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The risk-weights in the New Basel Capital Accord: Lessons from bond spreads based on a simple structural model

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Abstract

The Basel Committee designed a system of risk weights ("standardised approach") to measure the riskiness of banks' loan portfolios. We investigate its ability to adequately reflect risk through an analysis of the economic capital implied in corporate bond spreads. This is based on a dataset of issuance spreads, ratings and other relevant bond variables including 7232 eurobonds issued by an internationally-diversified sample during 1991–2003. Three main results emerge: the spread/rating relationship is strongly significant; the estimated spreads per rating class indicate a steeper risk/rating relationship than the one approved by the Basel Committee; no significant difference appears in the spread/rating relation of banks and non-financial firms issuers.

JEL classification: G15; G21; G28

Keywords: Eurobonds; Credit ratings; Spreads; Structural models; Capital regulation; Deposit insurance; Banks

1. Introduction

In June 2004, the Basel Committee for Banking Supervision released its reform of the capital adequacy framework originally introduced with the 1988 Accord. This reform is based on three mutually reinforcing pillars: (i) minimum capital requirements, (ii) supervisory review process,

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Table 1
Proposed risk-weights per rating bucket—standardised approach

	(1) Basel 1999 proposed risk weight (%)	(2) Basel 2004 proposed risk weight (%)	(3) Altman–Saunders proposals (%)
AAA to AA−/ Aaa to Aa3	20	20	10
A+ to A−/ A1 to A3	100	50	30
BBB+ to BBB−/ Baa1 to Baa3	100	100	30
BB+ to BB−/ Ba1 to Ba3	100	100	100
B+ to B−/ B1 to B3	100	150	100
Below B−/B3	150	150	150

Source: Altman and Saunders (2001), Basel Committee on Banking Supervision (2004).

and (iii) market discipline.[1] As far as the first pillar is concerned, the New Accord is based on minimum capital requirements for credit, market and operational risks. Credit risk capital requirements, in turn, would be set according to a standardised approach or an internal ratings-based approach (IRB). In the standardised approach[2] the 1988 risk weights based on some broad borrower categories (sovereign, banks or non-financial corporations) are to be refined by reference to a rating provided by an external credit assessment institution, such as a rating agency. Column (2) of Table 1 reports the new risk weights for corporate loans (banks would be assigned a more favourable set of weights).

In the years leading to the New Accord, a lively stream of literature focused on the structure and implications of the IRB approach, which undoubtedly constitutes the most unprecedented part of the reform.[3] However, the risk weights introduced by the new standardised approach also are likely to have a significant impact on the banking industry. Their appropriateness was discussed, e.g., by Altman and Saunders (2001) who criticised their broad degree of granularity (only three buckets for rated corporate loans were envisaged). Using data on historical corporate bond defaults and losses per rating class to simulate expected and unexpected losses, those authors showed that the three weights of 20% (AAA to AA−), 100% (A+ to B−) and 150% (below B−) were too broad to reflect the relative risk of unexpected losses in each bucket.[4] Based on their empirical findings, Altman and Saunders (2001) recommended a revised risk-weighting scheme that included splitting the A+ to B− bucket into two separate buckets (A+ to BBB− and BB+ to B−), reflecting the distinction between investment and non-investment grade borrowers (see column (3) of Table 1).[5]

[1] For an analysis of the relationship between capital requirements and market discipline, see Berger et al. (1995).

[2] Under the IRB approach banks would be allowed to use their own estimates of a borrower's probability of default produced by an internal rating system, conditional on specific criteria and on validation by national supervisors. The IRB approach also confers varying degrees of independence to banks in setting the parameters determining risk weights: the 'foundation' approach entails less independence than the 'advanced' one. Under both the standardised and the IRB approaches the original 8% minimum capital to risk-weighted assets is maintained.

[3] See e.g. Gordy (2003), Repullo and Suarez (2004).

[4] Altman and Saunders' critique lead to some fine-tuning in the weights approved in 2004, which are slightly different from those originally proposed by the Basel Committee in 1999 (also reported in Table 1).

[5] Note that Altman and Saunders themselves mention that their revised risk-buckets underestimate risk for grades BB, B and below B−.

Following this and other comments, the final weighting structure approved by the Basel Committee in 2004 split the second bucket into three: A+ to A−, with a 50% risk weight, BBB+ to BB− (100%), and below BB− (150%, see column (2) of Table 1).

In this paper, we further investigate the appropriateness of this choice. Rather than historical loss rates per rating class, corporate bond spreads[6] are used to estimate the risk/rating relationship. More precisely, eurobond issuance spreads are used to estimate the implied economic capital allocations of different rating buckets. This empirical analysis is based on two separate exercises. First, "typical" credit spreads per rating class are estimated through a multivariate regression based on a sample of 7232 eurobond issues completed by major corporations from 64 countries between 1991 and 2003. Second, these credit spreads are used to capture the amount of risk capital associated with different rating grades. This is done by estimating the amount of capital that is consistent with a theoretical framework that draws on the work by Merton (1974) and Flannery (1991).

The use of a wide sample of Eurobond issues has several main advantages. First, contrary to historical losses, bond spreads are forward looking and reflect the actual risk associated to different rating classes, as perceived by the investors. Second, while default and loss rates provided by rating agencies mostly come from US dollar-denominated bonds issued by US firms in their domestic capital market, eurobonds are denominated in different currencies and internationally issued by companies from different countries. They therefore look as a more adequate empirical background for evaluating a regulation aimed at banks competing internationally on global markets. Third, yield spreads—compared to historical default rates—directly incorporate both components of the credit risk embedded in an exposure: expected loss and unexpected loss; hence, one does not have to estimate the unexpected losses through a credit risk portfolio model like, e.g., in Altman and Saunders (2001). Finally, while default rates tend to be somewhat volatile and imprecise for investment-grade issues (especially, for AAA issues, where defaults are rare events), in the case of yield spreads a large amount of data is available also for highly-rated exposures.

This study uses issuance spreads rather than secondary market ones: this, in turn, has two advantages. First, yields on new issues reflect actual transaction prices rather than brokers' "indicative prices", i.e., estimates derived from pricing matrices or dealers' quotes.[7] As such, they provide a more accurate measure of the actual risk premium demanded by investors. Second, primary market spreads represent a better measure of the actual cost of debt faced by bond issuers.

