 CRR which uses the turnover criterion of Article 2 of Recommendation 2003/361/EG as the single criterion to identify SMEs and define the benchmark group large corporates as firms with an annual turnover above 50 mln. €. The rich population of SMEs in both samples allows to distinguishing additional SME size classes. Figure 1 show the time series of default rates for different firm size buckets. For France there are indications of a size dependence of default rates. At each point in time the default rates are negatively related to firm size, i.e. the default rates are generally lower for larger turnover classes. The picture for Germany is less straightforward, as there is no clear indication of a size dependence that is consistent over time. On the contrary, it can be inferred that both some of the highest and some of the lowest default rates observed over time can be allocated to larger turnover classes.

To assess the impact of the SME SF on regulatory capital requirements, both samples contain information on the outstanding loan volume ("obligo" hereafter). As the data has been extracted from the French credit register, only borrowers with a minimum obligo of EUR 25 000 are covered. This total obligo includes not only funds effectively granted to the firm (or drawn credit), but also the bank's commitments on credit lines (or undrawn credits) and guarantees, as well as specific operations (medium and long-term lease with purchase option, factoring, securitized loans, etc...). For Germany, the amount owed as defined in Article 501 CRR is used. The structural differences between the French and the German SME sectors are mirrored in the descriptive statistics presented in Table 2 which depicts the percentage of

SME SF eligible loans in each turnover class. On total, 86% of all loans towards French SMEs and 64% of all loans towards German SMEs are eligible for the application of the SME SF. The percentage of SME SF eligible loans decreases with firm size. The SME SF may be applied to nearly all of the French loans and roughly seven out of ten loans to German firms in the smallest size class. In contrast, only half of the loans to German or French medium-sized corporates with a turnover just below EUR 50 million are eligible to benefit from the SME SF. In contrast with Germany, the distribution of loans in France is very skewed as the 14% of loans not benefiting from the SF represent more than 50% of the total outstanding loans.

Figure 3: Default Rates over time (all ratings, by size)

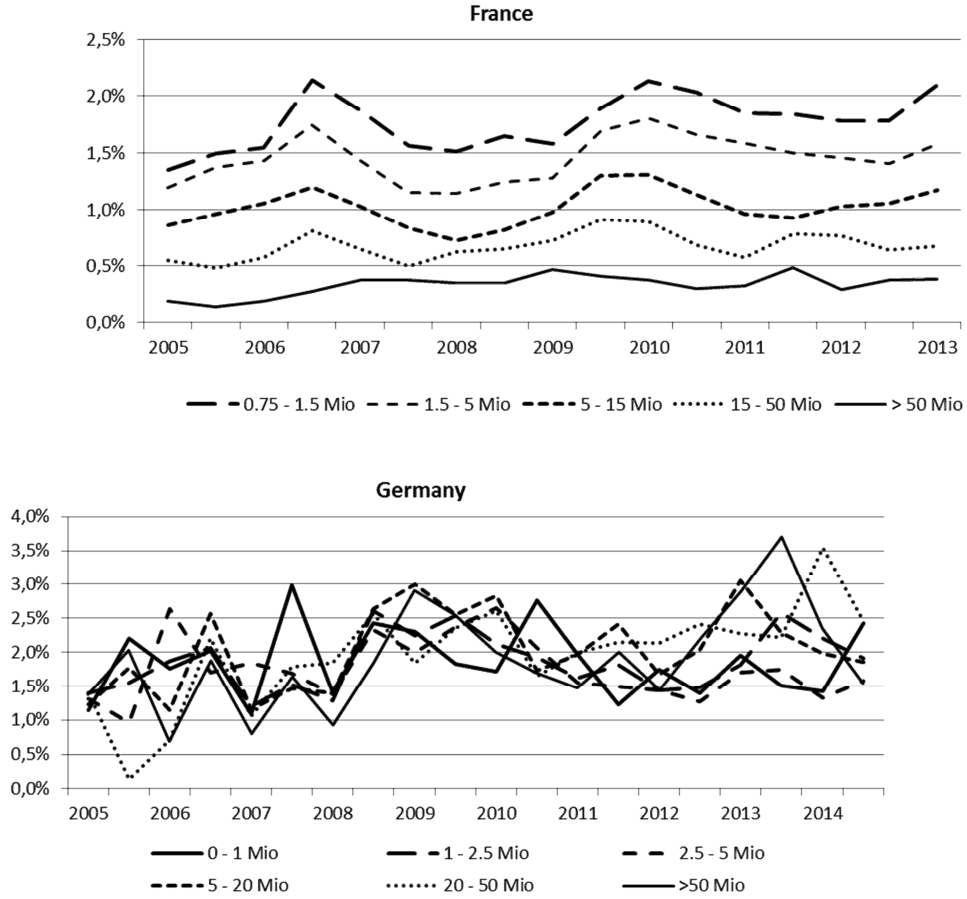


Table 1: Overview applied data bases for Germany and France

Country	France	Germany

Country	France	Germany
Sources	French Credit Register and Banque de France (BdF) rating system	Data provided by significant proportion of German banks. Use of IRBA ratings mapped to a consistent master scale
Time period	Q4-2004 to Q4-2013 (20 observations)	Jan 2005 to Dec 2014 (20 observations)
Data frequency	Quarterly aggregated to semi-annual	Semi-annual
Credit exposure amount	>EUR 25 000	All; measured in terms of "amount owed" as defined in Art.501 CRR
Default definition	Two criteria: legal failure (bankruptcy) and bank default, which corresponds to severe banking problems	Basel II/III default definitions
Firm's size classes definition	Restricted to firms with turnover over EUR 0.75 million; Five size classes turnover measured in EUR million: 0.75 to 1.5, 1.5 to7.5, 7.5 to 15, 15 to 50, And over 50.	Six size categories turnover measured in EUR million: [0;0.1], (1;1.25], (2.5; 5], (5;20], (20;5], And over 50.
Number of rating grades	4, from 10 in the master scale	5, from 6 in the master scale

Table 1: SME loans eligible for SME Supporting Factor in relation to total loans (in percent)

France	**Turnover in EUR million**	**Retail**	**Corporate**			
		0,75 - 1,5	**1,5 - 5**	**5 - 15**	**15 - 50**	**all**
	% of loans	96%	90%	67%	44%	86%

Germany	**Turnover in EUR million**	**Retail**		**Corporate**		
		0 - 1	**1 - 2.5**	**2.5 - 5**	**5 - 20**	**20 - 50**	**all**
	% of loans	69%	68%	63%	55%	45%	64%

Table3: Mean weights for ratings per Turnover class

	Turnover in mio €	Retail	Corporate			
		0,75 - 1,5	1,5 - 5	5 - 15	15 - 50	BM
France	**Low Risk 3**	39.2%	49.4%	54.8%	56.2%	63.8%
	4	21.3%	20.1%	20.1%	20.7%	17.6%
	5	21.0%	16.2%	12.3%	11.8%	9.6%
	High Risk 6	18.6%	14.3%	12.8%	11.3%	9.0%

	Turnover in mio €	Retail		Corporate			
		0 - 1	1 - 2.5	2.5 - 5	5 - 20	20 - 50	BM
Germany	**Low Risk I-II**	33.7%	40.4%	44.9%	48.9%	56.2%	58.5%
	III	21.5%	22.9%	18.7%	18.4%	20.0%	19.7%
	IV	17.4%	17.3%	16.1%	15.9%	12.7%	13.6%
	V	11.9%	10.4%	10.6%	9.8%	6.8%	6.0%
	High Risk VI	15.5%	9.0%	9.6%	7.0%	4.4%	2.2%

4. Estimation methodologies and relative calibration

In this section, we firstly present the conceptual framework that we use, which is the structural single-factor model devised by Merton (1974). This widely known Asymptotic Single Risk Factor (ASRF) model is also the foundation of the IRB risk weight functions for credit exposures in the banking book (Gordy, 2003). Secondly, we specify this model as a generalized linear mixed model (GLMM) to produce estimates of the asset correlation parameters. Thirdly, we present our "relative calibration" methodology where large corporates IRB risk weights serve as benchmarks.

