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Credit Risk Versus Capital Requirements under Basel II: Are SME Loans and Retail Credit Really Different?

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Abstract

Under Basel II, retail and SME credit (R&SME) receive special treatment because of a supposedly smaller exposure to systemic risk. Most research on this issue has been based on parameterized credit risk models. We present new evidence by applying Carey's [Carey, Mark. "Credit Risk in Private Debt Portfolios." *Journal of Finance* 53, no. 4 (1998), 1363–1387.] nonparametric Monte-Carlo resampling method to two banks' complete loan portfolios. By exploiting that a sub-sample of all borrowers has been assigned an internal rating by both banks, we can compare the credit loss distributions for the three credit types, and compute both economic and regulatory capital under Basel II. We also test if our conclusions are sensitive to the definitions of R&SME credit. Our findings show that R&SME portfolios are usually riskier than corporate credit. Special treatment under Basel II is thus not justified.

Key words: Internal ratings, credit risk, Value-at-Risk, banks, Basel II, retail credit, SME credit, corporate credit, regulatory capital, economic capital.

JEL classification: C14, C15, G21, G28, G33

1. Introduction

Although non-financial corporate debt (bond issues and privately issued debt) has become more common in the past 10 to 20 years, bank loans are still the prime source of business finance, especially for small and medium size enterprises (SMEs). As a consequence, banks' ex-ante assessment of the riskiness of loan applicants and their resulting decision to grant credit (or not) at some risk-adjusted interest rate, are of great importance for businesses. Bank regulators increasingly lean on the risk assessments made

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by banks: in the Basel Committee's new capital adequacy rules, the so-called Basel II Accord (Basel Committee, 2004), internal risk ratings produced by banks have been given a prominent role.[1] Unlike previous regulation, the rules of Basel II will, for many big and internationally active banks, make the size of the required buffer capital contingent on their own appraisal of ex-ante individual counterpart risk. It will be up to the banks to characterize the riskiness of the counterparts and loans in their portfolios by means of risk categories or "rating classes." A special feature of the new regulation is that retail credit and loans to SMEs will receive a different treatment than corporate loans and will require less regulatory capital for given default probabilities. The main reason for this differential treatment is that small business loans and retail credit are generally found to be less sensitive to systematic risk. Their risk of default is thought to be largely of an idiosyncratic nature and, as a result, default probabilities are assumed to be more weakly correlated when compared with corporate loans. Another reason for the preferential treatment of retail credit lies in a technical assumption by the Basel Committee that maturities are shorter.

The Basel II Accord has been criticized extensively because of its implications from its first conception. Altman and Saunders (2001) found, among other things, that relying on traditional agency ratings may produce cyclically lagging rather than leading capital requirements and that the risk based bucketing proposal lacks a sufficient degree of granularity. Instead they advised to use a risk weighting system that more closely resembles the actual loss experience on loans. Criticism like this has spurred subsequent research by authors such as Carling et al. (2004), Dietsch and Petey (2002), Estrella (2004), Calem and LaCour-Little (2001), and Hamerle et al. (2003). Their work employs credit risk models for the ultimate goal of calculating capital requirements under a variety of alternative systems and makes clear, among other things, how the proposed internal ratings based (IRB) approach relates to general Value-at-Risk (VaR) models of credit risk and state-of-the-art risk rating and how the technical specification of the final IRB design will affect banks' policies.

To what extent a different treatment of retail credit and SME loans is justified will depend on at least two factors: the ability of banks' internal risk rating systems to adequately capture the differences between different loans and different types of assets, and the methods used to calculate the relevant risk measure. Several authors have studied the ability of banks' internal ratings systems to handle differences between (portfolios of) assets and the implications for credit risk measurement and the eventual functioning of Basel II. Gordy (2000) shows that ratings-based bucket models of credit can be reconciled with the general class of credit Value-at-Risk (VaR) models. Carey (2000) concludes that the success of the IRB approach will depend on the extent to which it will take into account differences in assets and portfolio characteristics, such as granu-

1 The Basel II Accord (Basel Committee, 2004) is organized around three so-called pillars. The first pillar describes the rules for determining banks' minimum capital requirements for credit risk, operational risk, and trading book issues. Pillar 2 provides guidelines for the supervisory review process, while Pillar 3 contains disclosure requirements to promote market discipline.

larity, risk properties and remaining maturities. Jacobson et al. (2002) find that IRB parameters such as the target forecasting horizon, the method to estimate average probabilities of default (PDs) and banks' business cycle sensitivity will also affect the way in which the IRB system can function. Carey and Hrycay (2001) study the effect of internal risk rating systems on estimated portfolio credit risk and find that some of the commonly used methods to estimate average probabilities of default (PDs) by rating class are potentially subject to bias, instability, and gaming. Jacobson et al. (2005) investigate the consistency of internal ratings at two major Swedish banks. They find that loan size and portfolio size are very important determinants of the shape of credit loss distributions and that the banks differ significantly in their perceptions of an identical loan portfolio's riskiness.

Differences between corporate loans and both SME and retail credit have been the subject of a range of studies. A large part of the literature has focused on the special character of small business lending and the importance of relationship banking for solving information asymmetries. Cole (1998), for example, finds empirical support for the theory that banking relationships generate valuable private information about borrower quality. In more recent work, Degryse and Ongena (2005) report evidence that confirms the importance of geographical distance for monitoring (costs). Petersen and Rajan (2002) find that firms with long distances to their lenders, typically SMEs, no longer need to be the highest quality counterparts, indicating that they have obtained greater access to credit. In response to the work of the Basel Committee, a number of authors has looked more explicitly into the differences in risk properties between credit types. A range of currently available methods to measure retail credit risk is surveyed by Allen et al. (2004). Schmit (2003) studies retail lease portfolios by means of a Monte Carlo resampling method and finds that the Basel II framework insufficiently recognizes collateral. Perli and Nayda (2003) model future margin income and show that the capital ratios generated by the Basel formula best match those generated by their model for low-risk portfolio segments. Their results suggest some inadequacies in the Basel framework. Capital ratios for high-risk segments can, for example, sometimes be lower than for low-risk segments. They also indicate that Basel's assumptions about the interaction between asset correlations and the probability of default may be inaccurate, especially at the extreme ends of the risk spectrum. With respect to SME loan portfolios, Dietsch and Petey (2002) propose two parametric methods for estimating credit risk. They establish, when applying these methods, that actual capital requirements are significantly lower than those derived under Basel II. Dietsch and Petey (2004) also find that SMEs are riskier than large businesses and that PDs and asset correlations are not negatively, as assumed by Basel II, but positively related to each other.[2] Glennon and Nigro (2003)

2 The comparisons made in the work of both Perli and Nayda (2003) and Dietsch and Petey (2002, 2004) are based on the consultative document that the Basel Committee released in 2003. The final text contains a number of modifications. In addition to the introduction of expected and unexpected lossess, these concern mainly minor changes in the calibration of the risk weight mappings, e.g., the assumed values of the correlations for SME loans and retail credit.

analyze small businesses' repayment behavior on Small Business Administration loans and determine that default characteristics can vary widely within the SME segment, depending on the original maturity of the loan.

This paper also investigates the differences between SME, retail, and corporate credit, and specifically the assumption that SME and retail loan portfolios display smaller (unexpected) loss rates than corporate loan portfolios, but it takes a different avenue than earlier studies. Using data from two major Swedish banks' complete business loan portfolios over the period 1997Q1–2000Q1, we explore not only if the retail and SME definitions employed in the Basel documents justify the use of more favorable risk weights for these types of credit, but also if other definitions would do so. For this purpose, we compute the credit loss distributions and the implied IRB capital requirements for both SME, retail, and corporate loan portfolios. Our strategy in this paper is to exploit the very large number of loans in each loan portfolio to apply a non-parametric Monte Carlo resampling method, as suggested by Carey (1998).[3] This avoids making unnecessary assumptions about the distribution of default risk and hence guarantees robustness of our results. Another convenient characteristic of our experiments is that we can resample a benchmark portfolio with a constant risk profile by exploiting the presence of 17,476 observations of firms that borrow in both banks simultaneously. This ensures that any differences in the riskiness between loan portfolios are exclusively due to the fact that we sample from SME or retail loans instead of corporate loans, and not the result of a different rating grade composition.

We start by studying the loss distributions of SME loans, retail credit, and corporate loans when applying the standard Basel definitions. Next, we verify if our findings would change if one alters the definitions of what constitutes an SME loan or a retail credit. That is, we compute the credit loss distributions using different threshold values for total sales to divide the banks' loan portfolios into SME and corporate loans and different thresholds for total credit exposure to split up the data into retail and corporate credit. Our objective with these experiments is to verify (i) if the assumptions about the risk properties of SME, retail, and corporate credit that underlie the Basel framework are - if not exactly - at least approximately satisfied in the data. Moreover, we want to know (ii) whether the "simple" risk mapping functions that large banking corporations will have to apply under the Basel Committee's new rules are likely to capture the actual riskiness of loan portfolios and thus provide regulators with a correct and consistent picture of banks' loan portfolio credit risk.

Our results show that there is little support for the hypothesis that SME loan portfolios are less risky, or require less economic capital, than corporate loans. Occasionally, SME loans are associated with smaller (unexpected) loss rates, but this finding is highly dependent on the particular SME definition chosen, bank specific, and the portfolio size. For retail credit we obtain similar results. Hence using "simple" risk weight mappings, as

3 The loan portfolios contain approximately 180,000 and 300,000 loans, respectively. During the sample period, the two banks represent approximately 40 percent of the Swedish market for business loans.

is envisioned by the Basel Committee, may create large inequalities between banks, owing to, among other things, differences in the shape of loss distributions between banks.

The organization of the remainder of this paper is as follows. First, in section 2, we begin with a characterization of the two banks' business loan portfolios and their internal rating systems. Section 3 outlines how retail and SME credit are treated under the Basel II Accord and how this differs from the treatment of corporate loans. Section 4 contains the implied credit loss distributions of corporate, SME, and retail credit portfolios. Here we also display both banks' IRB capital requirements. Section 5 concludes the paper.