Using data from a thirteen-year period (1991–2003) that includes at least one full economic and credit cycle allows us to get reliable estimates of the spread/rating relationship that are not biased by any particular state of the economy.

Three main results emerge from our empirical analysis. First, the spread/rating relation is strongly significant, with spreads increasing when ratings worsen. Second, the estimated spreads per rating bucket indicate a steeper risk/rating relationship than the one proposed by the Basel Committee. Finally, while eurobonds issued by banks have a better average rating than those issued by non-financial companies, no significant difference emerges in the spread/rating relationship between banks and non-financial firms. This indicates that the distinction between banks

[6] By "spread" we mean the difference between a corporate eurobond's yield to maturity and that of a Treasury security with similar maturity, denominated in the same currency.

[7] Secondary market prices can even be misleading if dealers quote strategically. Assume a dealer does not want to buy a specific bond. She would quote a higher price which would in turn signal high demand and a lower spread. For more on the problems related to secondary market prices and spreads, see Hancock and Kwast (2001).

and non-financial in the New Accord firms has no economic justification once external ratings are accounted for.

Following these empirical findings, we propose three main changes to the standardised approach. First, no distinction should be made between banks and non-financial companies, as far as the risk-weights already depend on ratings. Second, five rating buckets should be considered rather than four (as proposed by the Basel Committee). Third, the risk weights should be adjusted in order to reflect a steeper relationship between risk and rating.

This paper proceeds as follows. Section 2 presents the model and variables used in our empirical analysis. Section 3 describes the data sources and summarises sample characteristics. Section 4 presents the empirical results. Section 5 presents a simple structural model linking spreads and optimal capital and elaborates on the implications of our results for the system of risk weights proposed in the New Basel Capital Accord. Section 6 concludes.

2. Model and variables

The empirical analysis presented in this study is restricted to eurobond issues[8]; eurobonds were chosen for our empirical analysis mainly for three reasons. First, they are issued in relatively large amounts in a highly competitive market open to different kinds of investors (mostly institutional ones) from different countries. This enhances liquidity and minimises the risk of price anomalies.

Second, the eurobond market is relatively unregulated: issues are not subject to queueing or other costly procedures, listing only occurs for a minority of the issued amount in order to meet institutional investors' needs, investors are not subject to withholding tax, and bonds are mostly in bearer form. These factors significantly enhance the possibility to compare different bonds' spreads.

Finally, eurobonds are denominated in different currencies and issued by companies from different countries. This makes them a more adequate database for evaluating the effectiveness and fairness of the internationally-adopted Basel weights.

Recent empirical studies indicate that several characteristics of corporate bonds, beyond rating categories, convey information about their pricing (Elton et al., 2000). These include maturity, coupon, time from issuance, trading volumes and face value. Our empirical analysis is largely consistent with these results, as it is based on cross-sectional regressions where maturity, coupon and face value all appear as independent variables.[9]

In short, the model tested will be based on the following structure:

$$\begin{aligned} Spread = f(&risk, maturity, amount, tax, currency, \\ &market\ efficiency, market\ conditions, country). \end{aligned} \tag{1}$$

[8] "Eurobonds are purchased from the issuer by syndicates of investment banks that are formed on a case-by-case basis. The lead bank (the arranger) draws up the agreement and collects a management fee, which is shared with other syndicate members. The members purchase the issue according to a formula agreed upon in the syndication agreement. The participation fees are usually allocated in similar proportions. The lead bank negotiates conditions with the borrower. It prepares a "term-sheet" or "information memorandum" about the issue that is circulated to potential syndicate participants. It also prepares, with the customer, the necessary bond issue documentation. Once the information regarding the issue is finalised, the distribution agreement is drawn up" (Melnik and Nissim, 2003). See also Levich (2001) for further details and a general overview of the eurobond market.

[9] Note that, since time from issuance equals zero for all corporate bonds in our sample, only trading volumes are missing, since they are not available when issuance spreads are used.

The dependent variable of our regressions, "spread", is the "nearest-on-the-run" spread (that is, the difference between the yield to maturity at issuance of each individual Eurobond and the yield to maturity of the Treasury bond denominated in the same currency and with the nearest maturity).[10] The use of secondary market spreads is avoided because of the relatively poor liquidity of the secondary market for some minor eurobond issues. Using primary market spreads also permits the use of "fresher" ratings because new issues are rated near the time of issuance.

Issuance spreads reflect the issuer's credit risk and the market conditions. As such, in (1) they are a function of eight main factors[11]: (1) the bond's default and recovery risk, (2) the time to maturity of the issue, as this affects its default risk premium (Merton, 1974), (3) the issue amount, as this in turn is believed to affect secondary market liquidity, (4) the expected tax treatment to which investors will be subject, (5) the currency of denomination,[12] (6) the efficiency of the bond's primary market, (7) the bond market conditions at the time of the issue, and (8) the macroeconomic conditions of the country of the issuer.

The variables used to represent these eight factors are briefly outlined below.

2.1. *Default and recovery risk*

Our empirical analysis is based on the use of Moody's and Standard and Poor's *issue* ratings as proxies of the bonds' default and recovery risk:

ISSBUC_01...ISSBUC_5 Rating dummies. Each dummy variable is equal to 1 if the average Moody's and Standard and Poor's (S&P) rating[13] falls into the corresponding "rating bucket" (see Table 2 for rating scales) and zero otherwise.[14] These dummy variables

Table 2
Rating scales

#	1	2	3	4	5	6	7	8	9	10
Moody's	Aaa	Aa1	Aa2	Aa3	A1	A2	A3	Baa1	Baa2	Baa3
S&P's	AAA	AA+	AA	AA−	A+	A	A−	BBB+	BBB	BBB−
Our scale	1	2	3	4	5	6	7	8	9	10
Our bucket	1	1	1	1	2	2	2	3	3	3

#	11	12	13	14	15	16	17	18	19	20	21
Moody's	Ba1	Ba2	Ba3	B1	B2	B3	Caa1	Caa2	Caa3	–	–
S&P's	BB+	BB	BB−	B+	B	B−	CCC+	CCC	CCC−	CC	D
Our scale	11	12	13	14	15	16	17	18	19	20	21
Our bucket	4	4	4	5	5	5	5	5	5	5	5

[10] Note that this spread is computed directly by our data provider (Dealogic Capital Data Bondware), and this makes it impossible for us to explore alternative ways to compute the spreads (such as spreads based on the Treasury's constant-maturity series) and their effects for our empirical results.