4.1 The asymptotic credit-risk framework

The ASRF model belongs to the class of structural credit risk models devised by Merton (1974). In this approach, losses at the portfolio level can be defined as the sum of individual losses on defaulting loans in the portfolio, adjusted for the severity of individual losses; in other words, portfolio-level losses may be regarded as the sum of the losses given default for each individual loan in the portfolio that goes unpaid. Thus, if u_i is defined as the loss given default (LGD) of an obligor i and if $\mathbf{1}_{D_i}$ is defined as the default indicator variable of obligor i, then the total portfolio losses L may be defined as follows:

$$L = \sum_{i=1}^{n} u_i \mathbf{1}_{D_i}$$

In structural credit risk models, default occurs if the value of an obligor's assets is smaller than the value of the obligor's debt that is due. Because asset and debt values may be difficult to observe, this framework has been extended by generalizing the modeling of default as the crossing of an unobservable threshold.

Thus, default is triggered in this model if the ability-to-pay process Y_i of firm i falls below an exogenous default threshold γ_i. Y_i follows a standard normal distribution. It can be decomposed into the return of a systematic and unobservable factor X and an idiosyncratic firm-specific part ε_i :

$$Y_i = \sqrt{\rho_i}\ X + \sqrt{1-\rho_i}\ \varepsilon_i$$

X and ε_i are independent for every obligor i and follow a Gaussian distribution. The factor loading $\sqrt{\rho_i}$ of the systematic risk factor can be interpreted either as the sensitivity against systematic risk or as the square root of the asset correlation ρ_i. For this analysis the common assumption of a constant ρ_i is applied. The Bernoulli variable L_i describes if a credit event has occurred during the considered horizon (L_i = 1) or not (L_i = 0). It is important to

differentiate between the unconditional and the conditional default probability. The unconditional default probability of obligor i for the time period t is defined as follows:

$$P(L_i = 1) = P(Y_i < \gamma_i) = \Phi(\gamma_i)$$

where Φ denotes the cumulative distribution function of a standard normal distribution.

The implementation of the single model requires to specify the dependence structure of risk factor and to estimate the default thresholds and factor sensitivities. When using a random effect specification of the risk factor, there is a correspondence between the conditional default probability and econometric approach grounding on generalized linear mixed models (GLMMs).

4.2 Econometric estimation of the portfolio's credit-risk parameters

Thus, to estimate default thresholds and risk factor sensitivities, we use an model that belongs to the class of generalized linear mixed models. This model combines fixed and random effects for observable and (latent) unobservable factors. Detailed presentations of GLMM models in credit risk modeling can be found in Frey and McNeil (2003) and McNeil and Wendin (2007).

If, in a general case, Y is defined as the ($N \times 1$) vector of observed default data and if γ is defined as the ($K \times 1$) vector of random effects, then the conditional expected default probability of obligor i may be expressed as follows:

$$E[Y_i = 1|\gamma] = g(X_i\beta + Z\gamma)$$

where $g(\cdot)$ is a differentiable monotonic link function, Y_i is the default indicator variable for obligor i (Y_i takes a value of 1 if there is a default and equals 0 otherwise), X is a ($N \times P$) matrix that contains the (observed) fixed effects, and Z is the ($N \times K$) design matrix for the random effects. In case of a single factor specification, K is equal to one.

In the following application, we will consider the effect of a single random general factor and we will focus on the probit link function because the normal distribution is the underlying link function that is assumed by the Basel II framework of credit risk; thus, $g(x) = \Phi(x)$. The random effect is assumed to follow a standard normal distribution. In the equation above, β is the vector of parameters that is associated with fixed effects. Considering a portfolio of N obligors who are categorized into $r = 1, \ldots, R$ (non-default) rating classes and given a vector $\gamma_t$of random effects, the conditional default probability of borrower i at time t may be expressed as follows:

$$P(Y_{ti} = 1|\gamma_t) = \Phi(x'_{ti}\mu_r + z'\gamma_t)$$

where μ_r denotes the vector of parameters from the fixed effect of the borrower's rating class. If the rating scale is properly built, we expect these thresholds to be ordered and increasing as credit quality decreases. In the above equation, $x'_{ti} = [0,...,1,...0]$ is a $(1 \times R)$ vector of dummies that defines the rating of borrower *i* during time period *t*. Because we assume that borrowers in a given size class are interchangeable, the estimation of this vector does not involve individual borrowers but instead uses the periodical default rates within segments. This approach leads to an assumption of borrower homogeneity for each credit rating that is examined.

In this application, we restrict the model to one random factor and one fixed factor (the firm's rating). We assume that the general risk factor (the risk factor of the single factor model) represents the impact on default rates of variations in general economic conditions. In this specification, the linear predictor in the regression contains an intercept term that randomly varies at the year level, the highest level in the modelling, where all other effects are nested in. In other words, a random intercept is drawn separately and independently for each year. This structure implies that a given obligor is only affected by the factor representative of general economic conditions.

4.3 Minimum capital requirements and relative calibration

Since we are ultimately concerned with the calibration of capital requirements, we do not consider only the asset correlation estimates but also capital requirements dependent on these estimates. More precisely, we consider the empirical risk weight function, i.e., the risk weight function based on the empirically estimated asset correlations $\hat{\rho}$, rather than the asset correlation estimates themselves, in order to assess the calibration of the capital requirements:

$$RW^{Est}(\hat{\rho}, PD) = 1.06 \cdot 12.5 \cdot LGD \cdot \left[\Phi\left(\frac{\Phi^{-1}(PD) + \sqrt{\hat{\rho}} \cdot x^*_{99.9\%}}{\sqrt{1-\hat{\rho}}}\right) - PD\right] \cdot f(M, PD)$$

where LGD denotes the Loss Given Default, $x^*_{99.9\%}$ the 99.9% quantile of the standard normal distribution function and f(M, PD) the maturity adjustment dependent on the effective maturity M and the PD with f(M, PD) = (1 + (M – 2.5) ·b(PD))/(1–1.5 · b(PD)) and b(PD) = $(0.11852–0.05478 \cdot \log(PD))^2$. The LGD is set to 0.45 and the maturity M to 2.5 years in our analysis.

