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This paper is an extended version of the authors' article "Regulatory capital volatility" in *Risk*, May 2001.

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A value-at-risk approach to banks' capital buffers: An application to the new Basel Accord

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Esa Jokivuolle – Samu Peura
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Abstract

The rating-sensitive capital charges on credit risks under the new Basel Accord are likely to increase the volatility of minimum capital requirements, which may force banks to hold larger capital cushions in excess of minimum requirements. We analyse this claim on the basis of numerical simulations on hypothetical bank portfolios, in which the bank's choice of capital cushion is assumed to satisfy a value-at-risk-type constraint. The results suggest that the size of the cushion depends on the bank's credit portfolio risk and its chosen approach for calculating the minimum capital requirement. Although the more ratings-sensitive internal ratings based approach imposes lower minimum capital requirements on sufficiently high-quality credit portfolios than does the standardised approach, this capital relief is countered by the need for larger relative cushions under the former approach. The results imply that the cushions induced by greater rating sensitivity may influence both banks' choices between proposed approaches for calculating capital requirements as well as the aggregate level of post-reform bank capital. Hence these cushions should be given due consideration in the final calibration of the Basel risk weights.

Key words: new Basel Capital Accord, credit risk, internal ratings, value-at-risk

Uuden Baselin sopimuksen vaikutus pankkien pääomapuskureihin

Suomen Pankin keskustelualoitteita 15/2001

Esa Jokivuolle – Samu Peura
Tutkimusosasto

Tiivistelmä

Baselin pankkivalvontakomitean luottoriskeille ehdottamat uudet vakavaraisuussäännökset perustuvat luottokelpoisuusluokituksiin. Koska tämä saattaa lisätä vakavaraisuusvaatimusten vaihteluita, pankit ehkä joutuvat kasvattamaan minimivaatimukset ylittäviä pääomapuskureitaan. Tutkimme tätä väitettä simuloimalla kuvitteellisten pankkiportfolioiden luottokelpoisuusmuutoksia ja luottotappioita. Pankin pääomapuskuri määräytyy value-at-risk-tyyppisen rajoitteen mukaisesti. Tulosten mukaan puskurin koko riippuu pankin luottosalkun riskistä sekä menetelmästä, jota pankki käyttää minimipääomavaatimuksen laskentaan. Vaikka ns. sisäisten luokitusten menetelmä edellyttää luottokelpoisuudeltaan riittävän hyvissä salkuissa pienempää minimipääomavaatimusta kuin standardimenetelmä, suhteellisesti suuremman puskurin tarve sisäisten luokitusten menetelmässä kuitenkin vähentää tätä ”pääomahelpotusta”. Tulosten perusteella voidaan otaksua, että puskurien erilainen sopeuttamistarve eri menetelmissä voi vaikuttaa pankkien menetelmän valintaan. Puskurien sopeuttaminen voi vaikuttaa myös pääoman kokonaismäärään pankkisektorilla uudistuksen jälkeen. Näistä syistä Baselin pankkivalvontakomitean tulisi ottaa pankkien puskurien tarve huomioon määrittäessään pankkien saatavien lopullisia riskipainoja.

Asiasanat: uusi vakavaraisuuskehikko, luottoriski, sisäiset luokitukset, value-at-risk

Contents

1 Introduction

The second-round proposal for the new Basel Accord in January 2001, following the first initiative published in summer 1999, is a serious attempt to increase the risk-sensitivity of the rules according to which banks are required to hold capital.[1] The purpose of the reform is to further improve the stability of banking, to correct possible distortions in the market and to contain capital arbitrage which has gradually undermined the effectiveness of the current accord. To increase risk-sensitivity, new risk-weight categories for the currently recognized risk types are added and entirely new risk types, such as operational risks, are incorporated. Highly detailed rules are planned for taking into account various risk mitigation techniques ranging from traditional collateral to credit derivatives in determining net exposures, and treatment for securitised assets are being developed. Moreover, an overall evolutionary approach is emphasized in that the framework offers different options of varying degrees of sophistication, which banks can pursue as their resources and capabilities develop. Finally, to complement the reforms in the area of direct risk measurement and the minimum capital requirements based on them, the supervisory review process will be strengthened and banks' disclosure requirements will be increased.

Perhaps the most important and visible part of the reform is the differentiation of corporate credits, currently all receiving 100 per cent risk-weight, into a number of risk-weight categories based on credit ratings provided either by external rating agencies or banks themselves. The use of external ratings constitutes the new standardised approach (SA) in which unrated counterparties still reveice the 100 per cent weight but in which rated counter-parties receive weights ranging from 20% to 150%. The approach based on internal ratings (IRBA) is the more sophisticated and detailed one, also making use of additional elements such as the credit portfolio's degree of diversification. Moreover, two options, the foundation and the advanced approach, are available within the IRBA. While the SA constitutes the obligatory part of the new capital framework, a bank can choose to use the IRBA instead, subject to supervisory approval of a bank's internal credit rating systems. On the whole, the IRBA offers potentially much more risk-sensitivity than the SA. Many banks have expressed great interest in using the IRBA which would be much better aligned with their economic capital models and which would more accurately reward low-risk portfolios with a lower capital requirement.