2. Data

This section provides a detailed description of the data that we use in sections 3 and 4. The primary sources of our data are two of the four major Swedish commercial banks and the leading credit bureau in Sweden, Upplysningscentralen AB (UC). For bank A, the data set is a panel consisting of 338,118 observations on bank customers, covering 13 quarters of data on all 39,521 Swedish *aktiebolag* companies that had one or several loans outstanding at the bank on the last day of at least one quarter between January 1, 1997, and March 31, 2000. For bank B we have 183,392 observations on 20,966 *aktiebolag* between January 1, 1997, and June 30, 2000. *Aktiebolag* are by approximation the Swedish equivalent of US corporations and UK limited businesses. Swedish law requires every *aktiebolag* to have at least SEK 100,000 (approximately USD 10,000) of equity to be eligible for registration at the Swedish Patent and Registration Office (PRV). Although we have annual report data on small firms such as general partnerships, limited partnerships and sole proprietors, these will be disregarded because we could not dispose of the relevant credit histories. Observe, however, that a large part of the sample still consists of relatively small enterprises: respectively 65 percent and 53 percent of the banks' observations concern businesses with 5 or fewer employees. During the sample period, from January 1, 1997, until March 31, 2000, 2,880 of these businesses simultaneously have one or more loans in both banks for at least one quarter. This results in 17,476 "overlapping" observations, making the average overlap duration just over six quarters.

Both banks have supplied a full history of internal credit-related data for all debtors, including the unique, government-provided company identification number. By means of the latter, we have been able to match the banks' data with UC's database, which contains quarterly updated official annual report data and payment remarks information on all Swedish companies. The annual accounting data are collected by UC from PRV, to which firms are required to submit their annual report, and includes all typical balance-sheet and income statement data, such as turnover, inventories, short and long-term debt, total assets, and a range of earnings-related variables. We will discuss the specifics of the data in greater detail below.

Both banks are general commercial banks, with a nationwide branch network serving both private and business customers; neither of them has any particular specialization profile within these groups. To verify this, we converted the various types of credit into three broader groups, also used by the banks for certain analytical purposes: short-term,

Table 1. **Profile of companies in bank loan portfolios**

No. of employees			Granted credit (SEK)			Total sales (SEK mn.)		
	A	B		A	B		A	B
0	11.07	14.32	0–50 k	13.65	2.37	<0.5	12.36	8.10
1	16.72	9.38	50 k–100 k	13.27	2.24	0.5–1	11.00	6.67
2–5	37.67	29.79	100 k–250 k	19.85	6.53	1–2	15.67	10.56
6–25	24.42	32.46	250 k–500 k	15.71	12.17	2–3	9.52	8.10
26–50	4.27	6.65	0.5 mn–1 mn	11.20	20.52	3–4	6.36	6.63
51–100	2.54	3.86	1 mn–2.5 mn	10.76	23.80	4–5	4.74	5.43
101–250	1.83	2.26	2.5 mn–5 mn	5.75	12.68	5–7.5	8.08	9.80
250–1000	1.07	0.90	5 mn–10 mn	3.82	7.97	7.5–10	4.83	6.40
>1000	0.41	0.38	10 mn–1 bn	5.91	11.59	10–25	12.04	17.17
			1 bn–	0.08	0.13	25–50	5.63	8.12
	100.00	100.00				50–100	3.76	5.57
				100.00	100.00	100–250	2.97	4.44
						250–1000	2.07	2.12
						>1000		
							0.97	0.89
							100.00	100.00

medium-term, and long-term lending. Of all customers at bank A (B) 69 (71) percent have short-term loans and 72 (68) percent have a long-term or some other type of loan.[4] Having multiple loans is quite common too: about 30 percent of A's and B's customers have both a short-term loan and at least one other loan. The average censored duration of a firm's presence in the bank portfolio is 8.6 (8.7) quarters. On average, bank A's and B's portfolio have a size of SEK 168.4 bn. and 143.7 bn. and contain 24,895 and 12,642 customers respectively; B thus typically grants its customers over 50 percent larger loans than A does: 11.37 mn. kronor, on average, compared with 6.76 mn. for A.

Table 1 offers some more perspective on the composition of banks' portfolios in terms of customer size. Both grant an important part of their loans to small and medium size enterprises: of all customers, 65 percent at A and 55 percent at B have few or fewer employees; A is somewhat better represented among businesses with one to five employees.[5] Only 6 to7 percent of all customers at both A and B have more than 25 employees. The third column of table 1 supports our first impression of A being slightly more specialized in small businesses: approximately 40 percent of all its customers have sales below SEK 2 mn. and 25 percent even stay below SEK 1 mn.,

4 Owing to different granularities in the banks' classification systems, it is difficult to make detailed comparisons beyond short-term loans.

5 Companies without any employees are either owner-run businesses or holding/finance units within a larger concern. Although we believe the number of holding/finance units to be small, we are not able to verify this in our data. For the purpose of our analysis, this distinction is not of importance, however, because we select businesses by means of their total turnover or total credit facility.

compared to 25 and 15 percent at B. Obviously, B has a larger presence among firms with higher sales; close to 40 percent have revenues over SEK 10 mn. whereas only 25 percent at A do so. Only two percent of each bank's customers does not classify as an SME according to the Basel definition.[6] In terms of total credit exposure, the non-SMEs are significant enough, though, owing to the size of their credit lines: at bank A they represent about 35 percent of total credit, while they stand for just over 20 percent at bank B.

Table 1 also reveals that not only the average but also the median size of credit lines varies between banks, implying that differences occur not only at the tails of the distribution. In bank A the median credit line has a size between SEK 250 k and SEK 500 k, quite a bit below its average of SEK 6.76 mn., while bank B has a median credit facility between SEK 1 mn. and SEK 2.5 mn., somewhat closer to its average of SEK 11.37 mn. Although it is difficult to identify a single explanation, one can point out some differences. Bank A is strongly represented in the loan size segment up to SEK 1 mn., while more than 50 percent of the customers in bank B have a total exposure over SEK 1 mn.; only about 10 percent of its loans stays under SEK 250,000. Overall, bank B has a greater share of its customers in industries with larger credit lines, such as real estate, energy and water, and forestry and paper. In addition, it lends more to some businesses than A does, for example in telecom and other services. If we employ the Basel definition of "other retail exposure," approximately 94 percent of all customers in bank A and about 88 percent in bank B could potentially qualify as retail exposure. The "corporate" exposure, however, represents the bulk of each bank's loan portfolio: 88 percent in A and 86 percent in B.

For the purpose of better understanding the data used in the experiments of section 4, we have broken down the loan portfolios of bank A and B into separate corporate, SME, and retail portfolios.[7] Table 2 shows that the composition of the banks' portfolios is quite similar in many respects. Most industries have very similar shares in the banks' portfolios, both in terms of customers and most of them also in terms of total exposure. In terms of customer numbers, other manufacturing, wholesale trade, and real estate are the three greatest corporate customer groups in both banks: together they account for roughly half of the customer stock.[8] Bank B has more loans outstanding in the corporate real estate sector, while bank A is better represented among manufacturing corporates. When expressed in terms of share of total credit, real estate, financial services, and other manufacturing are most important. In the SME portfolios, other services companies play an important role in bank A (21.5 percent of all customers), while B is more active

6 Total sales below EUR 50 mn, which corresponds to approximately SEK 450 mn.

7 In table 2, we break down the data using only the official Basel definitions. As we have already mentioned, we will, in Section 4, also use other split-ups.

8 Real estate business includes, among other things, the exploitation of land, trade in real estate, intermediation, rental and management of both commercial and private real estate, and tenant-owners associations.

Table 2. **Industry composition of portfolios when divided into corporate, SME and retail credit along the official Basel definitions**

Industry composition of portfolios when divided into corporate, SME and retail credit along the official Basel definitions. Corporate = Total sales above €50 mn. SME = Total sales below €50 mn. Retail = total credit below €1 mn. Nobs (A) = 323,671, Nobs (B) = 176,985.

	As a percentage of all counterparts						As a percentage of all credit					
	Corporate		SME		Retail		Corporate		SME		Retail	
Industry	A	B	A	B	A	B	A	B	A	B	A	B
Agriculture and fishing	0.83	0.36	3.37	3.78	3.47	4.15	0.07	0.01	1.10	0.91	2.80	3.17
Forestry and paper	5.90	5.38	1.11	2.26	1.07	1.87	4.98	8.92	1.26	2.66	1.71	2.41
Electro	3.82	1.54	1.10	1.09	1.08	1.11	2.56	0.32	2.12	0.69	1.56	1.37
Chemical	3.51	2.59	0.47	0.45	0.45	0.48	4.43	1.32	1.47	0.50	0.84	0.50
Energy and water	5.09	6.73	0.24	0.65	0.19	0.39	4.02	11.56	3.27	3.31	0.30	0.63
Construction	2.54	2.99	9.94	8.25	10.23	8.79	1.60	0.82	4.64	4.58	6.87	6.40
Other manufacturing	25.13	20.54	13.20	15.27	12.87	15.31	16.68	8.21	22.07	9.05	18.76	17.32
Wholesale trade	20.20	18.41	17.57	19.47	17.77	19.74	7.51	6.72	11.57	10.88	21.50	21.22
Retail trade	2.37	4.59	9.84	9.38	10.24	10.34	4.72	3.68	2.06	1.92	7.57	7.66
Hotel and restaurant	0.64	0.43	2.58	2.59	2.63	2.75	0.66	0.09	0.93	1.15	1.90	1.86
Transport	7.69	6.00	6.86	7.34	7.08	7.54	5.41	3.27	4.32	4.75	6.83	7.06
Telecom	1.09	1.71	0.09	0.08	0.10	0.08	0.33	3.49	0.18	0.12	0.13	0.06
Finance	5.37	6.66	1.42	1.08	1.27	0.91	18.25	14.89	6.16	6.31	1.66	0.88
Real estate	8.17	13.29	6.69	13.74	5.43	11.41	23.98	30.08	28.22	33.83	11.59	17.24
Other services	6.80	8.37	21.51	11.70	21.98	12.06	4.48	6.38	9.30	17.09	13.35	9.39
Government and health	0.84	0.43	2.95	1.37	3.08	1.51	0.30	0.24	0.54	0.28	1.49	0.92