The current Basel III capital requirements are calculated according to the IRBA formulae for corporate exposures:

$$RW^{BIII}(PD, S) = 1.06 \cdot 12.5 \cdot LGD \cdot \left[\Phi\left(\frac{\Phi^{-1}(PD) + \sqrt{\rho(PD,S)} \cdot x^*_{99.9\%}}{\sqrt{1-\rho(PD,S)}}\right) - PD\right] \cdot f(M, PD)$$

Turnovers above €50 million are lumped together in a single bucket since the risk weight curve would remain flat above this turnover threshold (for a constant PD). For a turnover

above €2.5 million, we have applied the corporate risk weight function including the capital relief due to the turnover dependence of the asset correlation:

$$\rho(PD,S) = 0.24 - (0.24 - 0.12) \cdot (1 - e^{-50PD}) \cdot \left(1 - \frac{\min\{50, \max\{S, 5\}\} - 5}{45}\right)$$

with the last term of the function being the size adjustment for SMEs.

The retail risk weight curve (other retail) has been applied for a turnover below €2.5 million.[10] The retail risk weight curve differs from the one for corporate exposures because it does not depend on the effective maturity M and size S. The corresponding asset correlation is lower than the one for the corporate portfolio and ranges from 0.03 to 0.16:

$$\rho(PD) = 0.16 - (0.16 - 0.03) \cdot (1 - e^{-35PD})$$

In both cases, the capital charge is determined by multiplying the exposure at default with the risk weight and the solvability coefficient of 0.08. The risk weights in the RSA are not based on models. More precisely, they are determined by a simple step function with 100% for loans in the corporate portfolio without an external rating and 75% for loans in the retail portfolio. This construction implies that the RSA risk weights are only partially risk-sensitive. In Germany SMEs typically do not have external ratings.

In the CRR/CRD IV risk weights for SME loans differ from the risk weights under Basel III as defined above. The CRR has introduced in Art. 501 a deduction in capital requirements for exposures to SMEs by applying the SME Supporting Factor of 0.7619 to the capital requirements. This capital discount came into force in January 2014. The SME SF can be applied to all loans granted to SME borrowers which fulfil the following criteria. (1) The loan is allocated to the corporate, retail or secured by immovable property portfolio. (2) The borrower represents an SME defined as turnover is below € 50 mln. (3) The total amount owed to the lending institution, its parent and subsidiary undertakings shall not exceed € 1.5 mln. Against this background, the risk weights for loans to SMEs under the CRR/CRDIV are derived as follows:

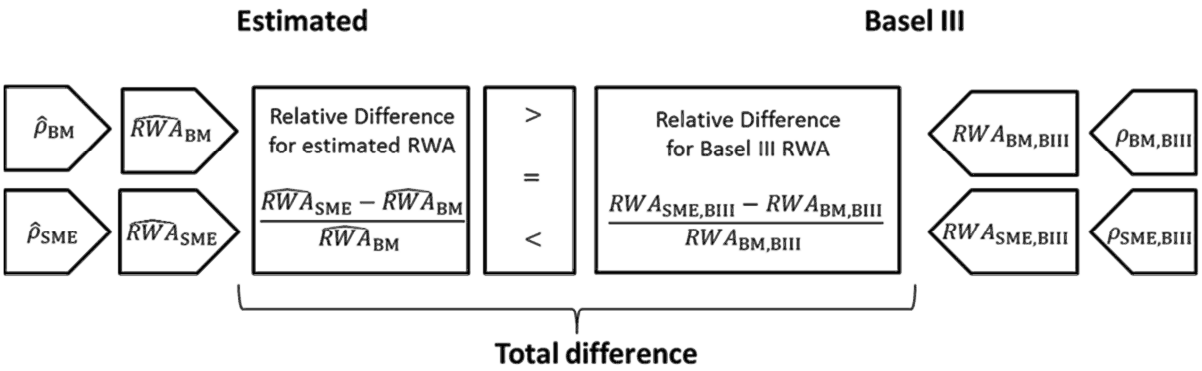
$$RW^{CRR}(PD,S) = 0.7619 \cdot RW^{BIII}(PD,S) \quad \textbf{\textit{if borrower is an SME}}.$$

The formulas for the regulatory asset correlations remain in the similar way. The risk weights for non-SMEs which are in our study only large corporates are not affected by the SME SF.

[10] Analyses of the Bank for the Accounts of Companies Harmonised (BACH) database from the European Committee of Central Balance Sheet Data Offices support the consideration of the first three turnover classes as other retail since the average ratio of turnover to liabilities of credit institutions amounts to 3.1 in 2009 and €1 million is the exposure threshold for the retail portfolio.

The conducted analysis is very much in the spirit of previous analyses that were carried out for the relative calibration of Basel II and explores the dependence of systematic risk on firm size and compares the size of this effect with the capital relief granted to SME lending in the regulatory minimum capital requirements of Basel III and CRR/CRD IV (Figure 3).[11] The asset correlations are estimated based on the ASRF model underlying the IRBA capital requirements. We use large corporates (that is corporates with a turnover of more than EUR 50 million) as a benchmark, which means that they are assumed to be correctly calibrated in level. This is motivated by the fact that the BCBS has spent substantial effort on calibrating these portfolios due to their immense economic importance. For each size class we therefore compare the relative difference (difference in capital requirements for this size class of SMEs relative to capital requirements for the benchmark, i.e. for large corporates) of both (1) capital requirements based on estimated asset correlations and (2) the current IRBA capital requirements.

Figure 4: Illustration of framework to compare estimated and regulatory risk weights[12]



[11] In this study, we consider only the relative calibration since the appropriate level of regulatory capital cannot be satisfactorily assessed for the following two reasons: 1) The overall level of capital requirements was determined in the top-down calibration of the whole Basel II framework, also involving for example the 99.9% confidence level of the value-at-risk, the scaling factor of 1.06 for credit-risk-weighted assets, and the benchmark maturity of 2.5 years. There is no reason to believe that this very different calibration goal will provide asset correlations similar to the estimates from time series of default rates. 2) Gordy and Heitfield (2010) and Düllmann et al. (2010) show that asset correlation estimates can generate significant downward biases when the underlying time series of default rates are short. Through a relative comparison of asset correlation estimates for large companies with SMEs, both of which are affected by this estimation bias, we expect to mitigate the impact of this effect.

[12] BM refers to the benchmark group (i.e. large corporates, turnover larger than € 50 mln). To differentiate the risk weights calculated using the empirical asset correlations (left hand side) from the regulatory risk weights (right hand side) the later are indexed BIII (for Basel III).

5. Results

5.1 Asset correlation estimates

For the relative calibration, following Frey and McNeil (2003), we run the model separately for each size class. So, the firm's rating acts as a potential driver of the estimation of asset correlations (e.g, Hahnenstein, 2004; Düllmann and Scheule, 2006; Düllmann and Koziol, 2014), beside a general random risk factor. This two-dimensional dependence is also reflected in the current IRB risk weight functions. Therefore, we estimate the asset correlation for each turnover class taking into account all information on the different rating classes. This is an advantage in comparison to the ML estimator for which asset correlations have to be estimated for each rating and size buckets separately. The estimation results for the asset correlations using the GLMM Single Factor estimator are presented in Table 4.