The increased risk sensitivity of the regulatory risk weights is likely to be reflected in the volatility of the regulatory capital charge. While under the current accord shocks to banks' regulatory solvency ratios have mainly resulted from unexpected losses, under the new framework these would also result from unexpected changes in the risk-weighted assets due to ratings migration. If the volatility of the minimum capital requirements rises relative to the current accord, banks are likely to further increase their capital cushions above the minimum requirements. This is because – as both theory and empirical evidence since the introduction of the Basel 1988 Accord suggest – banks prefer to hold such capital cushions in order to avoid the various costs, related to supervisory intervention

[1] The Basel proposal is paralleled by that of the European Union, first published in the fall 1999. One difference between the two is that, within the EU, not only credit institutions but also investment firms are subject to capital adequacy regulation.

and market discipline, which would result from approaching, let alone falling below, the regulatory minimum capital ratio (see Furfine, 2000). The 8 per cent minimum ratio is like a regulatory default point in excess of which banks need to hold their actual amount of capital.

Banks' response to the reform will impact the overall level of capital in the banking sector. Moreover, the cushions banks prefer to hold may have implications for banks' choice between the standardised approach and the internal ratings based approach. As the two approaches involve different degrees of rating-sensitivity in calculating risk-weighted assets, banks would choose to hold different amounts of additional capital cushions under the two approaches. The minimum capital requirement plus the additional cushion, not the minimum capital charge alone, is likely to influence banks' choice between the two approaches. This is something Basel might need to take into account in the final calibration of the absolute risk-weights between the two systems, one of the aims of which is to provide banks with capital incentives to start using the more sophisticated internal ratings based approach.

In this paper, we illustrate using hypothetical bank portfolios the likely effects of changing regulatory capital volatility on the effective capital levels in the different capital requirement regimes and, therefore, on banks' choices between these regimes. Our results indicate that especially for low-risk portfolios the additional capital cushion chosen by banks over the minimum requirement could be substantial in the most risk-sensitive internal ratings based approach. Interestingly, for high-risk portfolios the additional cushions would be reduced relative to the current capital accord. A failure to account for these effects in the final risk-weight calibration could result in a different subset of banks opting for the internal ratings based approach from what is intended by Basel. We also argue that it is important to understand the way banks would likely respond to the reform when interpreting, and comparing across banks, the regulatory capital ratios in the new regime.

2 The setup

We consider a bank having all its assets in illiquid corporate loans. We argue that there are essentially three constraints that the bank would need to meet when determining how much capital to reserve against its portfolio. First, there is the minimum regulatory capital requirement associated with the bank's current portfolio. Second, the bank will want to reserve enough capital to absorb the fluctuations in its minimum capital requirement over its planning horizon, say one year, with a reasonable confidence level, without recourse to new external funds.[2] This confidence level would reflect the various implicit costs the bank would incur from approaching the minimum capital ratio. The higher these costs are, the higher probability the bank would choose. A 95% probability, e.g., would imply

[2] Using the one year horizon is a common practice in economic capital calculations. There is a number of reasons for this choice. First, it is generally viewed that credit portfolios are so illiquid and external capital is so hard to raise that it will take at least a year to restore a deteriorated capital base. Second, estimates for the key parameters needed in credit value-at-risk models to calculate economic capital, such as probabilities of default, are not readily available for higher frequencies than a year.

that the bank would tolerate a fall below the minimum capital ratio on average once in 20 years. Third, the bank will also want to satisfy an economic capital constraint, which implies reserving enough capital to cover credit losses and therefore to avoid bankruptcy, with a sufficiently high probability. The probability of remaining solvent would typically be chosen to be consistent with the bank's overall rating target. For instance, a Aa target would imply a solvency probability of order 99.95% in a year. In general, the bank would choose the minimum amount of capital that satisfies each of these three constraints. We call this amount the *minimum acceptable capital* held by the bank. This divided by the risk-weighted assets is called the *minimum acceptable (regulatory) capital ratio*.

Let us introduce the following notation:

C_0 = capital in period 0
L_1 = portfolio credit losses in period 1
$E_0[L_1]$ = expectation at time 0 for period 1 losses
R_t^k = total risk-weighted assets in period t, t = 0,1, under regulatory capital regime k, k = CA (current approach), SA (new standardised approach), IRBA (internal ratings based approach)[3]
y = confidence level associated with the regulatory capital constraint
y' = confidence level associated with the economic capital constraint.