[11] Despite the cross-sectional nature of the empirical analysis, some temporal variation is present as many companies issued eurobonds more than once over the sample period. Regressions with the inclusion of fixed effects are also estimated.

[12] The latter is a relevant factor because of the different credit standing and liquidity of Treasury securities. The spread of a eurobond issue is computed as the difference between the bond yield to maturity and the equivalent Treasury one. A US dollar denominated eurobond issue could, other things being equal, have a higher spread than an Italian lira denominated one simply because the Italian Treasury security has a lower credit quality and liquidity than the US one.

[13] These are ratings assigned by one or both rating agencies to the single issue at the time of issuance. As such, they reflect both the issuing company's creditworthiness and the bond seniority and security structure.

should capture the difference in both issuers' creditworthiness and bonds' seniority and security structures.[15] The rating buckets are the same as defined in the Basel Committee's standardised approach, except that an extra bucket was defined for BBB-rated debt, to avoid mixing investment-grade and junk exposures.

In addition to that, the following variables are used:

SUBO A dummy variable that equals 1 if the issue is subordinated, zero if it is senior. The expected coefficient sign is positive, as subordinated issues have a lower expected recovery rate in case of default than senior bonds and therefore require a higher return. However, its statistical significance could be poor as subordination is already reflected in the rating.[16]

BANK A dummy variable that equals 1 if the issuer is a bank and zero otherwise. This variable should control for differences between banks and non-financial firms that motivated the use of two separate sets of weights in the Basel proposal. Such differences might be due, e.g., to the presence of implicit government guarantees, such as the too-big-to-fail effect, that are not already incorporated into the issue rating.

AUT, BIS, BANK, CHE, COM, CON, ELE, ENG, FEB, FIN, GOV, HEA, HOT, IND, INS, MAN, MED, OIL, OTI, RET, TEL, TRA, UTI[17]—Industry dummies equal to 1 if the eurobond issuer's main activity is in the corresponding industry, 0 if not. These variables should capture investors' expectations concerning specific industries evolving economic conditions that are not already implicitly reflected in the average rating of those industries. A positive coefficient would indicate that investors' perception concerning the industry's prospects are worst than the ones implicit in the corresponding issue ratings, and vice versa.

[14] When the ratings assigned by S&P and Moody's differ, we proceed as follows: first, ratings are converted into a numerical value based on the scale shown in Table 2; second, the average value of the S&P and Moody's value is computed, rounding to the lower (less risky) value; third, the rating bucket is chosen based on this average value. An alternative based on the lower integer value has been tested and found to produce similar results.

[15] Since our analysis aims at assessing the appropriateness of the risk weights proposed by Basel Committee, which are in turn based on ratings, the latter represent the measure of credit quality on which we have to focus. However, ratings have been shown to present relevant limitations as leading indicators of credit quality. Using equity and liability data for US firms, Delianedis and Geske (1999), construct alternative credit risk measures and compare their forecasting performance to that of ratings. They find these accounting-based measures to increase well in advance of rating downgrades and conclude that ratings are slow in reacting to new evidence. Comparing actual market values and ratings for a large number of dollar-denominated international bonds, Perraudin and Taylor (1999) report highly persistent inconsistencies between ratings and prices (a bond's price is defined as inconsistent with its rating if it is above/below the price it would have if it were valued using yields corresponding to a higher/lower rating category). However, these empirical studies are based on spread changes and tend to focus on the limitations of ratings as leading indicators of credit quality. Since our attention is focused on the cross-sectional variability of issuance spreads, these limitations should be much less relevant.

[16] Rating agencies tend to rate subordinated issues one notch below senior debt if the latter is investment grade and two notches below if it is speculative grade.

[17] These represent: Automobile, Building Societies, Banks, Chemicals, Computers, Constructions, Electronics and Electrics, Food and beverages, Financial companies (excluding banks, insurers and building societies) and holding companies, Government-controlled concerns, Health and pharmaceuticals, Hotels and Leisure, Industrials, Insurance, Manufacturing, Media & Publishing, Oil and mines, Other Industries, Engineering, Retail, Telecommunications, Transportation, Energy and Utilities. The Other Industries (OTI) variable includes industries for which less than 20 observations were available.

2.2. Maturity

MATU The time to maturity (in years) of the issue.[18]

2.3. Secondary market liquidity

AMOUNT The natural log of the bond issue US dollar equivalent amount (face value). A higher issue amount is generally believed to improve, ceteris paribus, secondary market liquidity. A negative coefficient is therefore expected for this variable.[19]

2.4. Tax treatment

The following two variables are used to proxy for the expected tax treatment of different eurobond issues:

COUPON The level of the annual coupon paid by the bond. The effect of this variable on the bond spread depends on the relative tax rates on capital gains and interest income. In some countries these two rates are different; however, given the wide range of nationalities of eurobond investors, the a priori effect of COUPON on the bond after tax value is uncertain. In addition to that, as most eurobonds are in bearer form, avoiding tax is relatively easy for investors. Nevertheless, since in most countries capital gains are paid at the time of sale, bonds with lower coupons may be more valuable because some taxes are postponed until the time of sale and because the investor decides when these taxes are paid (tax timing option). A positive coefficient is therefore expected.

REG A dummy variable that equals 1 if the bond is a registered one and zero if it is in bearer form. A positive coefficient is expected as eurobond investors would find it easier to avoid tax payments in the case of bearer bonds.[20]

2.5. Primary market efficiency

The following four variables are used to proxy for the different primary market efficiency of different eurobond issues:

MANAGERS The number of financial institutions participating in the bond issuance management group (book runners, lead manager, any co-lead manager, and co-managers). A negative coefficient is expected as this would indicate that a larger syndicate is able to achieve, ceteris paribus, a larger number of potential investors. This would in turn result in a higher demand for the issuing bonds and in a lower spread.[21]

[18] To avoid biases due to a couple of very long-term issues in our sample, all maturity above 20 years were truncated at that threshold.