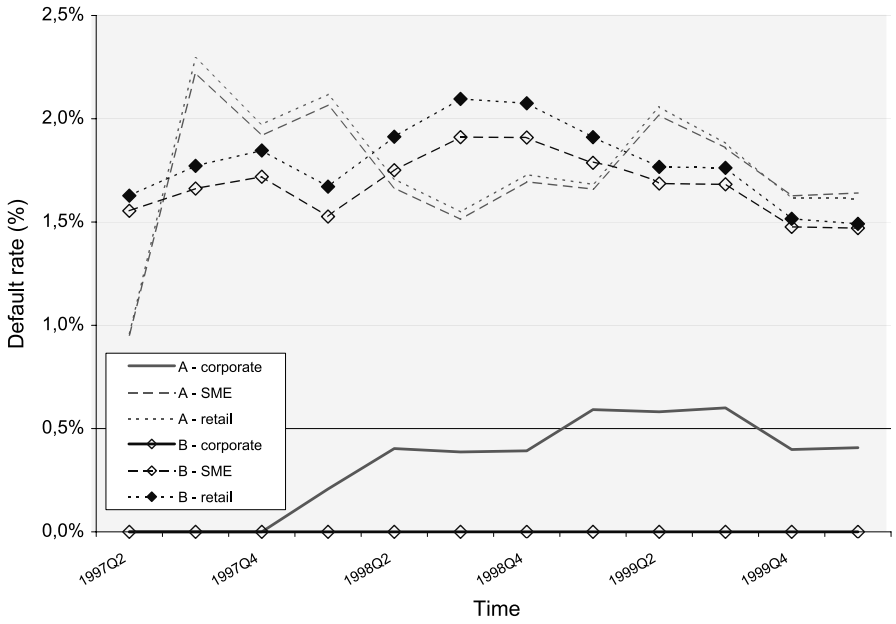

Figure 1. **Quarterly default rates for counterparts in sub-portfolios of banks A and B.**

among smaller real estate businesses.[9] When looking at their share of total credit, both banks lend more than two out of three kronor to a real estate, a wholesale trade, other manufacturing business or other service firm. In the retail credit segment, the image is quite similar, but retail trade business make up 8 to 10 percent of the portfolio. Despite these apparent similarities between bank A and B, there are also a number of differences to speak of, mainly related to the variation in the size of average credit lines between industries. First of all, bank B grants loans that are on average nearly double the size of a loan in bank A. As one might expect, the quantitatively important differences occur in the corporate segment. Table A1 in the Appendix shows that bank B grants loans to telecom businesses that are about 10 times bigger than those of bank A. Also in energy and water, forestry, and government and health, bank B grants substantially bigger loans. Bank A, on the other hand, grants loans twice as big in the retail trade sector. In the SME segment, the differences are smaller. A grants bigger loans to finance companies, and

9 Broadly, other services is composed of three main groups: business, and publicly and personally oriented service companies. The first consists mainly of computer and software consultancy, R&D and all other remaining business service companies, including law firms, accountants and (non-computer) consultants. The second comprises cleaning, waste management and special interest organizations. The last group includes, apart from any other services that most people regularly purchase, artistic professions, radio, TV, museums and leisure activities.

other service businesses. In the retail portfolio, loans are, by their nature, small and on average between SEK 0.4 mn. and SEK 2.7 mn., depending on the industry. The relative sizes of loans differ substantially however, usually by up to a factor of two, and in nearly each sector, one of the banks is clearly the more generous lender.

Figures 1 and 2 provide us with some further insight into the customers of both banks. Figure 1 summarizes the available information on default behavior among customers in the corporate, SME, and retail sub-portfolios of each bank. Although the sample period covers only 13 quarters, the default rates display quite some fluctuation, both over time and between portfolio types. In bank A defaults among SME and retail exposures reach their maximum rate in the fourth quarter of 1997 at levels of 2.2 to 2.3 percent. In bank B the sample peak is reached four quarters earlier, at 1.9 to 2.1 percent. Within the sample period, SME and retail default rates fluctuate between 0.9 and 2.3 percent, with SME exposures consistently displaying default rates that are between 0.05 and 0.2 percent lower than for retail loans. Default behavior among corporates is completely different, both when contrasted with SME and retail exposures and when compared between banks. In bank A, the maximum default rate among corporates is 0.6 percent, while in fact no defaults at all occurred among the corporate borrowers of bank B.

Both institutions maintain an internal credit rating scheme. Bank A requires each business customer to be assigned to one of 15 credit rating classes, while B uses seven classes. At A, rating class one represents the highest credit quality and class 15 stands for the lowest credit quality (factual default) with the intermediate grades intended to imply a monotonically increasing risk profile. Bank B has the most creditworthy customers in rating class one and the least creditworthy ones in class seven. Two conditions must be satisfied for a customer to be assigned to the default category. First, payments on the principal or interest must be at least 60 days overdue. Second, a bank official needs to make a judgment and conclude that any such payment is unlikely to occur in the future. A comparison with data from the credit bureau (not shown here) shows that ratings A15 and B7 are both highly correlated with (the officially registered) bankruptcy. Generally the rating class leads the latter by one or more quarters, most likely because of the length of legal procedures that have to be completed before bankruptcy is officially invoked. In the remainder of this paper, when talking about a default, we will refer to the above definition used by the banks: a loan that is assigned to rating class 15 in bank A or class 7 in B.

The assignment of an internal rating to a new loan or the re-evaluation of a customer rating is performed according to a set of quantitative and qualitative criteria. There are two quantitative measures. First, the credit bureau, UC, provides an external rating that reflects the assessment of customer bankruptcy risk over the next eight quarters. This rating is calculated using information available from the tax authorities, PRV, and credit remark data.[10] Second, the banks estimate the probability of default by means of models that use both the information available from UC and internal information as inputs. Our understanding is that these models have been inspired by the Z-score model of Altman

10 For details and an evaluation of their model-based approach, see Jacobson and Lindé (2000).

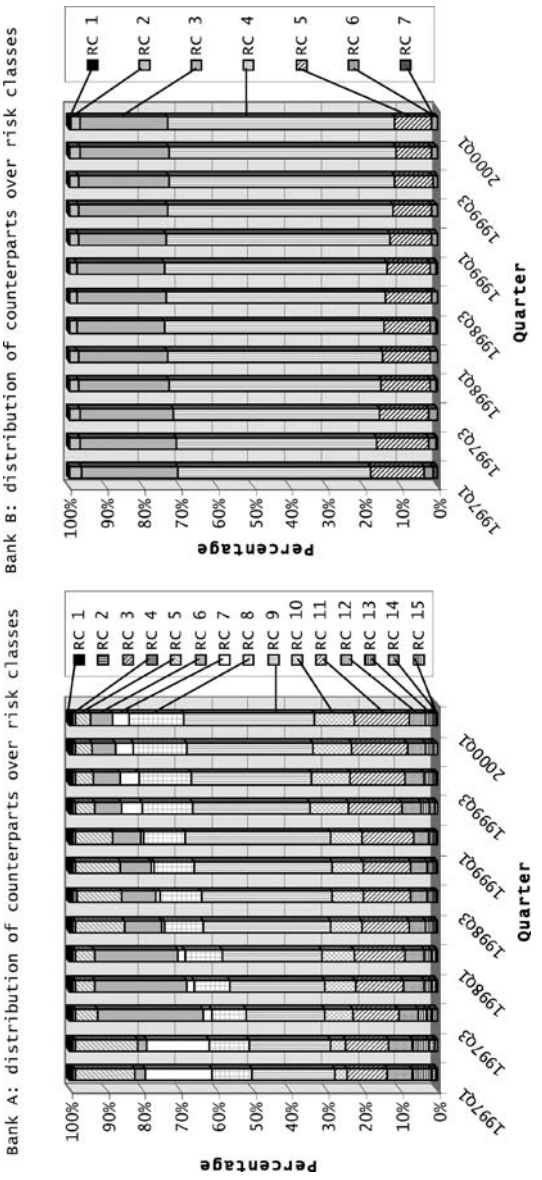

Figure 2. **Distribution of debtors over risk classes in the complete portfolios of banks A and B.**

(1968), the Zeta model of Altman et al. (1977) and the KMV model (2005). Bank A maps these probabilities of default into a rating class scheme such that the classes should mimic the ratings of Moody's and Standard and Poor's. The qualitative criteria are summarized in customer rating classification handbooks.[11] Credit ratings are updated at least once every 12 months.

Figure 2 shows how the customers in the complete portfolios were distributed over all rating grades. A number of characteristics are worth mentioning. First, both banks appear to allocate a large share of debtors to one risk class. Over the sample period, A has between 20 and 40 percent of all customers in class nine, while B has 50 to 60 percent in rating class four. To a large extent, this phenomenon reflects the fact that new loans generally enter the system in these two classes. Given the inertia in risk ratings, this automatically creates a concentration in the "entrance" class. More generally, customers tend to be confined to a subset of the available grades: between 95 and 99 percent are located in nine (three) classes in bank A (B). In both banks the relative importance of each class varies quite a bit over time, although the pattern is simpler and clearer in bank B owing to the smaller number of grades. The effect of these composition changes on the average riskiness of the portfolios can be determined with a weighting scheme for the loans in each rating class. Carling et al. (2002), for example, calculate loss distributions using a default risk model and evaluate the effect of customer migrations on different measures of risk. In this paper we use only the rating *transitions* (to be exact: the probabilities that a customer in risk class i defaults within time horizon s) in the Monte Carlo draw and can therefore ignore the effect of changes in the composition of the portfolio on its riskiness.[12] For a detailed treatment of the complete data set we refer to Jacobson et al. (2002).

Figure 3 displays the distribution of loans over the various rating grades for the corporate, SME, and retail sub-portfolios. Not completely surprisingly, the profile of SME and retail loans is quite similar. Corporate loans have, on average, better ratings than loans to smaller firms and smaller loans. For the experiments in section 4, this doesn't matter however, since we will sample portfolios with a standardized risk profile-to avoid the bias that may result from such differences in rating grades as we showed in Figure 3.

3. The Basel II treatment of retail and SME credit

In the new Basel regulatory framework, banks will be permitted to choose from three systems to calculate the minimum capital requirements for credit risk. One alternative will be to measure credit risk following the *standardized approach*, that has been

11 The handbook provides so-called verbal definitions (descriptions) of the properties of firms in a given rating class along a number of dimensions. The criteria are not weighted according to some *formal* scoring procedure in the rating decision. Ultimately, a so-called credit committee aggregates all information and decides to what class a counterpart is assigned. Jacobson et al. (2002) contains a description of the essentials of bank A's handbook characterization of the rating classes.

12 For our purposes we need only to rely on the stability of transition patterns.

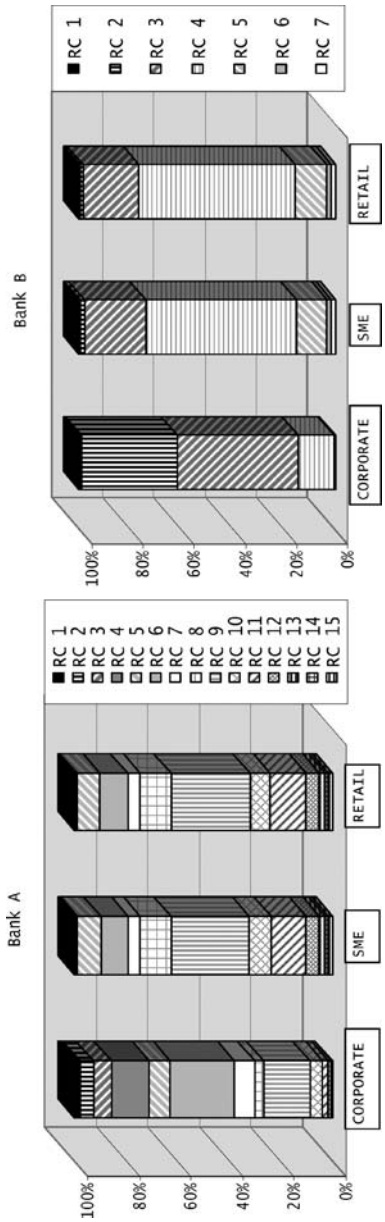

Figure 3. **Distribution of loans over rating classes for the corporate, SME, and retail portfolios.**

designed to be implementable for all banks. Under this approach, a portfolio of bank loans is characterized by (a relatively small number of) risk categories and the risk weight associated with each category is based on an external risk assessment institution's evaluation of credit risk.