The three capital constraints can now be stated as

$$C_0 \geq 0.08 \cdot R_0^k \tag{2.1}$$

$$\begin{aligned} &P\left[C_0 - L_1 + E_0[L_1] \geq 0.08 \cdot R_1^k\right] \geq y \Leftrightarrow \\ &P\left[C_0 \geq 0.08 R_1^k + L_1 - E_0[L_1]\right] \geq y \end{aligned} \tag{2.2}$$

$$P\left[C_0 \geq L_1 - E_0[L_1]\right] \geq y' \tag{2.3}$$

Equation (2.1) is the current minimum capital requirement. Equation (2.2), which determines the regulatory capital cushion, states that capital and provisions for expected losses reserved in period 0, net of credit losses realised in period 1, need to equal or exceed 8% of period 1 risk-weighted assets, with the desired probability, y. Both credit losses and risk-weighted assets in period 1 are random variables driven by rating migrations and defaults.[4] In formulating this constraint, we have simplified away from considering the bank's profits as well as any new lending during period 1. Equation (2.3) is the economic capital constraint.

Let us define the random variable $X = 0.08 R_1^k + L_1 - E_0[L_1]$, with cumulative distribution function denoted by F. Then the constraint (2.2) can be reformulated

[3] In the SA exposures are assigned a risk-weight according to their rating only. In the IRBA risk-weights are derived from a continuous function based on the obligor's probability of default and the exposure's loss given default. Moreover, an adjustment depending on the portfolio's degree of exposure concentration is added to the total risk-weighted assets calculated in the first stage. The details of calculating the risk-weighted assets in the SA and in the IRBA are described in Basel (2001). In the CA all exposures regardless of rating receive the common 100 per cent risk-weight.
[4] In reality, other things, such as changes in drawn commitments and in collateral values, would also cause unexpected changes in the risk-weighted assets.

as $C_0 \geq \inf\{c|F(c) \geq y\}$. Similarly, we define the random variable $Z = L_1 - E_0[L_1]$, with associated distribution function G. The economic capital constraint (2.3) can then be written as $C_0 \geq \inf\{c|G(c) \geq y'\}$. Given a hypothetical portfolio, we solve for F and G from a credit portfolio model of the CreditMetrics™ type, which is appropriately modified to produce realisations of X and Z under the alternative capital requirement regimes. In the model, latent correlated normal random variables representing customer firms' asset values are used to simulate rating migrations and defaults (see J.P. Morgan, 1997, for details). The power of this type of credit risk portfolio modeling lies in the fact that it naturally and intuitively accounts for the default and rating migration correlations within the portfolio, which is quite essential to produce the strongly skewed distributions of defaults and rating changes that are consistent with the empirical observations.

2.1 Discussion of the set-up

In general, the bank's choice of capital level would not be independent of its choice of portfolio, dividend policy, and growth strategy. Hence our approach is a partial equilibrium application from economic theory perspective, mainly intended to provide practitioners with operative guidance in capital adequacy planning. Indeed, what we do is to introduce an additional constraint to a bank's value-at-risk problem of reserving enough economic capital against its credit portfolio. As it turns out, this is a non-trivial extension because for reasonable values of the parameters y and y' the new constraint is binding in most cases we consider.

In a more complete optimization framework we should specify the bank's objective function and model how the bank actually chooses y and y' and its portfolio composition along with the choice of regulatory capital approach and capital level.[5] It is possible that these choices are connected in subtle ways which are not given due consideration in our simplified approach. Nonetheless, as a first approximation y, y', and the bank's portfolio could well be taken as given. As y and y' are directly related to the costs from falling below the minimum capital ratio and defaulting, respectively, they can be viewed as resulting from separate optimization problems outside our framework. As for the bank's portfolio choice, there could well be considerable costs in the form of, say, losing information advantages from changing the portfolio allocation to a different group of borrowers.

As noted in the previous section we also do not explicitly consider margin income which is affected by the bank's cost of capital which, in turn, depends on the probability of default that the bank ends up with for itself. As Kupiec (1999) points out, it is difficult to consider the effect of the cost of capital on the choice of capital level in a value-at-risk framework because these two things are inter-related.

[5] However, doing such modeling work would obviously come at the cost of abandoning the realistic value-at-risk model for the bank's portfolio and the detailed consideration of the Basel rules within it.

3 Results

3.1 Example portfolios and parameter values

We calculate the capital requirements according to (2.1)–(2.3) in the SA, in the *foundation* IRBA, and in the current accord (CA), for nine hypothetical corporate debt portfolios in which each obligor is equivalently rated both externally and internally, assuming a rating scale corresponding to that of Moody's.[6] The resulting risk-weights applied are displayed and graphed out in table 1 and figure 1, respectively.[7] Each portfolio consists of equal size obligors and a total exposure of 100. The portfolios differ in two risk dimensions: the obligor ratings distribution ("aggregate", "investment grade" and "non-investment grade") and the degree of exposure concentration ("500", "100" and "50", denoting the number of equal size obligors). To obtain a realistic distribution of obligors over the rating classes, we refer to the annual data on total U.S. corporate long-term debt by rating category, rated by Moody's in years 1987–1999. In the aggregate portfolio, the portion of obligors per rating class corresponds to the time-series average share of total debt in that category over 1987–1999. The investment grade and the non-investment grade portfolios are constructed in a similar fashion. In the former, we only include debt in investment grade categories each year, whereas the latter includes total debt in categories Ba1 or less. All exposures in each portfolio are assumed to be senior and uncollateralized. Table 2 displays the rating distributions of the example portfolios.