[19] Another variable that is generally believed to affect a bond's market liquidity is its age. This measure rests on the belief that newly issued bonds are more liquid than bonds that have been in the market for a longer period of time (Elton et al., 2000). However, our sample bonds are all newly issued as the empirical analysis is based on issuance spreads.

[20] Only 22.98% of the sample eurobond issues (1662 over 7232) are registered (see Table 4).

[21] Note that an increase in costs associated to a larger number of syndicate members would already be captured by the FEES variable. Quite surprisingly, these two variables are not significantly correlated: their Pearson correlation coeffi-

PRIVATE A dummy variable that equals 1 if the bond issue is a private placement and zero if it is public.[22] Other things equal, private placements represent a less efficient issuance process as a smaller number of potential investors is directly reached. A negative coefficient is expected as investment banks are generally able to exploit a stronger placing/selling power in a private placement than in a public issue.

FEES The amount of gross fees charged by the bond issuance syndicate to the issuer. These include underwriting fees, management fees and selling concession.[23] No clear theoretical a priori conclusion can be reached on the expected sign of this variable. A negative sign would indicate that issuers can translate the higher fees to the final investors through a lower spread. A positive one would suggest that issuers who are less appealing for the investors (resulting in a higher spread), also face higher bookrunning costs, reflected into higher fees.

FIXED A dummy variable that equals 1 if the eurobond issue is a fixed-priced one and zero if it is an open-priced one. While in a fixed-priced issue the investment banks of the underwriting group set the issuing price according to their estimates of the demand for the bonds, in an open-priced one the final investors play a role in determining the actual price. As the investment banks participating in the management group take a higher underwriting risk with fixed-priced issues than with open-priced ones, a more efficient primary market is achieved in this kind of issues. This should in turn results in a lower spread. A negative coefficient is therefore expected.

2.6. Currency

DEM, DFL, EURO, FFR, STG, USD, CAN—Currency dummies that equal 1 if the issue is denominated in the corresponding currency and zero otherwise. All other currencies are grouped together and account for less than 2% of the total issues. These variables should capture both the different credit standing and liquidity of the national Treasury securities and eurobonds investors' currency preferences.

2.7. Bond market conditions at time of issuance

QUARTERLY DUMMIES Each dummy variable is equal to 1 if issue *i* has been completed during the corresponding quarter and zero otherwise.

BBB_SP Spread over the risk-free rate earned by dollar-denominated, BBB-rated corporate bonds in the quarter when each eurobond in our sample was issued. This spread captures the variations in bond market conditions when the bonds were issued, in a more parsimonious way than quarterly dummies.

cient is indeed low (0.306) and statistically not significant. Moreover, MANAGERS is not significantly correlated with AMOUNT: indeed, the correlation coefficient is negative (−0.114), indicating that larger issues are not associated with a higher number of managers.

[22] Only 120 of the 7232 eurobonds in our sample were issued through a private placement (see Table 4).

[23] The selling concession is a fee paid by the issuer to the members of the selling group in the form of a discount on the price of the bonds.

2.8. Country

CAN, FRA, GER, JPN, NET, UK, USA—Country dummies. All other countries are grouped together and account for less than 3% of the total issues. These dummy variables should capture cross-country differences in macroeconomic conditions and regulatory frameworks.[24]

3. Data sources and sample characteristics

Our data come from two main sources: Capital Data BondWare and Moody's Corporate Default. Capital Data reports information on the major debt and equity issues worldwide. As far as eurobonds are concerned, it provides information on both issuers (nationality, industry, etc.) and issues (Moody's and Standard and Poor's rating, currency, closing date, years to maturity, spread at issuance, issue type, face value, coupon, subordination, gross fees, number of managers, cross-default and other clauses). Moody's Corporate Default Database is a complete history of Moody's long-term rating assignments for both US and non-US corporations and sovereigns. Both ratings on individual bonds and issuer ratings are included, as are some bond and obligor characteristics such as borrower names, locations, ultimate parent companies, bond issuance dates, original maturity dates, seniority, and coupon.

All bonds with special features (e.g. callable bonds, perpetual bonds, floating rate bonds) that would affect their price have not been included in our empirical sample. Spreads at issuance for all issues of fixed rate, non-convertible, non-perpetual and non-callable eurobonds during the 1991–2003 period were collected. This amounts to 7232 bonds (see Tables 3 and 4). Bonds issued by central banks, supranational institutions, central or local governments were not considered.

This sample suffers from two potential selection biases. First, a relatively larger number of issues has been completed during the second half of the sample period. This is partly due to a general increase in the average number of eurobond issues, and partly the consequence of the

Table 3
Sample descriptive statistics (continuous variables)

	Spread	Rating	Amount	Maturity	Coupon	Managers	Fees
N	7232	7232	7232	7232	7232	7232	7232
Mean	88.5	4.5	432.0	97.7	6.0	10.2	1.0
Median	52.6	4.0	256.1	72.0	6.1	8.0	0.7
Max.	1014.0	21.0	7000.0	1200.0	15.0	54.0	6.5
Min.	−23.50	1.00	0.10	12.00	0.00	1.00	0.00
Std. Dev.	115.9	3.7	564.8	75.0	2.4	8.9	0.8

Notes. SPREAD: "nearest-on-the-run" spread, i.e., difference between the yield to maturity at issuance of each individual Eurobond and the yield to maturity of the Treasury bond denominated in the same currency and with the nearest maturity. MATURITY: the time to maturity (in years) of the issue. AMOUNT: the US dollar-equivalent amount of the issue (US$ m). RATING: the equivalent value (see our scale in Table 2) of the average Moody's and Standard and Poor's issue rating. COUPON: the annual coupon (percent). MANAGERS: the number of financial institutions participating in the issuing syndicate. FEES: the total gross fees (%) earned by the eurobond issuing syndicate (underwriting fees, management fees and selling fee).

[24] National regulations (mainly: differences in bankruptcy laws, see e.g. Appendix G in Gupton et al., 1997) might have an impact on Eurobond spreads through differences in expected recovery rates in the event of default.