A second alternative, called the *IRB approach*, the application of which is subject to approval by national supervisors, allows banks with more internal data available to estimate risk parameters by themselves to employ internal ratings to assess the riskiness of their credit portfolios. Under both approaches, matching risk weight functions-mappings by which an asset's risk characteristics are transformed into capital requirements-have been created for a variety of asset types.[13] This reflects the fact that assets can have different risk parameters and that their credit loss distributions can be differently shaped. Moreover, for most asset classes, the IRB approach can be implemented at two different levels of sophistication: using either the so-called *foundation IRB approach or the advanced IRB approach*.[14] Since the data we have at our disposal contain information on internal ratings, we implement our analysis using the IRB approach. With respect to the *standardized approach*, we suffice here with observing that it builds on country-specific mappings, authorized by supervisory authorities, from external risk ratings, similar to those of rating agencies such as Moody's Investor Service and Standard and Poor's, into asset specific risk weights.

Under the new *Accord*, banks will have to categorize banking-book exposures into five broad classes of assets with different underlying risk characteristics: corporate, sovereign, bank, retail, and equity exposures. Within the corporate category, special rules for five separate sub-classes have been defined: project-, object-, and commodities finance, income-producing real estate, and high-volatility commercial real estate. Retail exposures belong to one of three subgroups: residential mortgages, qualifying revolving retail credit, and "other" retail exposures. Within the corporate category, loans to SMEs get a more favorable treatment through a firm-size adjustment factor. Relative to corporate exposure, retail credit also requires less regulatory capital. To what extent qualification of a loan as retail credit implies lower capital requirements than qualification as corporate/SME does will depend on the size of a firm. We will discuss these differences in greater detail in the presentation of the risk weight mappings below.

Compared with the *standardized approach*, the more elaborate *IRB approach* makes further use of the information collected, and processed in the bank's internal customer risk-rating operations. Banks that choose to apply the *IRB approach* will, for example, have to assign all counterparts an internal risk rating. The *foundation approach* only requires a bank to provide estimates of PD for each rating grade; the bank can rely on supervisory estimates for other risk components. The advanced approach also requires

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13 Although the categorization differs depending on the approach chosen, it tends to split up assets into corporate, sovereign, bank, retail, and equity exposures, with some of them further divided into subcategories.

14 This paper exlusively deals with the differential treatment of SME and retail loans in the calculation of minimum capital requirements for credit risk. Therefore, the description in this section will limit itself to the part of Pillar 1 in the new Basel Accord that deals with credit risk.

internally generated inputs on loss given default (LGD) rates, exposure at default (EAD) and maturity (M) estimates from a bank. For each asset type, the IRB methodology contains three key elements: the estimated risk factors, the mapping of risk factors into risk weights, and a set of minimum requirements that must be met in order for a bank to use the IRB method. For corporate-, sovereign-, and bank exposures, banks can choose between the foundation and the advanced approach. For retail credit there is no distinction between the foundation and the advanced approach, because banks must always provide their own estimates of PD, LGD, and EAD. For equity exposures, no foundation approach exists, but banks can decide to base their capital requirements on either an advanced- or a market-based approach.

Ultimately, by using the risk weight mappings calibrated by the Basel Committee, a bank that applies the IRB approach will calculate its minimum regulatory buffer capital as the product of the risk-weighted assets and the 8 percent absolute capital requirement, summed over all loans and asset types.[15]

3.1. Corporate and SME exposure

For all regular corporate exposure, the derivation of risk-weighted assets depends on estimates of the probability of default (*PD*), the loss given default rate (*LGD*), the effective maturity (*M*), and the exposure at default (*E*). The formula to calculate the risk weight (also-called capitalization rate or capital ratio) for any arbitrary corporate loan *i* is:

$$RW_i = LGD_i \times \left\{ N\left[(1-\rho_i)^{-.5}.N^{inv}[PD_i] + \sqrt{\left(\frac{\rho_i}{1-\rho_i}\right)}.N^{inv}[.999] \right] - PD_i \right\} \times (1-1.5\mu_i)^{-1} \times (1+\mu_i(M_i-2.5)), \quad (1)$$

where *PD* and *LGD* are both measured as decimals, and ρ_i is the calibrated "correlation" coefficient, to be computed as

$$\rho_i = .12 \times \left(\frac{1-e^{-50\times PD_i}}{1-e^{-50}}\right) + .24 \times \left(1 - \left(\frac{1-e^{-50\times PD_i}}{1-e^{-50}}\right)\right), \quad (2)$$

and the "maturity" adjustment factor μ_i is set equal to

$$\mu_i = (.11852 - .05478 \ln(PD_i))^2. \quad (3)$$

As mentioned earlier, banks that adopt the IRB methodology will be using internal data to estimate the risk parameters. Nevertheless, they are obliged to use a minimum

15 The 8 percent average capital requirement in the Basel I Accord has been maintained in Basel II. See equation (5) for the calculation of the capital ratio. The definition of eligible regulatory capital (the numerator) is also unchanged, although appropriate adjustments need to be made to account for the fact that expected credit losses are no longer covered by the minimum regulatory capital.

probability of default of 0.03 percent if the one-year PD_i associated with the borrower's internal risk grade falls below this lower bound, so that:

$$PD_i = \max\left\{0.0003, PD_i^{internal,\ 1\,year}\right\}. \tag{4}$$

How LGD_i will be calculated depends on whether a bank chooses the foundation or the advanced IRB approach. Under the foundation approach senior claims not secured by recognized collateral carry a 45 percent *LGD* compared with 75 percent for subordinated loans.[16]

To obtain the capital ratio, the denominator (total risk weighted assets, RWA) will be determined by multiplying the risk weight by a factor 12.5 (=1/0.08) and the relevant exposure E. The risk-weighted assets that result then become

$$RWA_i = 12.5 \times RW_i \times E_i. \tag{5}$$

Alternatively expressed, the amount of capital required, expressed in euros, is $RW_i \times E_i$.

In the new Basel Accord, the objective of minimum regulatory capital requirements is to protect banks against *unexpected* credit losses. As we mentioned earlier, there is evidence that smaller borrowers are exposed to more idiosyncratic risk than large corporate borrowers are. Therefore, highly granular pools of SME loans are expected to display thinner loss distribution tails. In spite of this, SME exposures may well be associated with bigger expected losses than corporate loans. At a bank that has adopted the IRB framework, this would normally be reflected by lower grade risk ratings for SME debtors relative to corporate borrowers. An argument pursued by the authors of the Accord is that lenders will be compensated for any higher expected risk by means of a higher price (interest rate). Hence, engaging in higher but predictable risks by banks is considered part of a chosen strategy to maximize bank profits, bringing about larger gross interest margins and dealt with by appropriately provisioning for them through loan-loss reserves. Unexpected losses, however, are thought to be smaller for SME loan portfolios than for corporate loan portfolios owing to a weaker default correlation.[17] This in turn would justify smaller regulatory risk weights. This favorable regimen for SMEs has been built in with the help of a size-adjustment factor of the correlation coefficient. For

16 An LGD of 35 percent can be set at national discretion for mortgages on office and/or multi-purpose/tenant premises or to employ a broader definition of subordination. Collateral is taken into account in a way that closely follows the comprehensive method under the *standardized approach*. To be allowed to apply the *advanced approach*, a bank must satisfy a number of minimum requirements, mostly concerning the quality of their internal loss rate data. The most important ones are that: (i) the estimate should be a long-term (also called default weighted) average, not an average of mean annual loss rates and (ii) the minimum data observation period should be at least seven years (five years for retail exposure). Exposure types for which the LGD fluctuates over the business cycle should be assigned an LGD that is typical for economic downturns.

17 The estimated amount of capital needed by a bank to support its risk-taking activities is generally termed required or allocated "economic capital." The economic capital is thought to be chosen such that the probability of unexpected credit losses exceeding the economic capital (the probability of insolvency) stays below some preferred level. The probability of insolvency is typically selected in a way that gives a bank the credit rating it desires. Expected losses should be provided for by a bank's loan loss reserves, not by economic capital.

corporate borrowers with annual sales below EUR 50 mn, the correlation coefficient is reduced by up to 0.04 for the very smallest firms (with annual sales of EUR 5 mn.).[18] Hence the correlation coefficient for SMEs is derived as

$$\rho_i^{SME} = \rho_i - .04 \times \left(1 - \frac{S_i - 5}{45}\right), \tag{6}$$

where S_i = max[5, S_i*] and S_i* represent total annual sales in millions of euros. As figure 3 shows, this correction implies that, depending on the size of the enterprises, as measured by total sales, the SME default risk correlations are assumed to range from 0.24 to 0.08, compared with an interval of 0.24 to 0.12 for corporate loans. The gain increases with default risk and falls with the firm size. Owing to data limitations and the confidential treatment of loan portfolio data, relatively little evidence is available to help determine empirically reasonable values for the correlation coefficients. In work on intra-industry correlation of default risk, Carling et al. (2004) find that the greatest default correlations lie in the range of 0.20. At first sight, the maximum correlations in the Basel II calibration seem consistent with this finding.

3.2. Retail exposure

For retail credit, three types of exposures exist in the Basel II framework, each with its own risk weight functions: residential mortgage exposures, qualifying revolving retail exposures, and other retail exposures. Typical for the retail formulas is that they automatically impose a maximum capital requirement equal to the LGD value and do not contain an explicit maturity adjustment as the corporate risk weight mappings do.

Exposure is defined as retail if it meets the "large number of exposures" requirement[19] and one of the following criteria:[20]

1. Exposure to individuals is typically eligible for retail treatment irrespective of the size of the credit. Typical examples are revolving credits, leases, car loans, study loans, in principle regardless of exposure size. For definitional purposes, regulators

18 Defined as businesses that have consolidated group sales of less than EUR 50 mn. If sales are not considered a meaningful measure of firm size, then supervisors may allow banks to replace total sales with total assets.