Table 4: GLMM SF estimates for assets correlations (in percent)

France	**Turnover in mio €**	**Retail**	**Corporate**			
		0.75 - 1.5	**1.5 - 5**	**5 - 15**	**15 - 50**	**> 50**
	Estimates	0.56	00.59	0.62	0.69	1.36
	st. errors	(0.15)	(0.15)	(0.18)	(0.22)	(0.54)

Germany	**Turnover in mio €**	**Retail**		**Corporate**			
		0 – 1	**1 - 2.5**	**2.5 - 5**	**5 - 20**	**20 - 50**	**> 50**
	Estimates	0.57	0.57	0.51	0.80	0.92	1.84
	st. errors	(0.19)	(0.19)	(0.18)	(0.28)	(0.36)	(0.67)

Table 5: Average Probability of Default at the one year horizon by size class and rating (in percent)

	Turnover in mio €	**Retail**	**Corporate**				**Weighted Avg.**
		0.75 - 1.5	**1.5 - 5**	**5 - 15**	**15 - 50**	**> 50**	
France	**Low Risk 1**	0.25%	0.22%	0.14%	0.10%	0.04%	0.20%
	2	1.07%	1.15%	0.92%	0.62%	0.33%	1.03%
	3	1.68%	2.04%	1.83%	1.12%	0.60%	1.80%
	High Risk 4	5.97%	5.64%	4.18%	3.09%	2.03%	5.38%

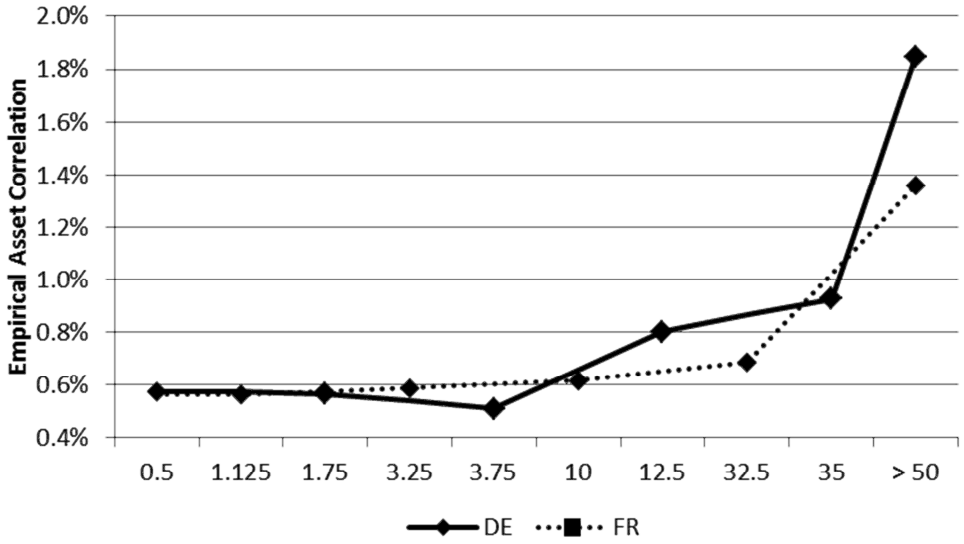
	Turnover in mio €	**Retail**		**Corporate**				**Weighted Avg.**
		0 – 1	**1 - 2.5**	**2.5 - 5**	**5 - 20**	**20 - 50**	**> 50**	
Germany	**Low Risk I-II**	0.60%	0.48%	0.48%	0.39%	0.41%	0.43%	0.50%
	III	1.57%	1.76%	1.67%	1.58%	1.76%	1.49%	1.63%
	IV	3.73%	4.27%	3.93%	3.70%	4.49%	3.78%	3.88%
	V	7.94%	10.60%	8.53%	9.07%	11.17%	10.35%	8.78%
	High Risk VI	24.23%	28.72%	25.42%	27.03%	27.07%	30.59%	25.33%

Since in the German sample the time periods in the sample cover six months we have transformed the estimates of a half-year PD_h by the formula $PD = 1 - (1 - PD_h)^2$ into PDs for a one-year horizon. This transformation is necessary for the analysis of the capital requirements since PDs in Basel III always refer to a one-year horizon. PD estimations by size and rating classes are illustrated in Table 5 using the ML estimator by Gordy and Heitfield (2010)[13].[14]

The overall results for the asset correlation results are consistent across Germany and France and robust for different estimators.[15] The study determines as a key finding that large corporates (Basel definition: corporates with turnover >50 mln €) face a considerable higher systematic risk than SMEs (Figure 4) and that there is a structural difference between loans to large corporates and SME loans. More precisely, the asset correlations for large corporates are estimated twice as high as the asset correlations for SME loans. For SMEs the systematic risk is rather stable and does not vary significantly with turnover. For Germany, the asset correlation estimates tend to increase with firm size. This is in line with the existent academic literature which finds that asset correlations increase with firm size (e.g. DE: Düllmann/Scheule (2006); Düllmann/Koziol (2014); FR: Dietsch/Petey (2004); Dietsch/Fraisse (2013); IT: Gabbi and Vozzella (2013); JP: Hashimoto (2009); US: Bams/Pisa/Wolff (2015)). Irrespectively of the sample used, the level of asset correlations never exceeds two percent and is on average considerably below the asset correlations in the IRB capital requirements. A possible underestimation of the asset correlations could result from the fact that for each size class the correlations were estimated for well diversified portfolios with respect to business sectors.

Figure 5: Estimated asset correlation subject to firm size (turnover in mln €)

[13] The estimation results are almost identical to the simple average of the default rates.
[14] In the course of the paper average PDs across each rating class are used.
[15] In addition to the GLMM single factor estimator, the ML estimator of Gordy and Heitfield (2010) and the GLMM multi factor estimator were applied. Their estimation results are line with the estimates for the GLMM single factor. (Tables C.1 and C.2 in the Appendix)



In the next subsection we compare the capital requirements in Basel III dependent on turnover with the estimated capital requirements based on the asset correlation and PD estimates. Afterwards, we evaluate the estimated capital requirements with respect to the RSA. The risk weights do depend considerably on the rating/PD and on the turnover. In the following we account for this two-dimensional dependence by weighting the IRB or RSA risk weights with respect to the number of borrowers in each rating category. The advantage of this aggregation is that we can condense the assessment of the asset correlation estimates in a single figure

5.2 Consistency of own funds requirements

By comparing the size dependence of estimated capital requirements (i.e., based on empirical asset correlation estimates) with the size dependence hard-wired into the corresponding IRBA capital requirements, the question of whether the size dependence of IRBA capital requirements is appropriate in light of the new empirical results can be answered. In the next step, the size dependence within the SA is investigated. For this purpose, the relative level of capital requirements implied by the asset correlation estimates are compared with the SA capital requirements. According to Basel III, the SA risk weight function is simply a step function with a risk weight of 100% if the firm is treated as a corporate exposure and 75% if it is assigned to the retail portfolio, i.e., if the exposure to the borrower does not exceed EUR 1 million, which is comparable with a turnover of up to EUR 2.5 million.