[6] In other words, in calculating the IRBA capital requirements we implicitly assume that the bank would be using an internal rating system that would produce corresponding ratings and the respective default probabilities as if it were using the Moody's system and the data. In particular, the system we use consists of 17 nondefault rating categories ranging from Aaa to Caa. According to The Basel Committee (2001) the IRBA approach would only require a minimum of 6–9 rating grades (for performing loans), so our choice of 17 categories represents a case where a bank takes full advantage of the risk-discriminating opportunities within the IRBA. Of course, the number of rating categories used by an IRBA bank and, ultimately, the probabilities of default assigned to them would affect our quantitative results, but hardly their qualitative implications. There is an issue of gaming, however, in that banks could start optimizing the number of internal rating categories they want to use within the IRBA in order to control the potentially undesirable effects of too much rating-sensitivity in their capital requirements.

[7] In case of the IRBA these are the risk-weights prior to the granularity adjustment. The maturity adjustment is neither considered.

Figure 1. **Risk weights in the three capital regimes**

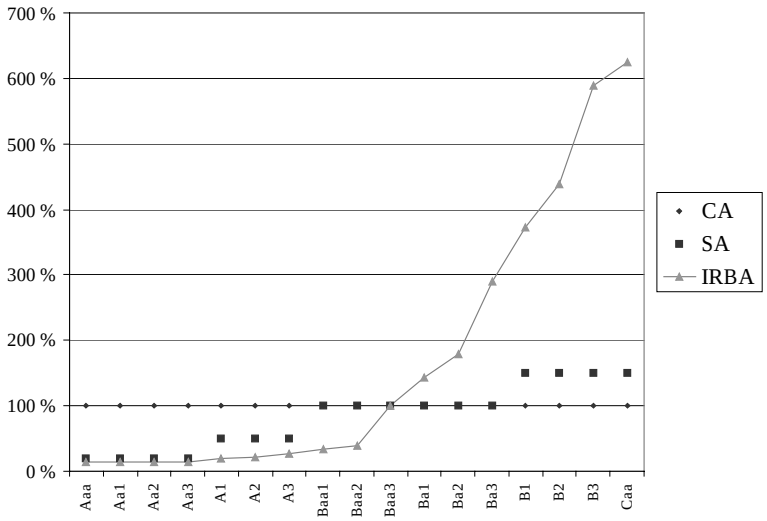


Table 1. **Risk weights in the three capital regimes**

Rating	PD	CA	SA	IRBA
Aaa	0.01%	100%	20%	14.1%
Aa1	0.02%	100%	20%	14.1%
Aa2	0.02%	100%	20%	14.1%
Aa3	0.03%	100%	20%	14.1%
A1	0.05%	100%	50%	19.1%
A2	0.06%	100%	50%	21.4%
A3	0.09%	100%	50%	27.4%
Baa1	0.13%	100%	100%	34.4%
Baa2	0.16%	100%	100%	39.2%
Baa3	0.70%	100%	100%	99.8%
Ba1	1.25%	100%	100%	143.8%
Ba2	1.79%	100%	100%	179.7%
Ba3	3.96%	100%	100%	289.8%
B1	6.14%	100%	150%	371.9%
B2	8.31%	100%	150%	438.1%
B3	15.08%	100%	150%	589.5%
Caa	29.87%	100%	150%	625.0%

PD = porbability of default, CA = current approach, SA = standardized approach, IRBA = internal ratings based approach. In the IRBA, an LGD of 50% is assumed accross all exposures.

Table 2. **Compositions of example portfolios**

Rating	Investment grade	Aggregate	Non-inv. grade
Aaa	7.83%	6.25%	
Aa1	2.98%	2.39%	
Aa2	6.72%	5.37%	
Aa3	12.42%	9.93%	
A1	16.94%	13.56%	
A2	16.88%	13.52%	
A3	11.08%	8.87%	
Baa1	9.05%	7.24%	
Baa2	8.69%	6.95%	
Baa3	7.41%	5.93%	
Ba1		2.54%	12.80%
Ba2		2.14%	10.87%
Ba3		2.74%	13.77%
B1		3.05%	15.23%
B2		4.04%	20.06%
B3		3.83%	19.05%
Caa		1.65%	8.23%
Average PD	0.11%	1.86%	8.83%

Each cell gives the percentage of portfolio nominal value invested in the particular rating class.