19 The exposure must be one of a large pool of exposures that are managed by the bank on a pooled basis. Supervisors may determine a minimum number of exposures for a pool to be recognized as such. Small business loans below EUR 1 mn may be treated as retail exposure if such loans originated in a similar manner and are handled as other retail exposures consistently over time in internal risk management sytems. They should be managed as part of a portfolio segment or pool of exposures with similar risk characteristics and must not be managed in a way comparable to corporate exposures. However, this doesn't preclude retail exposures from being treated individually at some stages of the risk management process. The fact that an exposure is rated individually does not in itself imply ineligibility for classification as retail.

20 The official text of the Basel II Accord (Basel Committee, 2004, p. 51) incorrectly states "all of the following criteria."

may set a formal exposure threshold in order to have an objective boundary between retail and corporate.
2. Residential mortgage loans are eligible for retail treatment regardless of size as long as the credit is extended to owner-occupiers, or a single or small number of condominiums- or cooperative residential housing units in a single building or complex.
3. Loans to small businesses that are managed as retail exposures, provided the total banking group's exposure (or on a consolidated basis where applicable) does not exceed EUR 1 mn. Small business loans extended through or guaranteed by an individual are subject to the same exposure threshold.[21]

For a sub-portfolio to be treated as a *qualifying revolving retail exposure*, it must in addition satisfy *all* of the following criteria:

1. The exposures are revolving, unsecured, and uncommitted (both practically and contractually); that is, the exposure fluctuates based on clients' decision to borrow and repay up to a contractual limit.
2. The borrower is an individual.
3. The maximum credit to a single individual is EUR 100,000.
4. The bank can demonstrate that the sub-portfolio exhibits a low volatility of loss rates, relative to the average level of loss rates, especially within the low PD bands.
5. Data on loss rates must be retained for the sub-portfolio to allow for an analysis.
6. The supervisor must agree that the treatment as a qualifying revolving retail exposure is consistent with the underlying risk characteristics of the sub-portfolio.

Because we work only with business loans in this paper, we restrict our discussion to "other retail exposure." For all "other retail exposure" risk weights will be assigned on the basis of another risk weight function than for corporate exposure:

For all corporate exposure i, the relevant risk weight is:

$$RW_i^R = LGD_i^R \times \left\{ N\left[\left(1-\rho_i^R\right)^{-.5}.N^{inv}\left[PD_i^R\right] + \sqrt{\left(\frac{\rho_i^R}{1-\rho_i^R}\right)}.N^{inv}[0.999] \right] - PD_i^R \right\}, \tag{7}$$

where PD and LGD again represent the probability of default and the loss-given-default rate (both measured as decimals) for the specific asset group, and the requirements for cal-

21 Such loans must have originated in a manner similar to that of other retail exposures and should not be managed in a way comparable to corporate exposures. Rather, they should be managed as part of a portfolio segment or pool of exposures with similar risk characteristics. However, this doesn't preclude retail exposures from being treated individually at some stages of the risk management process!

culation of the various risk components for retail exposure are broadly the same as for non-retail exposure. As before, PD_i has a minimum level of 0.03 percent for each rating class:

$$PD_i = \max\left\{0.0003, PD_i^{internal,\ 1\ year}\right\}. \tag{8}$$

The correlation ρ_i^R is calibrated differently for retail credit than for corporate loans.

$$\rho_i^R = .03 \times \left(\frac{1 - e^{-35 \times PD_i^R}}{1 - e^{-35}}\right) + .16 \times \left(1 - \left(\frac{1 - e^{-35 \times PD_i^R}}{1 - e^{-35}}\right)\right). \tag{9}$$

Figure 4 shows that retail credit is treated most favorably when compared with corporate loans and SME credit, irrespective of the expected probability of default. For high quality credit, the reduction in the assumed correlation is 0.08 relative to corporate loans and SME credit. For intermediate levels of default risk, correlations of SME loans and corporate credit on the one hand and retail credit on the other hand approach each other somewhat. As the riskiness of credit increases to levels over 8 percent (the absolute requirement of the Basel I Accord), this differential slowly grows to 0.09 and 0.05, respectively, when compared to corporate and SME credit portfolios.

As before, total risk weighted assets (RWA) are then derived by employing RW_i^R and the relevant exposures in equation 5

$$RW\ A_i = 12.5 \times RW_i \times E_i, \tag{10}$$

where E_i is the size of exposure type i.

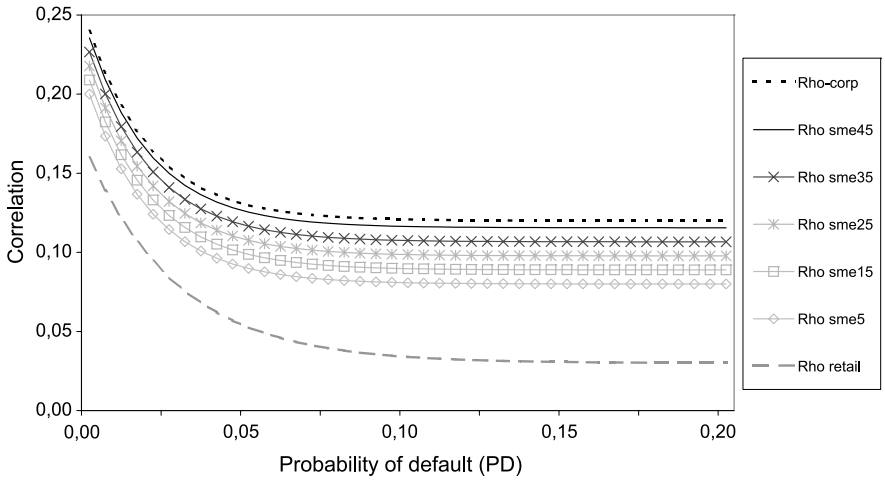

Figure 4. **The calibration of the correlation coefficient for corporate, SME, and retail credit.**

4. Results

In this section, we investigate the properties of both banks' credit loss distributions, as calculated using a non-parametric Monte Carlo resampling method. Our main interest is to investigate if the differential treatment of "other retail" credit and SME loans under the Basel II regulation is justified by the actual loss distributions in our data. For this purpose we look at the loss distributions of SME loans, retail credit, and corporate loans when we apply the Basel definitions and examine if the results change when altering the definition of an SME loan or a retail credit. We also compare our estimates of unexpected credit losses with the regulatory capital requirements derived from the Basel II formulae. The insights from these experiments can help us to get a better understanding as to whether Basel II's 'simple' risk mappings will be able to adequately capture the actual differences in the riskiness of banking corporations' loan portfolios and provide regulators with a correct and consistent picture of banks' loan portfolio credit risk.

4.1. Methodology

The sampling method that we use to estimate the portfolio loss distributions is a non-parametric Monte Carlo method that closely follows the approach of Carey (1998). By using this method we avoid the parametric assumptions about the form that many frequently used portfolio credit risk models use.[22] The most frequently made assumption is to postulate a common factor structure for the correlations between assets. owing to a lack of data, many assumptions about the correlation structure that are incorporated in portfolio credit risk models-but also in the Basel II framework-remain untested. The approach used here keeps clear of such conjectures.

The selection of the data is done as follows.

First, we set the definition of SME (or retail) exposure. For the case of SME loans, we will use nine different threshold values for a customer's (average) total sales to split up the data set into SME and corporate exposure. For the retail case, we employ six different thresholds for the bank's (average) total exposure to a customer to split up the data set into retail and corporate credit.

Next, for one of the two subsamples that we have created, we store, for each customer in each bank, the company number, the date (quarter t) of the observation, the loan size at t, and the risk rating at t.

Then, we determine for each observation present at date t if it is still present in the portfolio at quarter $t + h$, where h is the forecast horizon that we want to apply. If it is still present and has not defaulted, we store the rating class at $t + h$. If the company is still present but has defaulted, we store the actual exposure and a default indicator. If the company is not present anymore at $t + h$, we verify if it defaulted at any of the dates between t and $t + h$. If it did, we store the actual exposure at the date of default and a default indicator. For companies that were present at $t + h$, we also verify if they did not

22 A notable exception is Schmit (2003).

exit from the portfolio or defaulted at any intermediate quarter. Loans that defaulted at an intermediate date but returned before or at date $t + h$ are registered as a default. We assume that the banks are likely to incur at least some losses on such defaulting counterparts and then continue the relationship, most likely at renegotiated terms.[23] Firms that exited at an intermediate date but returned before or at $t + h$ are considered not to have transited and are therefore disregarded. For our experiments, this implies that we ignore any possible effect that exiting behavior may have on credit risk. However, since we are unable to determine the causes of the exit (voluntary exit by a healthy company or, for example, a forced exit of a potentially bad loan), we prefer to abstract from this effect.

After repeating this for all quarters that are at least h quarters away from the last quarter of the sample period, T, we obtain $T-h$ data matrices, one for each quarter $1, 2, \ldots T-h$. Each such data matrix contains four variables for each customer: the credit exposure and the corresponding risk rating, if any, at time t and, if any, at $t + h$; customers that were absent at one of these two points in time, or any intermediate quarter, have zero entries.

Although our prime goal is to evaluate Basel II's treatment of SME and retail credit, our experiments will implicitly include an evaluation of the banks' rating systems' ability to correctly classify counterparts. To avoid comparing portfolios with different levels of risk, one would prefer to have a benchmark loan portfolio that should be considered equally risky by both banks. Because our data include 17,476 overlapping loan observations, we can construct such a benchmark portfolio by calculating, for each possible risk grade, the percentage share of total exposure that the loans (in the overlapping portfolio) in a grade represent. We will call this the "standard" portfolio profile. We use the average size of the banks' loan portfolio as the standard portfolio size.

Once we have determined the number of portfolios we need to generate to obtain a loss distribution that has converged, we can start drawing observations from the data set. For our purpose, 10,000 portfolios turned out to be adequate.[24] Resampling then occurs according to the following steps. Before anything else, we impose two conditions when sampling.

First, to avoid having portfolio loss rates display "abnormal" outliers, no single loan may account for than a maximum of 3 percent of the total portfolio. Second, we do not sample any observations from a rating class if it contains fewer than 15 observations at that specific date to make sure that no single loan ends up making up a big part of a portfolio because it is repeatedly drawn "to fill the class" with enough loans.

Next we randomly draw a date. This determines from which quarter we will be sampling. By separating quarters, we prevent that drawing outcomes from both good and bad times for one portfolio will even out the calculated credit losses. Although our 13 quarters of data do not cover a full business cycle, figure 1 shows that there is quite some variation in the default rate within this period. Still, our results should not be seen as representative for a full business cycle.

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23 Had we had data on actual losses, then this effect would have been captured by the loss given default (LGD) rate.