After analyzing Basel III capital requirements, this study focusses on the capital requirements according to CRR/CRDIV including the SME SF. In doing so, the impact of the SME SF can be measured when we compare the size dependence of CRR risk weights with the one of the

estimated risk weights. It is assumed that the SME SF is applied to all SME loans which is a rather conservative assumption given that the percentages of all loans assigned to the SME SF amounts to 64% for DE and 86% for FR (Table 2).

In order to quantify the deviation of the estimated and the regulatory risk weights, the relative difference towards the benchmark of large corporates is compared by subtracting the relative difference[16] of the estimated capital requirements from the relative difference of the regulatory capital requirements. This difference, the total average difference (shown e.g. for Basel III capital requirements in the fourth row (C-A) in Tables 5 and 6) determines whether the size dependence of Basel III or CRR/CRD IV capital requirements complies with the one of estimated capital requirements. Tables 5 and 6 show the results for loans under the IRBA and the SA based on both the Basel III framework (C-A) and on the CRR/CRD IV (C-B).

For the Basel III framework, both (relative) differences are negative and the absolute value of the difference for the empirical estimates is significantly higher than that of the difference for the regulatory numbers for loans assigned to the corporate portfolio. This may be interpreted as an indication that the empirical results ceteris paribus would support lower Basel III capital requirements for SMEs. However, the gap between both relative differences from the benchmark is close to zero and insignificant for loans in the IRBA Retail portfolio as we define average total differences below ten percentage points as economically insignificant.

The results for the SA are considerably stronger and economically more significant than those for the IRBA under the Basel III framework. The estimated capital requirements differ to a much greater extent from the benchmark large corporates (-37% up to -56%) than the regulatory figures (0% up to -25%). For SMEs in the corporate portfolio, the results are directionally in line with those for the IRBA, but the average total differences are higher, up to a level of 56 percentage points. In comparison to the corporate portfolio, the empirical results for the SME loans in the retail portfolio indicate a lower but economically significant capital relief potential between 19 and 28 percentage points. To sum up, for all loans assigned to the SME portfolio, the empirical results suggest that the relative reduction compared to large firms is significantly higher than reflected in the current capital requirements under the Basel III framework.

[16] The overall relative difference per size bucket is derived from the respective relative differences for each rating category by weighting with the number of loans.

Under the CRR/CRD IV, the results in Tables 5 and 6 indicate for the IRBA that SME SF is able to compensate the difference between estimated and CRR/CRDIV capital requirements for loans in the corporate portfolio. For loans assigned to the retail portfolio the SME SF increases the size dependence even higher than the estimated risk weights suggest. The effect is almost zero for German loans, but stronger for French loans. These results are likely to overstate the additional impact of the SME SF on regulatory risk weights, as the assumption that all SME loans can be assigned to the SME SF appears to be very conservative in light of Table 2.

In case of the CRR/CRD IV SA, the SME SF reduces the total differences between estimated and CRR/CRD IV capital requirements. For loans assigned to the corporate portfolio the SME SF compensates some part of the total differences, but some differences still remain. For retail loans the differences are mostly captured by the SME SF which means that the SME SF achieves the expected purpose.

Table 5: Average total differences of capital requirements in the Basel III and CRR/CRDIV IRBA and SA for France

	Turnover (in EUR million)			Retail	Corporate			
				0.75 - 1.5	1.5 - 5	5 - 15	15 - 50	BM
IRBA	A	Regulatory	Basel III	-54.5%	-22.1%	-19.6%	-8.7%	0.0%
	B		CRR/CRDIV	-65.3%	-40.6%	-38.7%	-30.4%	0.0%
	C	Estimated		-43.5%	-42.4%	-40.8%	-36.7%	0.0%
	C-A	Average total difference Basel III		11.0 pp	-20.3 pp	-21.2 pp	-28.0 pp	0.0 pp
	C-B	Average total difference CRR/CRDIV		21.8 pp	-1.8 pp	-2.1 pp	-6.2 pp	0.0 pp

	Turnover (in EUR million)			Retail	Corporate			
				0.75 - 1.5	1.5 - 5	5 - 15	15 - 50	BM
SA	A	Regulatory	Basel III	-25.0%	0.0%	0.0%	0.0%	0.0%
	B		CRR/CRDIV	-42.9%	-23.8%	-23.8%	-23.8%	0.0%
	C	Estimated		-43.5%	-42.4%	-40.8%	-36.7%	0.0%
	C-A	Average total difference Basel III		-18.5 pp	-42.4 pp	-40.8 pp	-36.7 pp	0.0 pp
	C-B	Average total difference CRR/CRDIV		-0.6 pp	-18.6 pp	-17.0 pp	-12.9 pp	0.0 pp

Note: The average total difference is calculated as the difference between the regulatory and estimated relative difference in RWA. A negative difference means that the regulatory asset correlation leads to higher relative capital requirements than the risk weght based on estimated correlation (given the same level of other parameters). A positive difference means that the regulatory asset correlation leads to lower relative capital requirements than the risk weght based on estimated correlation (given the same level of other parameters).

Table 6: Average total differences of capital requirements in the Basel III and CRR/CRDIV IRBA and SA for Germany

	Turnover (in EUR million)			Retail		Corporate			
				0 - 1	1 - 2.5	2.5 – 5	5 - 20	20 - 50	BM
IRBA	A	Regulatory	Basel III CRR/CRDIV	-53.7%	-53.4%	-22.1%	-18.5%	-7.4%	0.0%
	B			-64.7%	-64.5%	-40.7%	-37.9%	-29.5%	0.0%
	C	Estimated		-51.8%	-52.8%	-55.8%	-42.0%	-36.9%	0.0%
	C-A	Average total difference Basel III		1.9 pp	0.6 pp	-33.6 pp	-23.5 pp	-29.5 pp	0.0 pp
	C-B	Average total difference CRR/CRDIV		12.9 pp	11.6 pp	-15.1 pp	-4.1 pp	-7.5 pp	0.0 pp

	Turnover (in EUR million)			Retail		Corporate			
				0 - 1	1 - 2.5	2.5 - 5	5 - 20	20 - 50	BM
SA	A	Regulatory	Basel III CRR/CRDIV	-25.0%	-25.0%	0.0%	0.0%	0.0%	0.0%
	B			-42.9%	-42.9%	-23.8%	-23.8%	-23.8%	0.0%
	C	Estimated		-51.8%	-52.8%	-55.8%	-42.0%	-36.9%	0.0%
	C-A	Average total difference Basel III		-26.8 pp	-27.8 pp	-55.8 pp	-42.0 pp	-36.9 pp	0.0 pp
	C-B	Average total difference CRR/CRDIV		-8.9 pp	-9.9 pp	-32.0 pp	-18.2 pp	-13.1 pp	0.0 pp

Note: The average total difference is calculated as the difference between the regulatory and estimated relative difference in RWA. A negative difference means that the regulatory asset correlation leads to higher relative capital requirements than the risk weght based on estimated correlation (given the same level of other parameters). A positive difference means that the regulatory asset correlation leads to lower relative capital requirements than the risk weght based on estimated correlation (given the same level of other parameters).