In simulating losses and capital requirements for these portfolios, we use a rating transition probability matrix for one-year horizon, which is based on Moody's historical average annual transition frequencies per rating category.[8] We further assume a uniform 20% asset correlation between each pair of obligors, corresponding to the underlying assumption made by Basel in producing the relative risk-weight structure for the IRBA. In calculating risk-weighted assets in the foundation IRBA, we use the uniform 50% recovery rate assumed in the new Basel rules for uncollateralized senior exposures. As the risk-weights are the same function of default probabilities both under the foundation and the advanced IRBA approach, our results are relevant also for the advanced IRBA. Note that the SA does not incorporate any explicit recovery rate assumption. In simulating actual losses, a uniform recovery rate of 50% is assumed across obligors.

3.2 Capital requirements

Table 3 shows the statistics of the credit loss distribution and the economic capital constraints for each portfolio. Unexpected loss is defined as the chosen percentile of the credit loss distribution less the expected loss, i.e., as a given percentile of

[8] Again, these are assumed to be representative of the probabilities with which the model bank changes its internal ratings. In reality banks may use rating systems, such as equity market based measures of default risk, which entail higher off-diagonal transition probabilities than the Moody's matrix (see Kealhofer et al., 1998). This would further increase the volatility of the minimum capital requirements.

the random variable $Z = L_1 - E_0[L_1]$. The unexpected loss with confidence level y' thus coincides with the economic capital requirement with the same confidence level. As expected, the degree of diversification of the portfolio does not affect the expected losses, whereas the measures of loss dispersion increase as diversification is reduced. Increasing the number of obligors from 100 to 500, e.g., still offers considerable diversification benefits. In relative terms, the benefits of diversification appear the higher, the better the portfolio credit quality.

Table 3. **Credit risk statistics and the economic capital constraint**

Portfolio		Expected Loss	Standard Deviation	Unexpected Loss		
				y'=99%	y'=99.9%	y'=99.95%
Investment	"500"	0.1	0.1	0.6	1.5	1.8
grade	"100"	0.1	0.2	1.0	1.9	2.4
	"50"	0.1	0.3	1.5	2.1	3.0
Aggregate	"500"	1.0	0.8	2.8	4.8	5.8
	"100"	1.0	1.0	3.5	5.5	6.5
	"50"	1.0	1.2	4.0	6.0	7.0
Non-	"500"	4.4	3.5	11.8	18.4	20.1
investment	"100"	4.4	3.7	12.1	19.1	21.1
grade	"50"	4.4	3.9	13.5	19.6	22.1

Unexpected loss is defined as the chosen percentile of the credit loss distribution less expected loss. Total exposure in each portfolio equals 100.

In tables 4a–c we report the 8 per cent regulatory minimum requirements, the minimum acceptable capital amounts and the minimum acceptable capital ratios, respectively, for each portfolio in each capital regime. All results are presented for parameter values y = 99% and y' = 99.95%. In cases in which the economic capital constraint is binding, the resulting minimum acceptable capital amount and minimum acceptable capital ratio are reported in parentheses in the respective cells. This is the case in the CA and the SA for the non-investment grade portfolio. Intuitively, unlike the IRBA, the CA and the SA are not sensitive enough to account for the high risk of this portfolio, so the bank's own economic capital requirement comes into play. On the other hand, knowing that a multiplier greater than one has been used in deriving the current IRBA benchmark risk-weights relative to the underlying economic capital, it is hardly surprising that the economic capital constraint never appears binding over the minimum capital requirement in the case of the IRBA (see Wilde, 2001).

Table 4a. **Minimum capital requirements**

		CA	SA	IRBA
Investment	"500"	8.0	4.3	2.4
grade	"100"	8.0	4.3	3.4
	"50"	8.0	4.3	4.7
Aggregate	"500"	8.0	5.6	7.9
	"100"	8.0	5.6	9.4
	"50"	8.0	5.6	10.8
Non-investment	"500"	8.0	10.5	29.9
grade	"100"	8.0	10.5	31.1
	"50"	8.0	10.5	33.2

The regulatory 8 per cent minimum capital requirements for the example portfolios. Total exposure in each portfolio equals 100. The lower of the capital requirement in the SA and of that in the IRBA is indicated with grey shading.

Table 4b. **Minimum acceptable capital amounts**

		CA	SA	IRBA
Investment	"500"	8.5	5.6	4.8
grade	"100"	8.8	5.8	6.1
	"50"	9.3	6.0	7.7
Aggregate	"500"	10.3	8.4	10.6
	"100"	10.8	8.8	12.1
	"50"	11.2	9.1	13.6
Non-investment	"500"	17.2 (20.1)	19.0 (20.1)	33.2
grade	"100"	17.5 (21.1)	19.4 (21.1)	34.6
	"50"	18.7 (22.1)	20.1 (22.1)	36.6

The minimum amounts of capital satisfying (2.2) for teh example portfolios, given y = 99.0%. Figures in parentheses are the economic capital requirements in cases it turns out to be the binding constraint for the most conservative choice y' = 99.95%. Total exposure in each portfolio equals 100. The bank's choice between the SA and the IRBA is indicated with grey shading.