24 By converging, we mean here that the estimated percentiles do not change more than marginally when increasing the number of portfolios generated.

Table 3. **A comparison of simulated portfolio loss rates and IRB capital requirement ratios for corporate and SME loan portfolios in bank A for varying definitions of SMEs**

Table shows the mean and various percentiles of the loss distribution and the capital ratio required under Basel II for bank A when the total sales threshold, by which SME's are defined, is varied from the SEK .5 mn up to SEK 450 mn. Risk profiles are maintained constant. The Basel SME definition requires total sales below EUR 50 mn., approx. SEK 450 mn. The forecast horizon is 4 quarters.

Portfolio characteristics												
Total sales threshold (mn SEK)	Business type	Simulated portfolio loss rates at loss distribution percentiles									IRB capital requirement	
		Mean	90	95	97.5	99	99.5	99.75	99.9	99.99	Mean	90
0.5	SME	1.81	5.02	5.39	5.65	5.95	6.16	6.31	6.46	6.69	6.76	11.16
	Corporate	*0.29*	*0.38*	*0.41*	*0.44*	*0.47*	*0.49*	*0.51*	*0.54*	*0.58*	*3.75*	*4.24*
1.0	SME	1.57	4.05	4.41	4.67	4.96	5.13	5.26	5.42	5.61	5.23	7.85
	Corporate	*0.29*	*0.38*	*0.40*	*0.43*	*0.46*	*0.48*	*0.49*	*0.51*	*0.52*	*4.09*	*4.54*
2.5	SME	1.09	2.78	3.15	3.37	3.56	3.71	3.82	4.02	4.22	4.57	6.95
	Corporate	*0.27*	*0.35*	*0.38*	*0.40*	*0.43*	*0.46*	*0.48*	*0.51*	*0.58*	*4.16*	*4.55*
5.0	SME	0.92	2.08	2.30	2.46	2.62	2.72	2.84	2.95	3.19	4.52	6.82
	Corporate	*0.25*	*0.34*	*0.37*	*0.40*	*0.44*	*0.47*	*0.48*	*0.52*	*0.58*	*3.96*	*4.17*
10	SME	0.60	1.02	1.15	1.24	1.35	1.40	1.48	1.55	1.65	3.99	5.44
	Corporate	*0.22*	*0.30*	*0.34*	*0.37*	*0.41*	*0.43*	*0.46*	*0.48*	*0.53*	*3.90*	*4.08*
25	SME	0.53	0.82	0.91	0.97	1.05	1.10	1.14	1.18	1.21	3.89	5.23
	Corporate	*0.18*	*0.29*	*0.33*	*0.36*	*0.41*	*0.44*	*0.48*	*0.52*	*0.61*	*3.52*	*3.92*
50	SME	0.48	0.63	0.68	0.73	0.78	0.82	0.85	0.90	0.97	3.72	4.66
	Corporate	*0.12*	*0.21*	*0.26*	*0.31*	*0.37*	*0.41*	*0.46*	*0.49*	*0.53*	*3.00*	*3.31*
100	SME	0.42	0.54	0.59	0.62	0.67	0.70	0.73	0.76	0.81	3.70	4.53
	Corporate	*0.09*	*0.21*	*0.26*	*0.29*	*0.34*	*0.38*	*0.44*	*0.51*	*0.55*	*2.25*	*3.18*
450	SME	0.35	0.43	0.46	0.48	0.52	0.54	0.56	0.59	0.64	3.83	4.69
	Corporate	*0.03*	*0.06*	*0.08*	*0.09*	*0.11*	*0.12*	*0.13*	*0.14*	*0.16*	*1.95*	*3.11*

We then draw loans from the rating classes in the respective bank's full (not only the overlapping) credit portfolio according to the proportions of the "standard" portfolio, until the desired portfolio size is attained. Losses are then calculated as the sum of all exposures at *the date of default* to counterparts that defaulted between t and $t + h$.[25] The full loss distribution is obtained by sorting the percentage loss rates according to size. A percentile is obtained by selecting the (*nobs* * percentile/100)th observation from the loss distribution. For further details, we refer to Carey (1998) and Jacobson et al. (2002).

4.2. Loss distributions, economic capital, and required IRB capital

If the proposed treatment of SME and retail credit in the Basel II regulation is justified, then we should observe that the unexpected loss rates for any pre-specified percentile of

25 We thus assume a zero recovery rate in the computation of VaR. When calculating the required regulatory capital, we adopt the 45 percent LGD rate that Basel II prescribes for unsecured senior claims.

the loss distribution is smaller for these asset types than for corporate exposure. The underlying idea is, as we described in sections 1 and 3, that the defaults of both SMEs and retail loans are more weakly correlated than among corporates. In general, defaults among bigger companies are thought to be primarily caused by systematic risk factors, while defaults by smaller businesses are considered to be driven by idiosyncratic risk factors [see for example Carey (1998)].

Our approach is as follows. First, we generate the credit loss distributions for retail, SME, and corporate credit portfolios and calculate the required economic capital implied by these distributions. Significant differences between the percentiles of the loss distributions and the regulatory "Basel II" capital should be indicative of an inability of the Basel risk weight function to represent (a relevant percentile of) banks' loss distributions. Second, we verify for what, if any, definitions of SMEs and retail credit the supposed presence of a lower correlation and concomitant smaller tail losses for SME and retail credit is supported by our data.

4.2.1. SME loans. Tables 3 and 4 show both the mean loss rate and a range of percentiles of the credit loss distributions, for bank A and bank B, respectively, when the

Table 4. **A comparison of simulated portfolio loss rates and IRB capital requirement ratios for corporate and SME loan portfolios in bank B for varying definitions of SMEs**

Table shows the mean and various percentiles of the loss distribution and the capital ratio required under Basel II for bank B when the total sales threshold, by which SME's are defined, is varied from the SEK 0.5 mn up to SEK 450 mn. Risk profiles are maintained constant. The Basel SME definition requires total sales below EUR 50 mn., approx. SEK 450 mn. The forecast horizon is 4 quarters.

Portfolio characteristics												
Total sales threshold (mn SEK)	Business type	Mean	Simulated portfolio loss rates at loss distribution percentiles								IRB capital requirement	
			90	95	97.5	99	99.5	99.75	99.9	99.99	Mean	90
0.5	SME	1.20	1.61	1.76	1.84	1.89	1.93	1.96	2.01	2.06	5.30	7.51
	Corporate	*0.27*	*0.41*	*0.47*	*0.51*	*0.56*	*0.59*	*0.62*	*0.67*	*0.72*	*3.75*	*4.38*
1.0	SME	0.75	1.03	1.12	1.16	1.21	1.24	1.28	1.30	1.34	4.58	6.47
	Corporate	*0.28*	*0.43*	*0.48*	*0.52*	*0.58*	*0.60*	*0.64*	*0.67*	*0.69*	*3.79*	*4.47*
2.5	SME	0.51	0.80	0.83	0.86	0.88	0.89	0.91	0.93	0.96	3.76	5.60
	Corporate	*0.27*	*0.43*	*0.49*	*0.53*	*0.58*	*0.62*	*0.66*	*0.67*	*0.71*	*3.68*	*4.34*
5.0	SME	0.36	0.43	0.45	0.47	0.49	0.50	0.51	0.53	0.54	3.37	3.71
	Corporate	*0.29*	*0.46*	*0.52*	*0.56*	*0.61*	*0.65*	*0.69*	*0.73*	*0.77*	*3.58*	*4.30*
10	SME	0.32	0.39	0.41	0.43	0.45	0.47	0.48	0.49	0.52	3.22	3.66
	Corporate	*0.29*	*0.49*	*0.55*	*0.61*	*0.67*	*0.71*	*0.74*	*0.79*	*0.86*	*3.65*	*4.18*
25	SME	0.30	0.36	0.38	0.40	0.41	0.43	0.44	0.45	0.47	3.25	3.69
	Corporate	*0.30*	*0.54*	*0.61*	*0.67*	*0.75*	*0.80*	*0.85*	*0.89*	*0.95*	*3.31*	*3.83*
50	SME	0.32	0.40	0.42	0.45	0.48	0.49	0.51	0.53	0.57	3.22	3.74
	Corporate	*0.28*	*0.53*	*0.59*	*0.65*	*0.70*	*0.74*	*0.77*	*0.82*	*0.93*	*2.92*	*4.34*
100	SME	0.32	0.41	0.45	0.48	0.52	0.54	0.57	0.60	0.64	3.30	3.83
	Corporate	*0.14*	*0.52*	*0.62*	*0.69*	*0.77*	*0.82*	*0.86*	*0.90*	*0.99*	*2.63*	*3.61*
450	SME	0.32	0.48	0.54	0.59	0.64	0.68	0.70	0.75	0.79	3.44	3.95
	Corporate	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*1.16*	*1.16*

borrowers are split up into SMEs and corporates using nine different threshold values of total sales. The last two columns contain (i) the mean regulatory capital requirement as a share of the loan portfolio and (ii) the 90th percentile of the capital requirement distribution corresponding to the loan portfolios that were generated to compute the credit loss distributions. In most empirical work investigating the impact of the new Basel Accord on capital requirements, one has sufficed with calculating the mean capital ratio. Calculating the full distribution of capital requirements gives us a better estimator of the regulatory capital requirement and, in addition, a measure of the uncertainty in a point estimate of regulatory capital, owing to stochastic variation in the default rate. For reasons of tractability and because the shape of the risk weight mapping causes the higher percentiles to closely track the 90th percentile, we do not show higher percentiles.

If we start with the loss distributions that result if we employ Basel II's actual SME definition, total sales below SEK 450 mn. (EUR 50 mn.), then table 3 shows that, despite both having a "standard" risk profile, the SME portfolio is actually riskier than the corporate portfolio in both expected and unexpected terms. Expected losses are more than 10 times larger for SMEs than they are for corporates. If one would consider 0.05 an acceptable probability of insolvency for the bank, then "unexpected" credit losses and thus the required economic capital are 0.19 (=0.54 − 0.35) for SME loans and 0.09 (=0.12 − 0.03) for corporates. But the SME portfolio generates bigger expected and unexpected losses than the corporate portfolio even if we use a total sales threshold between SEK 0.5 and SEK 100 mn. to define SMEs. The general impression that table 3 conveys is that the smaller the average firm in the SME portfolio is, the larger do both the expected and the unexpected SME portfolio loss rates become.[26] Table 4, with the results for bank B, possibly offers a different picture. As before, SME loans always produce bigger expected losses. However, for thresholds between SEK 5.0 mn. and SEK 100 mn., SME loans appear to generate smaller loss rates and unexpected losses than corporate loans. These differences are economically slight but may well be statistically significant.