The results are also valid when considering each rating class separately. Table 7 shows the relative differences of the estimated and the Basel III (IRBA) risk weights for each rating category. The relative differences are significantly negative for all loans assigned to the corporate portfolio. In each turnover class the differences vary slightly, but the overall result turns out clearly. Against this background, the results are independent of the rating class which means that the identified capital relief is determined for all rating classed of the borrowers.

Table7: Relative differences of IRBA capital requirements under Basel III

		Retail	**Corporate**			
		0,75 - 1,5	**1,5 - 5**	**5 - 15**	**15 – 50**	**BM**
France	**Low Risk 3**	13.3%	-22.6%	-23.1%	-29.3%	0.0%
	4	6.9%	-20.3%	-20.9%	-27.4%	0.0%
	5	6.8%	-18.6%	-19.3%	-26.4%	0.0%
	High Risk 6	15.5%	-14.4%	-15.5%	-24.1%	0.0%

		Retail		**Corporate**			
		0,1	**1, 2.5**	**2.5, 5**	**5, 20**	**20, 50**	**BM**
Germany	**Low Risk I-II**	-1.2%	-1.6%	-36.9%	-26.1%	-31.0%	0.0%
	III	-3.5%	-3.9%	-33.8%	-23.4%	-29.1%	0.0%
	IV	1.8%	1.4%	-30.0%	-20.1%	-27.1%	0.0%
	V	10.9%	10.5%	-28.4%	-18.7%	-25.8%	0.0%
	high Risk VI	9.2%	8.7%	-30.3%	-20.1%	-25.0%	0.0%

5.3 Impact of Exposure

In order to fully analyse the adequacy of the SME SF, the threshold for its application need to be taken into account. Thus, the study also aims to assess whether the systematic risk of SMEs depends on the amount owed ("obligo"). Against this background, asset correlations are estimated with respect to the borrower's loan volume considering the different rating classes. The estimated asset correlations subject to obligo are shown in Table 8 and Figure 5. Neither for Germany nor for France, any empirical evidence supporting the limit of € 1.5 mln currently implemented in Article 501 CRR is found. This means that the limit of € 1.5 mln million for the amount owed set in the Article 501 CRR does not seem to be indicative of any change in riskiness firms.

Figure 6: Estimated Asset Correlation subject to loan exposure (obligio in mio €)

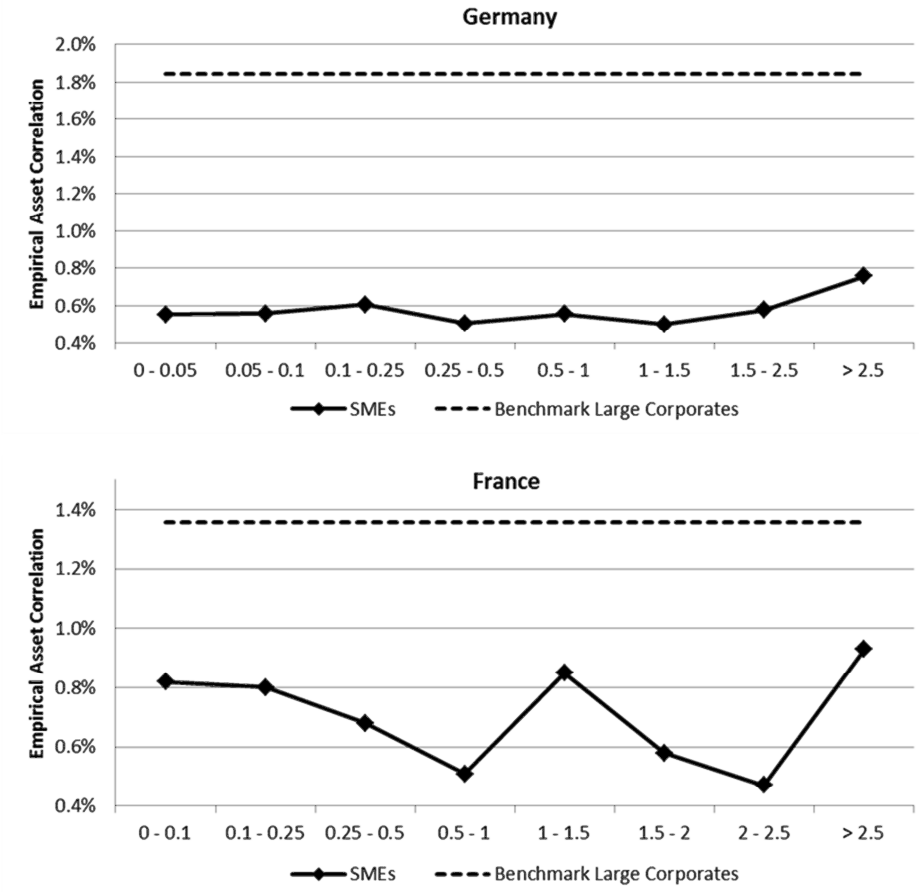


Table 8: Asset Correlation with respect to Exposure (in percent)

FR	**Obligo (mln €)**	**< 0.1**	**0.1 - 0.25**	**0.25 - 0.5**	**0.5 - 1**	**1 - 1.5**	**1.5 - 2**	**2 - 2.5**	**> 2.5**
	Estimates	0.82	0.80	0.68	0.51	0.85	0.58	0.47	0.93
	st. Errors	0.31	0.21	0.18	0.14	0.23	0.18	0.17	0.25

DE	**Obligo (mln €)**	**0 - 0.05**	**0.05 - 0.1**	**0.1 - 0.25**	**0.25 - 0.5**	**0.5 - 1**	**1 - 1.5**	**1.5 - 2.5**	**> 2.5**

	Estimates	0.55	0.56	0.61	0.51	0.56	0.50	0.58	0.76
	st. errors	0.22	0.23	0.24	0.20	0.23	0.26	0.31	0.40

6. Conclusion and policy implication s

Using comprehensive data sets covering a significant part of the German and French SME and large corporate population, this study contributes to two policy issues related to SME financing and provides significant results. The first issue concerns the relative calibration of capital requirements and the adequacy of capital requirements with the riskiness of SMEs in general. The second concerns the consistency of the supporting factor SME introduced in the CRR/CRDIV in particular. The study addresses these issues by using the asymptotic single risk model (Gordy, 2003) and assessing firm size as a driver of systematic credit risk in this framework. Therefore, in this study, the asset correlation is used as the key measure of systematic risk.