Table 4
Sample descriptive statistics (dummy variables)

	Subo	Reg	Cross	Pledge	Force	Private	Fixed	Bank
N. of issues for which data is available	7232	7232	4584	5106	4428	7232	7232	7232
N. of issues for which dummy = 1	419	1662	2864	3478	4388	120	5120	3698
% of Total available data	5.79	22.98	62.48	68.12	99.10	1.66	70.80	51.13

Notes. SUBO equals 1 if the issue is subordinated and zero if it is senior. REG equals 1 if the bond is registered and zero if it is in bearer form. CROSS equals 1 if the bond issue includes a cross-default clause and zero otherwise. PLEDGE equals 1 if the bond issue includes a negative pledge clause and zero otherwise. FORCE equals 1 if the bond issue includes a force majeure clause and zero otherwise. PRIVATE equals 1 if the bond issue is a private placement one and zero if it is a public issue. FIXED equals 1 if the bond issue is fixed priced and zero if it is open priced. BANK equals 1 if the bond issuer is a bank, zero otherwise.

availability of Moody's and Standard and Poor's ratings. This potential bias has been addressed by running separate analyses of the two sub-periods in our sample (see Section 4.2).

Second, as companies tend to issue eurobonds when the market is more receptive, the number of issues is particularly low in the third and fourth quarter of 1998, when the Russian crisis occurred, and particularly high during 1999, during a low interest rate environment. However, this potential bias should have a limited impact on a sample period covering thirteen years.

Moody's and Standard and Poor's (S&P) ratings at issuance for these 7232 issues are either from Capital Data BondWare or from the January, 2001 release of Moody's Corporate Default Database. Both Moody's and S&P ratings are available for 2700 eurobond issues which represent 37.3% of the entire sample issues. For the remaining 4572 issues (62.7% of the sample) only one of the two ratings is available. When both ratings are available, the corresponding numerical value is the same in 65.3% of the cases (1763 issues), is different by one notch only in 26.2% of the cases (708 issues) and by two notches in 6.2% of the cases (167 issues).[25]

More information on sample characteristics is provided in Tables 5 and 6. As shown by Table 5, most of the sample issues have been completed by US, German, UK, French and Japanese companies. Together, they account for more than two thirds of the issues and almost three quarters of the total amounts. The average spread is significantly higher than the sample average for UK, Canadian and US issuers.

Table 6 reports the main features of the sample by rating category. Most of the issues fall into the first six notches (from AAA to A in the S&P scale and from Aaa to A2 in the Moody's' one). However, the remaining grades account for more than 1800 bonds (that is, more than 25% of the total sample), with more than 500 speculative-grade issues. Therefore, we feel confident that the conclusions reached by our analyses still are reliable also for below-A borrowers. Average spreads per rating category increase almost monotonically with rating values, although classes below CCC+/Caa1, for which a limited number of issues is available, do not show any clear pattern. Note that banks are mostly concentrated in the top four rating classes (from AAA/Aaa to A+/A1).

[25] A difference of more than two notches is present in only 62 of the 2700 issues for which both ratings are available (2.3% of the issues). We checked for these differences for the banks' issuers subsample too, in order to test whether a higher degree of uncertainty is present. Results appear similar to those of the entire sample. Indeed, of the total 3698 bank issues, both ratings were available for 1562 only. When both ratings are available, the corresponding numerical value is the same in 72.3% of the cases (1129 issues), is different by one notch in 21.7% of the cases (339 issues), and is different by two notches in just 4.8% of the cases (75 issues).

Table 5
Sample descriptive statistics—corporate eurobond issues by issuer's country

Country	Total # of issues	% Tot. # of issues	N. of bank issues	% Bank issues	Avg. spread (b.p.)	Avg. rating	Total amount (US$ m)	% Tot. amount issued	Average amount (US$ m)	Average maturity (years)
Canada	286	4.0	125	43.7	97.5	5.5	85835	2.7	300.1	8.9
France	797	11.0	378	47.4	50.6	3.2	309359	9.9	388.2	9.1
Germany	1031	14.3	871	84.5	45.6	2.2	473918	15.2	459.7	6.9
Japan	717	9.9	178	24.8	38.5	6.4	197219	6.3	275.1	7.3
Netherlands	572	7.9	452	79.0	55.7	2.8	202371	6.5	353.8	7.0
United Kingdom	912	12.6	299	32.8	104.6	5.1	346879	11.1	380.3	11.0
United States	1412	19.5	678	48.0	100.4	4.4	1065020	34.1	754.3	7.8
Other (57 countries)	1505	20.8	717	47.6	151.6	6.3	443823	14.2	294.9	7.8
Total	7232	100.0	3698	51.1	88.5	4.5	3124423	100.0	432.0	8.1

Table 6
Sample descriptive statistics—corporate eurobond issues by average rating class

Rating class	Total # of issues	% Tot. number of issues	N. of bank issues	% Bank issues	Average spread (b.p.)	Std. dev. of spread (b.p.)	Total amount (US$ m)	% Tot. amount issued	Average amount (US$ m)	Average maturity (years)
AAA/Aaa	2292	31.7	1670	72.86	35.0	29.5	1128208	36.1	492.2	7.3
AA+/Aa1	512	7.1	366	71.48	39.1	34.8	151848	4.9	296.6	6.9
AA/Aa2	680	9.4	384	56.47	46.8	32.8	227619	7.3	334.7	7.3
AA−/Aa3	762	10.5	376	49.34	53.0	44.5	314685	10.1	413.0	9.1
A+/A1	556	7.7	233	41.91	85.0	48.6	280767	9.0	505.0	9.6
A/A2	565	7.8	268	47.43	100.4	49.5	328034	10.5	580.6	9.0
A−/A3	402	5.6	106	26.37	110.4	66.4	199085	6.4	495.2	9.4
BBB+/Baa1	420	5.8	100	23.81	122.0	79.6	208700	6.7	496.9	9.7
BBB/Baa2	311	4.3	56	18.01	117.8	78.3	113832	3.6	366.0	9.0
BBB−/Baa3	189	2.6	18	9.52	158.7	119.1	61575	2.0	325.8	9.0
BB+/Ba1	84	1.2	5	5.95	193.3	142.7	17436	0.6	207.6	8.3
BB/Ba2	115	1.6	16	13.91	235.2	165.8	21093	0.7	183.4	6.6
BB−/Ba3	74	1.0	19	25.68	346.7	191.6	12132	0.4	163.9	6.1
B+/B1	121	1.7	53	43.80	438.1	152.5	23380	0.7	193.2	5.8
B/B2	67	0.9	15	22.39	538.3	177.3	15741	0.5	234.9	7.9
B−/B3	51	0.7	12	23.53	591.9	186.9	11852	0.4	232.4	8.5
CCC+/Caa1	6	0.1	0	0.00	594.4	147.1	2130	0.1	354.9	9.2
CCC/Caa2	7	0.1	1	14.29	563.4	132.1	977	0.0	139.5	9.1
CCC−/Caa3	3	0.0	0	0.00	409.8	41.9	950	0.0	316.7	8.3
CC/−	4	0.1	0	0.00	105.3	24.7	600	0.0	150.0	14.3
D/−	11	0.2	0	0.00	362.9	219.4	3779	0.1	343.6	11.2
Total	7232	100.0	3698	51.13	88.5	115.9	3124423	100.0	432.0	8.1