Table 4c. **Minimum acceptable capital ratios**

		CA	SA	IRBA
Investment	"500"	8.5%	10.4%	16.0%
grade	"100"	8.8%	10.7%	14.4%
	"50"	9.3%	11.2%	13.1%
Aggregate	"500"	10.3%	12.0%	10.7%
	"100"	10.8%	12.7%	10.4%
	"50"	11.2%	13.0%	10.1%
Non-investment	"500"	17.2% (20.1%)	14.5% (15.3%)	8.9%
grade	"100"	17.5% (21.1%)	14.8% (16.1%)	8.9%
	"50"	18.7% (22.1%)	15.3% (16.8%)	8.8%

The minimum acceptable capital ratios for the example portfolios, given y = 99.0%. These are obtained by dividing the minimum acceptable capital amounts from table 3b by the total risk-weighted assets in period zero. Figures in parentheses indicate the minimum acceptable capital ratio, should the economic capital constraint be binding for the most conservative choice of y' = 99.95%. Total exposure in each portfolio equals 100.

Two obvious remarks can be made concerning the minimum capital requirements in Table 4a. First, while the current capital regime does not differentiate corporate exposures according to their credit risk, the SA and the IRBA indeed do so. Second, only the IRBA punishes or rewards portfolios according to their degree of diversification, measured by exposure concentration. The effects of diversification are captured by the granularity adjustment term in the IRBA, not the baseline risk weights themselves. Table 5 shows this, by decomposing the IRBA minimum capital requirements in Table 4a into components due to the baseline risk weights and the granularity adjustment, respectively. Table 5 further shows that the effect of the granularity adjustment is the largest in relative terms in high-quality portfolios. Moreover, both negative and positive granularity adjustments occur among our example portfolios.

Table 5. **The effects of granularity adjustment in the IRBA**

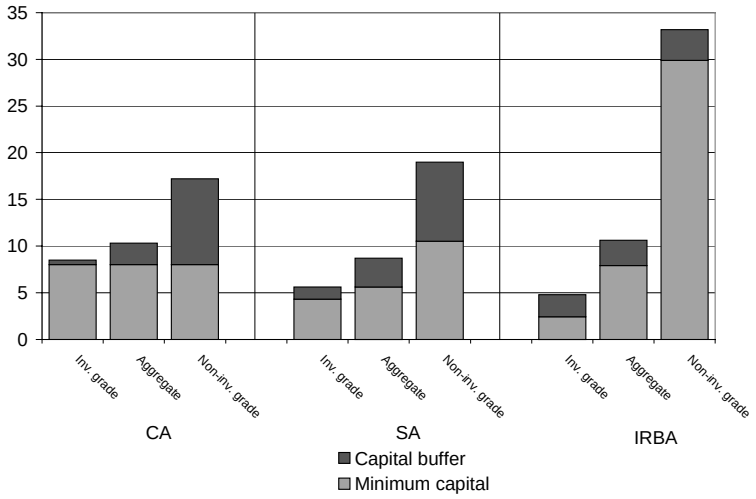
Portfolio		RWA	GA	RWA+GA	0.08* RWA	0.08* (RWA+GA)
Investment	"500"	28,0	2,0	30,1	2,2	2,4
grade	"100"	27,7	14,7	42,4	2,2	3,4
	"50"	28,6	30,5	59,1	2,3	4,7
Aggregate	"500"	99,4	–0,5	98,9	7,9	7,9
	"100"	103,7	13,4	117,1	8,3	9,4
	"50"	103,4	31,1	134,5	8,3	10,8
Non-	"500"	385,6	–11,5	374,0	30,8	29,9
investment	"100"	384,4	4,1	388,6	30,8	31,1
grade	"50"	390,9	23,5	414,4	31,3	33,2

RWA = risk-weighted assets, GA = granularity adjustment.

Looking at Table 4c, we note that in any capital regime and for any portfolio, the minimum acceptable capital ratio held by the bank would be higher – in some cases remarkably higher – than the 8 per cent minimum. Moreover, there are large

differences in the minimum acceptable capital ratios accross regimes for a given portfolio. As a general pattern, investment grade portfolios experience high capital ratios in the risk sensitive IRBA and low capital ratios in the non-risk sensitive CA. The reverse holds for non-investment grade portfolios. For example, the minimum acceptable capital ratio in the IRBA for the "500" investment grade portfolio is 16.0%, whereas in the current regime it is only 8.5%. The corresponding ratios for the "500" non-investment grade portfolio are 8.9% and 17.2 (20.1)%. The range of variability in these numbers demonstrates that changes in the volatility of the risk-weighted assets can have large effects on the capital buffers and therefore on the amounts of capital that banks would hold under the proposed new regimes. Figure 2 further decomposes the acceptable capital amounts into the minimum requirement and the buffer for the "500" portfolios in each capital regime. This illustrates the relative size of the buffer with respect to the minimum requirement. Although the biggest relative buffers are found in the case of the IRBA investment grade portfolios, of course the absolute acceptable capital amount in these cases is the lowest.