The first policy implication concerns a potential increase of the capital relief granted for SMEs which was supported in the Basel II accord. Either in the French or the German sample, results suggest that the relative differences between the capital requirements for large corporates and those for SMEs (in other words the capital relief for SMEs) are lower in the Basel III framework than implied by empirically estimated asset correlations. For all loans assigned to the SME portfolio, the empirical results suggest that the relative reduction compared to large firms is significantly higher than reflected in the current capital requirements under the Basel III framework. On average, the asset correlations for large corporates are estimated twice as high as the asset correlations for SME loans. Thus, results in this paper may indicate a potential for increasing the capital relief for SMEs exposures, whatever the form of this increase: through a lowering the regulatory capital requirements for SMEs, for instance by lowering the asset correlation values in the IRB formula, or through a lowering the RSA risk weights directly. But, before drawing this inference as a policy message of this paper, the following important caveats need to be carefully considered. The RSA was deliberately calibrated more conservatively than the IRB approaches. This can be explained by the significantly lower risk sensitivity of the RSA and the regulatory intention to retain incentives in terms of a ceteris paribus capital relief when banks switch to the more risk sensitive IRB approaches. The more conservative calibration is one reason why the capital requirements in the RSA currently are independent of the firm size which is one important driver for the empirically observed lower potential for reductions of the capital requirements. It also suggests that at least a substantial part of the 15%-35% difference between the current capital relief in the RSA and the capital relief implied by our new empirical results can be

explained by this original calibration target. Since the regulatory minimum capital requirements are internationally harmonized today, their modification appears reasonable because the results of this study cover SME lending in two major European countries and the used data set represents the largest coverage of the countries in the Eurozone.

The second policy implication concerns the SME supporting factor (SME SF). This study brings unambiguous support for the supporting factor, whatever the approach -- IRBA or RSA -- used to compute SME loans capital requirements. This result relies on the comparison of the dependence of CRR risk weights with the one of the estimated risk weights. In the IRBA approach, results show that SME SF in the CRR/CRDIV is able to compensate the difference between estimated and CRR/CRDIV capital requirements for loans in the corporate portfolio. For loans classified in the retail portfolio, the SME SF increases the size dependence even higher than the estimated risk weights suggest. In the RSA approach, the SME SF reduces the total differences between estimated and CRR/CRD IV capital requirements. For loans assigned to the corporate portfolio, it only compensates part of the total differences, so that some differences still remain. For retail loans, the differences are mostly captured by the SME SF which means that the SME SF achieves the expected purpose.

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Appendix A: Literature Overview

Appendix B:

Appendix C: Robustness checks for asset correlation estimations

Table C.1: ML estimates for assets correlations (in percent)

	Turnover in mio €	Retail	Corporate			
		0.75 - 1.5	1.5 - 5	5 - 15	15 - 50	> 50
France	**Low Risk 1**	1.41	1.22	0.69	0.57	3.16
	p-value	(0.00)	(0.00)	(0.08)	(0.22)	(0.17)
	2	0.72	0.70	0.80	0.64	1.99
	p-value	(0.00)	(0.00)	(0.02)	(0.10)	(0.15)
	3	0.61	0.60	1.59	1.18	6.26
	p-value	(0.00)	(0.00)	(0.01)	(0.02)	(0.03)
	High Risk 4	0.79	0.94	0.71	0.94	3.02
	p-value	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)

	Turnover in mio €	Retail		Corporate		
		0 - 1	1 - 2.5	2.5 - 5	5 - 50	> 50
Germany	**Low Risk I-III**	0.85	0.68	0.75	0.61	1.79
	p-value	(0.01)	(0.01)	(0.03)	(0.02)	(0.02)
	IV	0.58	0.74	0.52	0.53	2.10
	p-value	(0.01)	(0.02)	(0.06)	(0.03)	(0.04)
	High Risk V-VI	0.47	0.42	0.42	0.85	1.93
	p-value	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)

Table C.2: GLMM multi-factor estimates for assets correlations (in percent)

	Var-Cov-Matrix for Turnover Buckets (in mio €)		Retail	Corporate			
			0,75 - 1,5	1,5 - 5	5 - 15	15 - 50	> 50
France	Retail	**0,75 - 1,5**	**2.2%**	2.4%	0.8%	-0.9%	-3.3%
	Corporate	**1,5 - 5**	2.4%	**2.7%**	1.0%	-1.1%	-3.9%
		5 - 15	0.8%	1.0%	**0.7%**	0.4%	-0.3%
		15 - 50	-0.9%	-1.1%	0.4%	**2.1%**	4.4%
		> 50	-3.3%	-3.9%	-0.3%	4.4%	**10.3%**

	Var-Cov-Matrix for Turnover Buckets (in mio €)		Retail		Corporate			
			0 - 1	1 - 2.5	2.5 - 5	5 - 20	20 - 50	>50
Germany	Retail	**0 - 1**	**0.6%**	0.4%	0.4%	0.4%	0.2%	0.5%
		1 - 2.5	0.4%	**1.0%**	0.5%	0.5%	0.6%	0.7%
	Corporate	**2.5 - 5**	0.4%	0.5%	**0.5%**	0.6%	0.5%	0.7%
		5 - 20	0.4%	0.5%	0.6%	**0.7%**	0.8%	1.0%
		20 - 50	0.2%	0.6%	0.5%	0.8%	**1.0%**	1.2%
		>50	0.5%	0.7%	0.7%	1.0%	1.2%	**1.7%**

Appendix D: Detailed results for calculation of average total differences

Table D.1: Capital requirements in terms of risk weights per rating class (in percent) using the empirical framework

	Turnover in mio €	Retail	Corporate			
		0.75 - 1.5	1.5 - 5	5 - 15	15 - 50	> 50
France	Low Risk 1	1.7%	1.7%	1.8%	1.9%	3.1%
	2	6.0%	6.2%	6.4%	6.8%	10.6%
	3	9.2%	9.4%	9.7%	10.3%	16.0%
	High Risk 4	20.1%	20.6%	21.2%	22.6%	34.1%

	Turnover in mio €	Retail		Corporate			
		0 - 1	1 - 2.5	2.5 - 5	5 - 20	20 - 50	> 50
Germany	Low Risk I-II	3.5%	3.5%	3.3%	4.4%	4.8%	7.8%
	III	8.6%	8.5%	8.0%	10.6%	11.6%	18.2%
	IV	16.2%	16.1%	15.1%	19.8%	21.5%	33.3%
	V	28.2%	28.0%	26.4%	34.2%	37.1%	56.0%
	High Risk VI	50.5%	50.1%	47.3%	60.3%	65.0%	94.3%

Table D.2: Capital requirements in terms of risk weights per rating class (in percent) using the Basel II/III framework

	Turnover in mio €	Retail	Corporate			
		0.75 - 1.5	1.5 - 5	5 - 15	15 - 50	> 50
France	Low Risk 1	19.1%	36.3%	37.3%	42.1%	46.0%
	2	49.1%	77.4%	79.8%	90.4%	98.8%
	3	59.8%	91.4%	94.3%	107.6%	118.1%
	High Risk 4	70.9%	121.9%	126.6%	147.1%	162.8%