Sample issues were also broken down by year of issuance, currency of denomination and industry of the issuer (results not reported to save room). As concerns time, the total amount issued per year has grown from 43 billion USD in 1991 to more than USD 430 billion in 2003, with the average issue growing from just over 200 million USD to more than 500 million USD. The average spread has significantly fluctuated over time, reaching a peak of 126 basis points in 2000, while the average rating has significantly worsened, from 2.7 (equivalent to AA+/AA in the S&P scale) in 1991 to 5.6 in 2003 (approximately equivalent to A).[26] As far as the currency of denomination is concerned, three currencies (Euro, British pound sterling and US dollar) account for 64% of the issues and 80% of the amounts. Finally, the industry distribution of the sample issuers shows that more than half of the issues have been completed by banks (51%), while only two other industries (Telecommunications and Energy/Utilities) individually account for more than 5%. Significant differences emerge among industries' average spreads. These differences basically reflect differences in the industries' average ratings.

4. Empirical results

4.1. Regression analysis

Table 7 reports various estimates of our model coefficients and (White's heteroscedasticity-consistent) standard errors. Adjusted R^2s are shown at the bottom of the table, together with F-statistics.

Column (1) shows our basic regression: an adjusted R^2 of 0.84 indicates that ratings and other control variables explain a significant portion of the spreads' cross-sectional variability.

All rating dummies are statistically significant at the 1% level (the first bucket is omitted to avoid perfect collinearity, and can be thought to have a zero coefficient); the monotonic pattern of the coefficients indicates that spreads rise when ratings worsen. Not only are the dummy coefficients different from zero: what is more, the values assigned to adjacent rating buckets are always statistically different *from each other* at the 1% level, as shown by a set of Wald tests.[27]

MATU and FEES both have significant coefficients with the expected signs.[28] SUBO also has a positive (although statistically weaker) effect, indicating that investors require a higher risk premium on subordinated bonds than the one implicit in the agency ratings. Quite surprisingly, AMOUNT is not statistically significant. This result is consistent with previous empirical evidence[29] and could be attributed to two main factors: (i) the liquidity of the eurobonds' secondary

[26] Note that such averages were computed based on the numeric scale reported in Table 2, where the distance between two adjacent grades is supposed to be constant (that is, the difference between AAA and AA+ is supposed to be equivalent to that between a BBB− and BB+). This does not apply to our regression results, where each rating bucket is represented by means of a separate dummy.

[27] F-tests are: 281.6 (ISSBUC02 vs. ISSBUC03), 227.6 (ISSBUC03 vs. ISSBUC04), 142.8 (ISSBUC04 vs. ISSBUC05).

[28] As far as MATU is concerned, we tried two different specifications. The first one was based on Fons (1994), where it is shown that, although spreads increase with maturity for investment-grade bonds, the opposite is true for speculative issues. Hence, we tried to use estimate the effect of the "maturity" variable separately for junk bonds, by means of a multiplicative dummy. However, although a difference emerges between the two slopes, none of them is negative (this could be explained by the fact that Fons' regressions are univariate models, where maturity fails to be significant for most rating classes and the R-square never reaches 10%; our regressions, instead, use maturity as just one of the many drivers of bond spreads. In addition to that, our models are based on primary market spreads as a dependent variable, while Fons draws on secondary market data). The second variation involved an attempt to include maturity not only as a linear factor, but also as a quadratic and cubic term, in order to provide our model with more flexibility in fitting the spread/maturity relationship. Although a quadratic or cubic term works well when used *instead* of the linear one, when all three terms are jointly used, none of them appears significant, due to collinearity issues. A joint F-test (9.37, p-value of less than 0.00) leads to reject the hypothesis that they are all jointly zero; however, the hypothesis that the quadratic and cubic term can be excluded from the model cannot easily be rejected (the F-test taking a value of 0.56, with a p-value of more than 57%).

[29] Analysing yield differences between corporate bonds and medium-term notes (MTNs), Crabbe and Turner (1995) find no relationship between size and yields of MTNs that have the same issuance date, the same maturity and the same