If one excludes all businesses with total sales over SEK 2.5 mn. from the SME category, then the inequality reverses again and SME loans lead to higher loss rates and greater unexpected losses than corporates.

A comparison of implied loss rates with the corresponding regulatory capital points out a number of properties of the risk weight mappings.[27] First, both the SME and the corporate risk weight mappings capture the broad movements in portfolio credit risk. Generally, higher loss rates (and a higher required economic capital) are accompanied by higher regulatory capital requirements. However, equal levels of credit risk can well be associated with significantly different levels of regulatory capital. For example, in table 3 the corporate portfolios generated with thresholds of SEK 25 mn. and SEK 50 mn. have

26 Because smaller firms are underrepresented in the best rating grades, the SME portfolios generated with thresholds between SEK 0.5 mn. and SEK 5.0 mn. have a greater share of customers with higher risk grades. Although the size of expected and unexpected loss are still correct in this range, one cannot ascribe the increase in portfolio loss rates that occurs when we reduce the total sales threshold exclusively to the "SME" factor. Tables A1–A4 in the Appendix contain the exact portfolio compositions.

27 Regulatory capital is calculated using one-year cumulative PDs. The LGD rate is set at 45 percent, Basel II's rate for unsecured senior claims.

very similar loss rates at most percentiles, but their Basel capital requirement differs by 0.52 percent point. Second, if at all, then the SME risk weight function appears to be best at capturing actual credit losses for the very smallest enterprises. Especially in the range close to the definition used by the Basel document, the risk weight function seems to require much larger capital ratios than what is indicated by the loss distributions. Third, our results indicate that the probability of a match between the regulatory and the economic capital requirement will be highly dependent on bank-specific portfolio properties and the choice of other parameters, such as the definition of an SME.

4.2.2. Retail credit. In section 3, it was mentioned that, under certain conditions, loans to business with a total exposure of less than EUR 1 mn. can be treated as "other retail" credit. In the experiments in this section, we abstract from the other conditions, such as the internal risk system by which the loans are managed, and focus exclusively on the size of the exposure.

Tables 5 and 6 contain summary statistics of the credit loss distributions for bank A and bank B derived when the loans are split up into retail and corporate credit by means of six different threshold values for total customer exposure. As in the preceding tables, the last two columns contain (i) the mean regulatory capital requirement as a share of the loan portfolio and (ii) the 90th percentile of the capital requirement distribution corresponding to the generated loan portfolios. Table 5 makes clear that retail credit, irrespective of the definitions we consider, is characterized by both bigger expected and unexpected losses than corporate loans, independent of the relevant level of insolvency risk one considers. In bank B, however, the retail loans do, to some extent, exhibit the expected behavior: they experience higher expected losses but smaller unexpected losses than the corporate portfolio, owing to the slimmer tails of the retail loss distributions. These characteristics are invariant to the chosen definition. For bank A, the capital requirements implied by the Basel risk weight mapping for "other retail" exposures track the movements in the loss rates and unexpected losses reasonably well. For example, if we consider the 99.5th percentile of the loss distribution (or the corresponding unexpected losses) as we move from SEK 10 mn. toward the SEK 0.25 mn. threshold, the retail loss rate increases 1.40 percent, to 2.53 percent, while the corresponding average regulatory capital ratio rises 0.83 percent, to 2.86 percent. However, despite being less risky than the retail credit portfolio, the corporate portfolio requires a higher capital ratio. For bank B nearly the same holds and the corporate loan portfolios require more capital despite being equally or even less risky than the retail portfolios.

5. Summary and conclusions

This work is one of the few studies that takes the hypotheses about properties of SME and retail credit to the data. We employ data from two Swedish banks' business loan portfolios to investigate the assumption in the Basel II regulation that SME and retail

Table 5. **A comparison of simulated portfolio loss rates and IRB capital requirement ratios for corporate and "other retail" loan portfolios in bank A for varying definitions of retail credit**

Table shows the mean and various percentiles of the loss distribution and the capital ratio required under Basel II for bank A when the total credit threshold, by which retail credit is defined, is varied from SEK 0.25 mn to SEK 10 mn. Risk profiles are kept constant. The Basel definition of "other retail" credit requires an exposure below EUR 1 mn., approx. SEK 9 mn. Forecast horizon is 4 quarters.

Portfolio characteristics												
Total sales threshold (mn SEK)	Business type	Mean	Simulated portfolio loss rates at loss distribution percentiles								IRB capital requirement	
			90	95	97.5	99	99.5	99.75	99.9	99.99	Mean	90
0.25	Retail	1.22	2.47	2.50	2.51	2.52	2.53	2.53	2.54	2.55	2.86	4.43
	Corporate	*0.31*	*0.41*	*0.45*	*0.47*	*0.51*	*0.53*	*0.56*	*0.58*	*0.60*	*4.13*	*4.35*
0.5	Retail	1.03	1.99	2.02	2.04	2.05	2.06	2.07	2.07	2.09	2.47	4.27
	Corporate	*0.30*	*0.41*	*0.44*	*0.47*	*0.51*	*0.53*	*0.55*	*0.58*	*0.63*	*4.07*	*4.22*
1	Retail	0.98	1.64	1.69	1.71	1.72	1.74	1.74	1.75	1.77	2.30	3.36
	Corporate	*0.29*	*0.39*	*0.42*	*0.45*	*0.48*	*0.51*	*0.54*	*0.57*	*0.62*	*3.96*	*4.15*
2.5	Retail	0.84	1.38	1.42	1.45	1.47	1.48	1.50	1.51	1.53	2.13	2.86
	Corporate	*0.26*	*0.35*	*0.38*	*0.41*	*0.44*	*0.47*	*0.50*	*0.53*	*0.58*	*3.82*	*4.07*
5	Retail	0.80	1.22	1.27	1.30	1.32	1.34	1.35	1.37	1.39	2.10	2.78
	Corporate	*0.22*	*0.32*	*0.36*	*0.38*	*0.43*	*0.45*	*0.47*	*0.50*	*0.52*	*3.66*	*4.13*
10	Retail	0.72	0.96	1.03	1.06	1.08	1.10	1.11	1.12	1.14	2.03	3.58
	Corporate	*0.15*	*0.24*	*0.27*	*0.30*	*0.34*	*0.36*	*0.39*	*0.42*	*0.46*	*3.97*	*3.67*

Table 6. **A comparison of simulated portfolio loss rates and IRB capital requirement ratios for corporate and "other retail" loan portfolios in bank B for varying definitions of retail credit**

Table shows the mean and various percentiles of the loss distribution and the capital ratio required under Basel II for bank B when the total credit threshold, by which retail credit is defined, is varied from SEK 0.25 mn to SEK 10 mn. Risk profiles are kept constant. The Basel definition of "other retail" credit requires an exposure below EUR 1 mn., approx. SEK 9 mn. Forecast horizon is 4 quarters.

Portfolio characteristics												
Total sales threshold (mn SEK)	Business type	Mean	Simulated portfolio loss rates at loss distribution percentiles								IRB capital requirement	
			90	95	97.5	99	99.5	99.75	99.9	99.99	Mean	90
0.25	Retail	0,63	0.91	0.92	0.93	0.93	0.94	0.94	0.95	0.96	1.39	1.88
	Corporate	*0,29*	*0.44*	*0.48*	*0.53*	*0.58*	*0.61*	*0.64*	*0.67*	*0.72*	*3.92*	*4.44*
0.5	Retail	0.78	1.09	1.11	1.12	1.13	1.13	1.14	1.15	1.16	1.87	2.40
	Corporate	*0.29*	*0.43*	*0.48*	*0.52*	*0.56*	*0.59*	*0.62*	*0.66*	*0.71*	*3.86*	*4.40*
1	Retail	0.65	0.73	0.75	0.76	0.77	0.77	0.78	0.79	0.79	1.68	1.95
	Corporate	*0.28*	*0.43*	*0.48*	*0.52*	*0.57*	*0.60*	*0.64*	*0.68*	*0.72*	*3.86*	*4.56*
2.5	Retail	0.57	0.66	0.68	0.69	0.70	0.71	0.71	0.72	0.73	1.85	2.39
	Corporate	*0.27*	*0.44*	*0.50*	*0.54*	*0.59*	*0.63*	*0.67*	*0.70*	*0.73*	*3.44*	*4.50*
5	Retail	0.54	0.66	0.69	0.71	0.73	0.74	0.75	0.76	0.78	1.83	2.30
	Corporate	*0.25*	*0.44*	*0.49*	*0.54*	*0.59*	*0.63*	*0.65*	*0.69*	*0.76*	*3.15*	*3.85*
10	Retail	0.52	0.59	0.61	0.63	0.65	0.67	0.68	0.69	0.71	1.81	2.18
	Corporate	*0.22*	*0.43*	*0.50*	*0.55*	*0.61*	*0.65*	*0.69*	*0.75*	*0.79*	*2.55*	*3.58*

loan portfolios display smaller (unexpected) loss rates than corporate loan portfolios owing to a lesser dependence on systematic risk factors. The results presented here indicate that there is no evidence that SME loan portfolios are consistently less risky or require less economic capital, than corporate loan portfolios. We do find that changes in the definition of SMEs, in terms of total sales, sometimes lead to the finding that SME loan portfolios are associated with smaller (unexpected) loss rates. However, this finding is highly dependent on the particular SME definition chosen, bank specific, and likely to be sensitive to the size of the portfolio. Moreover, the Basel II risk weight function appears to be only modestly successful in matching the actual loss rates derived from our calculations. Similar results were found for retail credit.

Furthermore, there is little support for the idea of using a "simple" risk weight mapping, as in the Basel II framework, to approximate the actual credit risk exposure or economic capital requirement for a large variety of differentiated banks. Related work by Jacobson et al. (2002) has already shown that banks can have different perceptions of the riskiness of a portfolio with identical customers and that portfolio size is important for credit risk and economic capital requirements. Our results show that using "simple" risk weight mappings may create large inequalities between banks, owing to differences (i) in the shape of loss distributions between banks and (ii) between asset types. However, since a relatively simple mapping of probabilities of default (together with maturity and LGD) into credit losses can only match one percentile or moment of a loss distribution, our results should not be surprising.