	Turnover in mio €	Retail		Corporate			
		0 - 1	1 - 2.5	2.5 - 5	5 - 20	20 - 50	> 50
Germany	Low Risk I-II	34.5%	34.5%	58.4%	61.0%	68.7%	74.1%
	III	58.0%	58.0%	89.0%	93.2%	106.0%	114.7%
	IV	68.7%	68.7%	110.4%	116.5%	134.6%	146.6%
	V	77.1%	77.1%	147.1%	155.4%	179.5%	195.0%
	High Risk VI	116.1%	116.1%	210.6%	219.9%	245.9%	261.7%

Appendix E: Estimated and Basel III Risk Weights and Relative Differences in Capital Requirements in case of Germany

	Estimated						Risk Weights	Basel III					
	Retail		Corporate					Retail		Corporate			
	0,1	1, 2.5	2.5, 5	5, 20	20, 50	> 50		0,1	1, 2.5	2.5, 5	5, 20	20, 50	> 50
Low Risk I-II	3.5%	3.5%	3.3%	4.4%	4.8%	7.8%		34.5%	34.5%	58.4%	61.0%	68.7%	74.1%
III	8.6%	8.5%	8.0%	10.6%	11.6%	18.2%		58.0%	58.0%	89.0%	93.2%	106.0%	114.7%
IV	16.2%	16.1%	15.1%	19.8%	21.5%	33.3%		68.7%	68.7%	110.4%	116.5%	134.6%	146.6%
V	28.2%	28.0%	26.4%	34.2%	37.1%	56.0%		77.1%	77.1%	147.1%	155.4%	179.5%	195.0%
High Risk VI	50.5%	50.1%	47.3%	60.3%	65.0%	94.3%		116.1%	116.1%	210.6%	219.9%	245.9%	261.7%

	Estimated						Relative Differences in Capital Requirements by Rating and Turnover class	Basel III					
	Retail		Corporate					Retail		Corporate			
	0,1	1, 2.5	2.5, 5	5, 20	20, 50	> 50		0,1	1, 2.5	2.5, 5	5, 20	20, 50	> 50
Low Risk I-II	-54.7%	-55.1%	-58.0%	-43.8%	-38.2%	0.0%		-53.5%	-53.5%	-21.1%	-17.7%	-7.2%	0.0%
III	-52.9%	-53.3%	-56.2%	-42.1%	-36.7%	0.0%		-49.4%	-49.4%	-22.4%	-18.7%	-7.6%	0.0%
IV	-51.3%	-51.8%	-54.7%	-40.6%	-35.3%	0.0%		-53.1%	-53.1%	-24.7%	-20.5%	-8.2%	0.0%
V	-49.6%	-50.0%	-52.9%	-39.0%	-33.7%	0.0%		-60.5%	-60.5%	-24.5%	-20.3%	-7.9%	0.0%
High Risk VI	-46.5%	-46.9%	-49.8%	-36.1%	-31.1%	0.0%		-55.6%	-55.6%	-19.5%	-16.0%	-6.0%	0.0%

	Total Differences of Capital Requirements in BASEL III					
	Retail		Corporate			
	0,1	1, 2.5	2.5, 5	5, 20	20, 50	> 50
Low Risk I-II	-1.2%	-1.6%	-36.9%	-26.1%	-31.0%	0.0%
III	-3.5%	-3.9%	-33.8%	-23.4%	-29.1%	0.0%
IV	1.8%	1.4%	-30.0%	-20.1%	-27.1%	0.0%
V	10.9%	10.5%	-28.4%	-18.7%	-25.8%	0.0%
High Risk VI	9.2%	8.7%	-30.3%	-20.1%	-25.0%	0.0%

Estimated							Basel III					
Retail		Corporate					Retail		Corporate			
0,1	1, 2.5	2.5, 5	5, 20	20, 50	> 50		0,1	1, 2.5	2.5, 5	5, 20	20, 50	> 50
-51.8%	-52.8%	-55.8%	-42.0%	-36.9%	0.0%		-53.7%	-53.4%	-22.1%	-18.5%	-7.4%	0.0%

Average total difference					
Retail		Corporate			
0,1	**1, 2.5**	**2.5, 5**	**5, 20**	**20, 50**	**> 50**
1.9%	**0.6%**	**-33.6%**	**-23.5%**	**-29.5%**	**0.0%**

Appendix F: Estimated and Basel III Risk Weights and Relative Differences in Capital Requirements in case of France

	Estimated					Risk Weights	Basel III				
	Retail	Corporate					Retail	Corporate			
	0,75 - 1,5	1,5 - 5	5 - 15	15 - 50	> 50		0,75 - 1,5	1,5 - 5	5 - 15	15 - 50	> 50
Low Risk 3	1.7%	1.7%	1.8%	1.9%	3.1%		19.1%	36.3%	37.3%	42.1%	46.0%
4	6.0%	6.2%	6.4%	6.8%	10.6%		49.1%	77.4%	79.8%	90.4%	98.8%
5	9.2%	9.4%	9.7%	10.3%	16.0%		59.8%	91.4%	94.3%	107.6%	118.1%
High Risk 6	20.1%	20.6%	21.2%	22.6%	34.1%		70.9%	121.9%	126.6%	147.1%	162.8%

	Estimated					Relative Differences in Capital Requirements by Rating and Turnover class	Basel III				
	Retail	Corporate					Retail	Corporate			
	0,75 - 1,5	1,5 - 5	5 - 15	15 - 50	> 50		0,75 - 1,5	1,5 - 5	5 - 15	15 - 50	> 50
Low Risk 3	-45.3%	-43.8%	-42.1%	-37.8%	0.0%		-58.6%	-21.2%	-18.9%	-8.5%	0.0%
4	-43.4%	-42.0%	-40.2%	-36.0%	0.0%		-50.3%	-21.6%	-19.3%	-8.6%	0.0%
5	-42.6%	-41.2%	-39.5%	-35.3%	0.0%		-49.4%	-22.6%	-20.2%	-8.9%	0.0%
High Risk 6	-40.9%	-39.5%	-37.8%	-33.7%	0.0%		-56.5%	-25.1%	-22.3%	-9.7%	0.0%

Total Differences of Capital Requirements in BASEL III					
	Retail	Corporate			
	0,75 - 1,5	1,5 - 5	5 - 15	15 - 50	> 50
Low Risk 3	13.3%	-22.6%	-23.1%	-29.3%	0.0%
4	6.9%	-20.3%	-20.9%	-27.4%	0.0%
5	6.8%	-18.6%	-19.3%	-26.4%	0.0%
High Risk 6	15.5%	-14.4%	-15.5%	-24.1%	0.0%

Estimated				
Retail	Corporate			
0,75 - 1,5	1,5 - 5	5 - 15	15 - 50	> 50
-43.5%	-42.4%	-40.8%	-36.7%	0.0%

Basel III				
Retail	Corporate			
0,75 - 1,5	1,5 - 5	5 - 15	15 - 50	> 50
-54.5%	-22.1%	-19.6%	-8.7%	0.0%

Average total difference				
Retail	Corporate			
0,75 - 1,5	1,5 - 5	5 - 15	15 - 50	> 50
11.0%	**-20.3%**	**-21.2%**	**-28.0%**	**0.0%**