Table 7
Linear regressions of SPREAD

Variable		Quarterly dummies, full (1)	BBB spread, full (2)	BBB spread, reduced (3)	1991–1998 issues (4a)	1999–2003 issues (4b)	Banks (separate dummies) (5a)	Corporate (separate dummies) (5b)	Banks (separate models) (6a)	Corporate (separate model) (6b)	Moody's only (7a)	S&P's only (7b)
Constant		−253.54***	−178.91***	−181.58***	−72.45***	−257.65***	−173.28***	−173.85***	−82.07***	−272.1***	−138.34***	−185.08***
		(17.51)	(10.34)	(9.65)	(9.68)	(10.68)	(7.39)	(7.57)	(7.76)	(13.53)	(9.68)	(8.25)
Ratings	ISSBUC02	21.67***	29.47***	29.72***	24.94***	20.71***	27.92***	30.34***	28.78***	25.12***	34.43***	28.75***
		(1.38)	(1.40)	(1.37)	(2.37)	(2.05)	(2.62)	(2.31)	(2.11)	(2.67)	(2.38)	(1.86)
	ISSBUC03	56.73***	67.15***	66.57***	49.20***	56.19***	78.56***	64.15***	80.22***	54.74***	76.37***	65.51***
		(2.38)	(2.30)	(2.23)	(3.53)	(2.50)	(4.41)	(2.53)	(3.73)	(2.96)	(3.72)	(2.32)
	ISSBUC04	154.04***	172.46***	172.14***	227.23***	122.15***	222.65***	163.90***	268.22***	138.03***	228.61***	160.38***
		(6.85)	(7.08)	(7.02)	(5.16)	(4.53)	(8.73)	(4.12)	(6.93)	(4.92)	(6.91)	(4.00)
	ISSBUC05	282.44***	328.70***	328.71***	301.24***	280.78***	308.63***	338.92***	359.95***	283.41***	348.58***	342.60***
		(10.67)	(10.03)	(10.01)	(4.89)	(6.44)	(6.54)	(4.99)	(5.43)	(6.35)	(5.49)	(5.00)
Bond Features	SUBO	4.84*	3.05		4.86	1.94		3.50	15.49***	−0.98	10.54***	0.86
		(2.54)	(3.10)		(3.62)	(3.56)		(2.98)	(2.83)	(6.95)	(4.02)	(3.22)
	MATU	0.04**	0.08***	0.08***	0.06***	0.02		0.08***	0.13***	0.02	0.17***	0.05***
		(0.02)	(0.02)	(0.01)	(0.02)	(0.02)		(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
	BANK	0.71	1.74		−1.88	3.52*					−0.01	2.77*
		(1.32)	(1.48)		(1.92)	(1.85)					(2.08)	(1.63)
	AMOUNT	−0.69	3.09***	3.57***	−5.33***	1.48		2.67***	0.63	6.14***	1.06	2.45**
		(0.95)	(1.04)	(0.93)	(1.42)	(1.13)		(0.99)	(1.07)	(1.59)	(1.29)	(1.05)
	COUPON	29.41***	19.88***	19.88***	11.28***	38.16***		19.69	9.59***	29.90***	14.40***	22.15***
		(1.66)	(0.93)	(0.93)	(0.56)	(0.81)		(0.50)	(0.53)	(0.82)	(0.62)	(0.55)
	REG	20.43***	27.43***	26.82***	23.58***	24.37***		26.64***	13.19***	34.97***	22.12***	26.46***
		(2.65)	(2.98)	(2.94)	(3.03)	(2.85)		(2.32)	(2.66)	(3.62)	(3.39)	(2.47)
	MANAGERS	0.11	−0.85***	−0.85***	−0.54***	−0.12		−0.84***	−0.52***	−1.31***	−0.65***	−0.94***
		(0.09)	(0.09)	(0.09)	(0.11)	(0.19)		(0.10)	(0.09)	(0.21)	(0.12)	(0.12)
	FEES	8.15***	5.84***	5.68***	5.80***	10.30***		5.29***	−0.67	10.11***	4.66***	4.00***
		(1.28)	(1.43)	(1.42)	(1.25)	(1.53)		(1.10)	(1.17)	(1.82)	(1.35)	(1.18)
	PRIVATE	−4.68	−4.85		6.92	7.57		−5.05	−20.00*	−4.34	−7.66	−7.92
		(6.25)	(7.72)		(5.20)	(8.16)		(5.08)	(11.42)	(6.09)	(7.89)	(5.23)
	FIXED	1.08	−2.62		−6.75***	−0.54		−3.00*	−3.56*	−2.55	−0.47	−4.81***
		(1.53)	(1.73)		(2.15)	(1.88)		(1.62)	(1.86)	(2.47)	(2.14)	(1.72)

(*continued on next page*)

Table 7 (*continued*)

Variable		Quarterly dummies, full (1)	BBB spread, full (2)	BBB spread, reduced (3)	1991–1998 issues (4a)	1999–2003 issues (4b)	Banks (separate dummies) (5a)	Corporate (separate dummies) (5b)	Banks (separate models) (6a)	Corporate (separate model) (6b)	Moody's only (7a)	S&P's only (7b)
BBB_SP		–	28.50***	28.32***	21.68***	26.71***		28.21***	20.35***	35.95***	25.03***	29.45***
		–	(1.22)	(1.21)	(1.66)	(1.19)		(0.96)	(1.06)	(1.50)	(1.30)	(1.02)
	CAN	43.28***	25.28***	25.15***	24.80***	36.15***		25.72***	16.93***	30.54***	19.62***	29.09***
		(3.89)	(3.46)	(3.45)	(3.69)	(6.81)		(3.64)	(3.28)	(8.98)	(4.42)	(4.18)
	DEM	12.15***	2.85	2.92	11.34***	−5.95		3.13	−0.18	−8.98	−3.35	3.92
		(3.50)	(3.40)	(3.40)	(3.92)	(8.03)		(4.08)	(3.56)	(10.29)	(4.90)	(4.57)
	DFL	52.62***	14.57***	14.17***	17.80***			14.91***	0.07	35.11***	4.95	18.91***
		(4.78)	(4.02)	(3.98)	(4.76)			(5.07)	(4.34)	(13.47)	(6.17)	(6.00)
Currency	EUR	59.25***	25.29***	25.22***	26.68***	81.94*		25.40***	7.84**	44.09***	13.32**	30.78***
		(5.10)	(4.23)	(4.22)	(4.21)	(46.60)		(4.41)	(3.92)	(10.79)	(5.40)	(5.14)
	FFR	37.02***	42.77***	42.88***	33.61***	43.75***		42.62***	13.98***	63.89***	28.45***	46.70***
		(4.81)	(4.37)	(4.32)	(6.46)	(6.76)		(3.98)	(3.69)	(9.26)	(4.84)	(4.48)
	STG	34.67***	−0.53	−1.27	11.05***			−0.37	−9.93**	5.35	−13.48***	2.94
		(4.37)	(3.76)	(3.72)	(4.20)			(4.24)	(3.95)	(9.69)	(5.13)	(4.83)
	USD	30.12***	23.73***	23.59***	13.41***	44.03***		23.81***	7.46**	35.55***	13.40***	28.60***
		(4.07)	(4.03)	(4.05)	(4.33)	(7.16)		(4.09)	(3.80)	(9.52)	(4.90)	(4.66)
	YEN	89.52***	54.85***	54.20***	58.04***	148.08***		54.41***	4.17	108.91***	41.27***	71.05***
		(10.06)	(7.26)	(7.24)	(11.55)	(8.71)		(5.80)	(5.88)	(11.61)	(8.85)	(6.43)
	CAN	−20.68***	−23.79***	−24.21***	−14.80***	−17.66***		−22.98***	7.97*	−47.10***	−0.92	−29.74***
		(3.92)	(4.86)	(4.87)	(3.88)	(5.62)		(3.67)	(4.30)	(5.45)	(4.91)	(3.86)
	FRA	−18.24***	−22.33***	−22.73***	−13.72***	−22.50***		−21.70***	−2.96	−33.04***	−7.39**	−23.62***
		(2.11)	(2.32)	(2.31)	(3.18)	(3.39)		(2.68)	(2.93)	(4.26)	(3.43)	(2.88)
	GER	−13.81***	−10.15***	−9.89***	−7.78***	−14.26***		−9.49***	−1.50	−3.86	2.85	−14.43***
		(2.12)	(2.39)	(2.34)	(2.78)	(2.98)		(2.38)	(2.26)	(5.34)	(2.81)	(2.63)
Country	JAP	−33.16***	−44.66***	−44.94***	−12.78***	−53.73***		−44.38***	−20.60***	−51.23***	−11.63**	−50.18***
		(3.33)	(3.80)	(3.79)	(4.73)	(4.95)		(3.88)	(4.61)	(5.94)	(5.64)	(4.18)
	NL	−17.23***	−10.85***	−10.68***	−6.53*	−19.76***		−10.32***	1.49	−24.50***	−0.17	−13.27***
		(2.22)	(2.40)	(2.35)	(3.56)	(3.44)		(2.87)	(2.71)	(6.21)	(3.32)	(3.06)
	UK	−11.67***	−14.02***	−14.07***	−0.08	−15.56***		−13.73***	4.66	−30.89***	−4.63	−18.70***
		(2.30)	(2.65)	(2.66)	(3.08)	(3.10)		(2.52)	(3.00)	(3.79)	(3.19)	(2.69)
	USA	−15.28***	−8.50***	−8.50***	−6.69**	−19.29***		−7.83***	17.45***	−24.16***	6.36**	−13.08***
		(2.08)	(2.44)	(2.42)	(2.75)	(2.67)		(2.17)	(2.46)	(3.35)	(2.88)	(2.31)