Figure 2. **Decomposition of the acceptable capital amount into the minimum capital requirement and the buffer**



The case of "500" portfolios. The figure combines information from tables 4a and b. To focus on the effect of rating sensitivity, the effect of constraint (3) on acceptable capital amounts is not considered in this figure

Somewhat surprisingly, the relative size of the capital cushion for a given portfolio is not always higher in the more risk-sensitive IRBA than in the SA, or even in the current regime. In fact, in comparing the SA and the IRBA, the latter gives rise to a higher minimum acceptable capital ratio only in the case of the low-risk investment grade portfolios. Moreover, unlike in the CA and in the SA,

the ratio in the IRBA is actually decreasing as the risk of the portfolio increases.[9] Why would this be the case? Consider the two random components on the right-hand side of X: 1) the risk-weighted assets in period one and 2) the unexpected losses in period one. In a high-quality portfolio there can be mainly rating downgrades but very few losses. This implies that in a rating-sensitive capital regime, like the IRBA, rating migration can cause considerable variation in the risk-weighted assets part of X, whereas in a system relatively insensitive to ratings this is not the case. Therefore the minimum acceptable capital ratio for the investment grade portofolio is the highest in the IRBA, the second-highest in the SA, and the lowest in the current regime, CA. As for low credit quality portfolios, the unexpected loss component begins to contribute to the variation in X. Hence the minimum acceptable capital ratios in the risk-insensitive capital regimes are relatively high. In the risk-sensitive IRBA, on the other hand, the opposite happens because of two reasons. First, relative to a high-quality portfolio, there is more scope for rating upgrades which the risk-sensitive regime rewards with a lower capital charge. Secondly, and perhaps more importantly, the more risk-sensitive approach already accounts for much of the potential losses in the planning period because the lowest rated assets receive capital charges which are of the same order of magnitude as realized losses in the event of default. Indeed, the highest-risk exposures receive the cap risk-weight in the IRBA, which implies that their capital charge equals their loss-given-default. Therefore, when losses are realized on such assets, there is an exactly compensating reduction in the amount of risk-weighted assets, so the net effect on X is zero.

Finally, comparing the minimum acceptable capital amounts in table 4b across the different capital regimes for a given portfolio, we have indicated by grey shading the capital regime that the bank would choose on the basis of the lowest capital needed, ignoring other factors that could affect its choice. Only in case of the "500" investment grade portfolio would the bank opt for the IRBA, otherwise it would select the SA. Although the empirical relevance of our example portfolios is tentative, this is a rather striking result, given that the Basel Committee and, especially the EU, would like to see a fairly large number of banks moving to the IRBA.[10] Moreover, it is interesting to note that only in investment grade portfolios would better diversification provide sufficient incentives to move from the SA to the IRBA.

[9] This is the case in moving to portfolios of poorer credit quality, keeping the degree of diversification fixed. It is also the case in moving to less diversified portfolios, given the portfolio's overall credit quality, except in the non-investment grade portfolio in which the capital ratio is practically flat regardless of the degree of portfolio diversification.

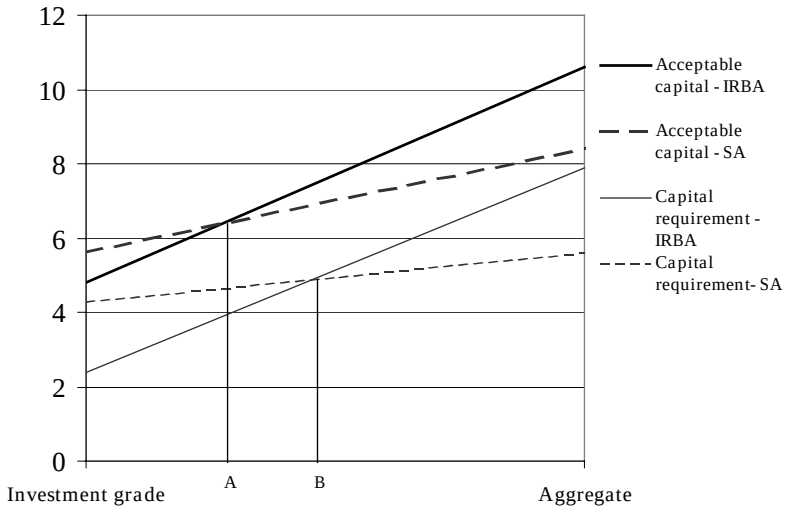
[10] One reason for obtaining results strongly in favor of the SA could be that we do not consider (in the lack of data) any risk mitigation which would benefit banks more in the IRBA than in the SA. Our assumption that all counterparties in our portfolios possess external ratings may also bias this comparison in favour of the SA. In the absence of external ratings, the SA basically collapses to the CA, thereby twisting the previous comparison in favour of the IRBA when it comes to investment grade portfolios.