Our conclusions require a number of reservations. First, the experiments in this paper take the banks' customer risk rating abilities for given. If, contrary to what was reported, the banks' loan officers did explicitly take firm size into account in their ratings, then this would affect our results because businesses of a certain size would be overrepresented in some rating classes. Second, owing to the concentration of larger (corporate) loans, relative to SME and retail credit, in higher grade rating classes, we were not able to get a perfect match with the "standard" portfolio risk profile in all experiments. Although these deviations were relatively small and unlikely to affect the qualitative outcomes, they warrant some caution when interpreting the quantitative results. Third, our data do not include a full business cycle, thereby limiting the variation in our default variable and our ability to calculate through-the-cycle PDs. The Basel Accord requires PDs to be calculated with at least five years of data. Through the curvature of the risk weight function, calculating risk weights based on average PDs over the business cycle could affect the size of the regulatory capital ratio. However, we believe it is unlikely that our results would change qualitatively had we added the years 2001–2004, since these years are characterized by relatively low default and loss rates in all credit categories.

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Appendix A

In this Appendix we provide information on the average size of credit lines in corporate, SME and retail loan portfolios (table A1) and show the exact risk profiles of the simulated portfolios.

Because customers of certain sizes, in terms of total sales or total exposure, may be over—or under represented in certain rating classes, simulated portfolios that impose a specific risk profile can fail to satisfy the exact profile of the "standard" portfolio. In the simulations for bank B this occurs only in the SME calculations with thresholds of SEK 0.5 mn. and SEK 1.0 mn. For bank A the problem occurs more frequently, owing to the finer grid of the ratings system. For the SME calculations, all portfolios generated with total sales thresholds up to SEK 5 mn. generate substantial deviations from the "standard" risk profile. The retail portfolio risk profiles generally match the standard profile reasonably well, possibly with some reservation for those generated with thresholds of SEK 0.25 mn. and SEK 0.50 mn.

Table A1. **Average credit line in segments of the portfolios when divided into corporate, SME, and retail credit along the official Basel definitions**

	Average credit line in SEK mn.					
	Corporate		SME		Retail	
Industry	A	B	A	B	A	B
Agriculture and fishing	11.41	4.96	1.36	1.98	0.71	1.35
Forestry and paper	109.79	277.16	4.75	9.62	1.40	2.29
Electro	87.00	34.64	8.10	5.21	1.27	2.20
Chemical	164.12	85.22	12.97	9.01	1.63	1.86
Energy and water	102.72	287.13	57.14	41.91	1.34	2.90
Construction	81.90	45.62	1.95	4.55	0.59	1.29
Other manufacturing	86.25	66.76	7.00	4.86	1.28	2.01
Wholesale and trade	48.32	61.01	2.75	4.58	1.06	1.91
Retail and trade	258.77	133.98	0.87	1.67	0.65	1.32
Hotel and restaurant	134.22	34.55	1.51	3.63	0.63	1.20
Transport	91.39	91.04	2.64	5.30	0.85	1.66
Telecom	39.10	342.16	8.27	12.09	1.22	1.32
Finance	442.04	373.47	18.18	47.98	1.15	1.72
Real estate	381.31	378.29	17.64	20.18	1.87	2.68
Other services	85.59	127.51	1.87	11.82	0.55	1.47
Government and health	47.02	92.40	0.77	1.70	0.42	1.08

Table A2. **True rating class distributions and simulated rating class distributions for bank A**

Portfolio characteristics														
Total sales threshold (mn SEK)	Business type	Portfolio share of each rating class												
		RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14
Complete portfolio		0.01	0.07	0.11	0.16	0.06	0.14	0.06	0.05	0.17	0.07	0.05	0.03	0.01	0.01
0.5	SME	0.00	0.00	0.00	0.11	0.09	0.20	0.06	0.07	0.24	0.10	0.07	0.04	0.02	0.01
0.5	*Corporate*	*0.01*	*0.07*	*0.12*	*0.16*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
1.0	SME	0.00	0.00	0.00	0.11	0.08	0.20	0.07	0.07	0.24	0.10	0.07	0.04	0.02	0.01
1.0	*Corporate*	*0.01*	*0.07*	*0.12*	*0.16*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
2.5	SME	0.00	0.00	0.00	0.19	0.08	0.18	0.08	0.06	0.21	0.09	0.06	0.04	0.02	0.01
2.5	*Corporate*	*0.01*	*0.07*	*0.12*	*0.16*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
5.0	SME	0.00	0.00	0.00	0.19	0.08	0.18	0.08	0.06	0.21	0.09	0.06	0.04	0.02	0.01
5.0	*Corporate*	*0.01*	*0.07*	*0.12*	*0.16*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
10	SME	0.00	0.00	0.08	0.19	0.07	0.16	0.07	0.06	0.19	0.08	0.05	0.03	0.02	0.01
10	*Corporate*	*0.01*	*0.07*	*0.12*	*0.16*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
25	SME	0.00	0.00	0.12	0.18	0.07	0.15	0.07	0.05	0.18	0.08	0.05	0.03	0.02	0.01
25	*Corporate*	*0.01*	*0.07*	*0.12*	*0.16*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.01*	*0.00*
50	SME	0.00	0.04	0.12	0.17	0.06	0.15	0.06	0.05	0.18	0.07	0.05	0.03	0.02	0.01
50	*Corporate*	*0.01*	*0.07*	*0.12*	*0.17*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.00*	*0.00*
100	SME	0.00	0.07	0.12	0.16	0.06	0.14	0.06	0.05	0.17	0.07	0.05	0.03	0.02	0.01
100	*Corporate*	*0.01*	*0.07*	*0.12*	*0.17*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.00*	*0.00*
450	SME	0.00	0.07	0.12	0.16	0.06	0.14	0.06	0.05	0.17	0.07	0.05	0.03	0.02	0.01
450	*Corporate*	*0.00*	*0.08*	*0.13*	*0.19*	*0.07*	*0.16*	*0.07*	*0.04*	*0.19*	*0.08*	*0.00*	*0.00*	*0.00*	*0.00*

Table A3. **True rating class distributions and simulated rating class distributions for bank B**

Portfolio characteristics							
Total sales threshold (mn SEK)	Business type	Portfolio share of each rating class					
		RC1	RC2	RC3	RC4	RC5	RC6
Complete portfolio		0.00	0.25	0.44	0.26	0.04	0.01
0.5	SME	0.00	0.08	0.55	0.32	0.05	0.01
0.5	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
1.0	SME	0.00	0.17	0.49	0.28	0.04	0.01
1.0	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
2.5	SME	0.00	0.26	0.44	0.25	0.04	0.01
2.5	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
5.0	SME	0.00	0.26	0.44	0.25	0.04	0.01
5.0	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
10	SME	0.00	0.26	0.44	0.25	0.04	0.01
10	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
25	SME	0.00	0.26	0.44	0.25	0.04	0.01
25	*Corporate*	*0.00*	*0.26*	*0.45*	*0.26*	*0.04*	*0.00*
50	SME	0.00	0.26	0.44	0.25	0.04	0.01
50	*Corporate*	*0.00*	*0.26*	*0.45*	*0.26*	*0.04*	*0.00*
100	SME	0.00	0.26	0.44	0.26	0.04	0.01
100	*Corporate*	*0.00*	*0.26*	*0.45*	*0.26*	*0.03*	*0.00*
450	SME	0.00	0.26	0.44	0.25	0.04	0.01
450	*Corporate*	*0.00*	*0.27*	*0.46*	*0.27*	*0.00*	*0.00*

Table A4. **True rating class distributions and simulated rating class distributions for bank A**

Portfolio characteristics															
Total sales threshold (mn SEK)	Business type	Portfolio share of each rating class													
		RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14
Complete portfolio		0.01	0.07	0.11	0.16	0.06	0.14	0.06	0.05	0.17	0.07	0.05	0.03	0.01	0.01
0.1	Retail	0.00	0.00	0.00	0.06	0.09	0.20	0.09	0.07	0.25	0.09	0.07	0.04	0.02	0.01
0.1	*Corporate*	*0.01*	*0.07*	*0.12*	*0.16*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
0.25	Retail	0.00	0.00	0.06	0.18	0.07	0.16	0.07	0.06	0.20	0.08	0.06	0.03	0.02	0.01
0.25	*Corporate*	*0.01*	*0.07*	*0.12*	*0.16*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
0.5	Retail	0.00	0.01	0.05	0.19	0.07	0.16	0.07	0.06	0.20	0.08	0.05	0.03	0.02	0.01
0.5	*Corporate*	*0.01*	*0.07*	*0.12*	*0.16*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
0.8	Retail	0.00	0.01	0.08	0.19	0.07	0.16	0.07	0.06	0.19	0.08	0.05	0.03	0.02	0.01
0.8	*Corporate*	*0.00*	*0.07*	*0.12*	*0.17*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
1	Retail	0.00	0.02	0.09	0.18	0.07	0.15	0.07	0.05	0.19	0.08	0.05	0.03	0.02	0.01
1	*Corporate*	*0.00*	*0.07*	*0.12*	*0.17*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
2.5	Retail	0.00	0.02	0.12	0.17	0.06	0.15	0.06	0.05	0.18	0.07	0.05	0.03	0.02	0.01
2.5	*Corporate*	*0.00*	*0.07*	*0.12*	*0.17*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
5	Retail	0.00	0.03	0.12	0.17	0.06	0.14	0.06	0.05	0.18	0.07	0.05	0.03	0.02	0.01
5	*Corporate*	*0.00*	*0.07*	*0.12*	*0.17*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.01*
10	Retail	0.00	0.07	0.12	0.17	0.06	0.14	0.06	0.05	0.17	0.07	0.05	0.03	0.02	0.01
10	*Corporate*	*0.00*	*0.07*	*0.12*	*0.17*	*0.06*	*0.14*	*0.06*	*0.05*	*0.17*	*0.07*	*0.05*	*0.03*	*0.02*	*0.00*

Table A5. **True rating class distributions and simulated rating class distributions for bank B**

Portfolio characteristics							
Total sales threshold (mn SEK)	Business type	Portfolio share of each rating class					
		RC1	RC2	RC3	RC4	RC5	RC6
Complete portfolio		0.00	0.25	0.44	0.26	0.04	0.01
0.1	Retail	0.00	0.22	0.47	0.27	0.04	0.00
0.1	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
0.25	Retail	0.00	0.25	0.44	0.26	0.04	0.00
0.25	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
0.5	Retail	0.00	0.25	0.44	0.26	0.04	0.01
0.5	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
0.8	Retail	0.00	0.25	0.44	0.26	0.04	0.01
0.8	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
1	Retail	0.00	0.25	0.44	0.26	0.04	0.01
1	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
2.5	Retail	0.00	0.25	0.44	0.26	0.04	0.01
2.5	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
5	Retail	0.00	0.25	0.44	0.26	0.04	0.01
5	*Corporate*	*0.00*	*0.26*	*0.44*	*0.25*	*0.04*	*0.01*
10	Retail	0.00	0.25	0.44	0.26	0.04	0.01
10	*Corporate*	*0.00*	*0.26*	*0.45*	*0.26*	*0.04*	*0.00*

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