4 Implications

The effect of the capital regulation reform on the overall bank capital depends on the cushions banks prefer to hold in excess of the new minimum requirements. The Basel Committee has stated as its goal that, after the reform, the overall level of capital should stay at about the same level as prior to the reform. Therefore the effect of the cushions might have to be considered in order to achieve this goal. Furthermore, the regulators' implicit criterion in determining the minimum capital requirements should be to achieve a socially desirable level of probability of default for banks themselves. If the minimum capital requirement would imply the desired default probability for a bank, then the minimum acceptable capital level chosen by the bank – minimum plus the cushion – would imply a lower effective probability of default to this bank. Comparing tables 4a and 4b we see that, for instance, for the investment grade portfolios, the minimum acceptable capital amount is roughly double the minimum requirement, indicating that the actual bank default probability may turn out to be much lower than the one pursued. This implies that the bank would be much too safe, i.e., it would hold large amounts of idle capital, even from society's point of view. To achieve the social target bank default probability, regulators should take into account banks' response to the reform.

Secondly, the cushions may give certain banks a disincentive to start using the IRBA. Other things being equal, a bank would choose the regulatory approach that would give it the lowest acceptable capital level, i.e., the lowest sum of the minimum capital requirement plus the cushion. Basel has indicated that in the final stage of the reform the IRBA risk-weights would be calibrated in such a way that a representative bank – and obviously banks with risks that are lower than those of the representative bank – would have an incentive in the form of a lower *minimum* capital requirement to use the IRBA rather than the SA. A calibration done in this way could lead to problems such as in the case of the investment-grade "100" portfolio for which the minimum capital requirement in the IRBA is lower than in the SA, whereas the minimum acceptable capital levels in the two approaches go vice versa (see the different coverage of the shadings in tables 4a and 4b). This incentive problem is further illustrated in Figure 3. There we have graphed out the simulation results for the "500" portfolios from table 3b. These show that the minimum acceptable capital amount in the SA and the IRBA can be equal for a different portfolio (A) than for which the minimum capital requirements intersect (B). Hence, ignoring the capital cushions in addition to the minimum capital requirements could lead Basel to provide capital incentives towards using the IRBA for a somewhat different set of banks (banks left of A) from what was intended (banks left of B).

Figure 3. **Illustration of capital incentives**



An illustration of the minimum acceptable and the minimum regulatory capital requirements in the SA and the IRBA, based on the numerical results for the "500" portolios in tables 5a and 5b.

Thirdly, we argue that, after the reform, banks' capital ratios would have to be interpreted with more care. For instance, in the IRBA it would be the lowest-risk banks that would hold the highest capital ratios (although, of course, their absolute capital amounts would be the lowest). Therefore, unlike in the current accord or in the SA, a high capital ratio of an IRBA bank would not be an indication of high portfolio risk, but on the contrary. We suggest that a simple leverage ratio – capital over nominal, not risk-weighted, assets – would be more directly related to a bank's portfolio risk after the reform, given that banks respect the constraints (2.1)–(2.3). Because the size of our example portfolios is normalized at 100, the minimum acceptable capital amounts in table 4b would coincide with such a leverage ratio.

Fourthly, our analysis indicates that banks may have incentives to try to dampen the capital requirement volatility especially in the IRBA. This may give rise to concerns for new types of capital arbitrage activities: banks may try to reap the image benefits from being an "IRBA bank" while simultaneously trying to delay their internal rating changes, in particular downgrades (see also footnote 5 above).

Finally, our analysis suggests that banks' adjusting their capital cushions may help in alleviating the pro-cyclical effects of the more risk-sensitive capital requirements that have been pointed out in the literature (see Blum and Hellwig, 1995). In particular, the cushions would lower the probability that banks minimum capital requirements would become binding in an economic downturn, which might force banks to cut back on their lending and hence further enforce the original shock to the economy. If banks have profitable long-term lending relationships which they want to preserve over the business cycles, they would have further incentives to reserve enough capital for bad times.

5 Conclusions

Our key findings in this paper are briefly summarized as follows:

- The use of ratings in the new Basel Accord, and the resulting increase in the volatility of the risk-weighted assets, can have a considerable impact on banks' precautionary capital cushions in excess of the new minimum capital requirements.
- These cushions will affect the level of overall capital in the sector after the reform as well as banks' choices between the standardized and the internal ratings based approach. The outcome will also depend on how the Basel Committee accounts for these effects in its final calibration of the risk-weights.
- The information content of banks' capital ratios would have to be interpreted with more care after the reform. In particular, the way that banks' capital cushions relate to banks' underlying portfolio risks would depend on the regulatory capital approach banks are using.
- Although the empirical relevance of the hypothetical bank portfolios considered in this paper is tentative, it is still interesting to note that only in one out of the nine portfolios considered would the bank have chosen the internal ratings based system, ignoring all other factors influencing this choice than minimizing the capital requirement.

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