(*continued on next page*)

Table 7 (*continued*)

Variable	Quarterly dummies, full (1)	BBB spread, full (2)	BBB spread, reduced (3)	1991–1998 issues (4a)	1999–2003 issues (4b)	Banks (separate dummies) (5a)	Corporate (separate dummies) (5b)	Banks (separate models) (6a)	Corporate (separate model) (6b)	Moody's only (7a)	S&P's only (7b)
N	7232	7232	7232	3524	3708		7232	3698	3534	3714	6218
R-squared	0.839	0.790	0.790	0.808	0.864		0.793	0.778	0.813	0.797	0.793
Adj. R-squared	0.837	0.790	0.790	0.806	0.863		0.792	0.776	0.811	0.796	0.792
F-statistic	464.24***	905.57***	1044.19***	488.9***	834.4***		808.5***	443.4***	524.4***	483.7***	789.7***
F-rating	1285.12***	1598.80***	1615.36***	1112.5***	529.6***	691.2***	1285.5***	1293.7***	542.4***	1062.6***	1300.1***
F-quarter	63.83***										

Note. Reported are regression coefficients and standard errors (in parenthesis). F-rating (-quarter, -country) denotes the F-statistic for the null hypothesis that the coefficients of all rating (quarter, country) dummies jointly equal zero.

* Statistical significance at the 10% level.

** Idem, 5%.

*** Idem, 1%.

market is not affected by the size of the issues, (ii) eurobond investors tend to hold these securities to maturity and are therefore indifferent to their secondary market liquidity.

COUPON and REG have a positive, significant coefficient as expected,[30] indicating that investors require a higher return on higher-coupon and/or registered issues due to their relatively worst tax treatment.[31] On the other hand, PRIVATE and FIXED do not appear statistically meaningful.

The BANK dummy lacks statistical significance. This means that, while eurobonds issued by banks do have a better average rating than those issued by non-financial companies, no significant difference emerges in the spread/rating relationship between banks and non-financial firms. This has some clear policy implications for the Basel Committee's "standardised approach" (in which banks actually enjoy a more favourable weighting scheme), and we shall return to this result in our final remarks.

All reported currency dummies have significant positive coefficients, indicating that those currencies command higher spreads than the remaining ones. This result flows from the higher credit standing and liquidity of their Treasury issues,[32] because spreads are computed by subtracting such Treasury yields from eurobond yields.

Country dummies also look significant: their joint F-statistic (not reported in the table) is 22.68, with a p-value of less than 1%. This could be explained by national macroeconomic conditions, as well as by national bankruptcy codes affecting investors' expectations on recovery rates in the event of default.

Finally, the joint F-statistic for quarterly dummies (63.8) is highly significant, suggesting that market conditions do affect Eurobond spreads. However, while quarter dummies help us achieve a better fit of *the past behaviour* of the eurobond market, they become useless for simulation purposes. In other words, when one wants to use the model in Table 7 to infer what spreads the market would expect from differently-rated bonds, it is impossible to specify a value for the dummies associated with *future quarters*.

To address this issue, we scrutinised our set of quarterly dummies more carefully, and found out that they were strongly correlated (63.8%) with the average level of BBB-rated, US dollar-denominated corporate bond spreads.[33] We therefore substituted all quarterly dummies with just one variable, BBB_SP, expressing the value of the corporate bond spread in the week when each eurobond issue in our sample was completed. This makes our model (see column (2) in Table 7) much more parsimonious and transparent (it can now be used also to run simulations, provided that a value the average BBB-spread is specified), while reducing the adjusted R-square only

issuer. Furthermore, they find that bonds and MTNs have statistically equivalent yields. This contrasts with the idea that large issues have larger liquidity and suggests that large and small securities issued by the same borrower are close substitutes.

30 This empirical result is consistent with Elton et al. (2000).

31 Based on the suggestion of an anonymous referee, we also tested an alternative specification of our model including a set of multiplicative dummies representing the interaction between COUPON and the country dummies; by doing so, the impact of the COUPON variable was estimated separately for each country. Although most of the new dummies proved significant, they did not significantly affect the overall explanatory power of the model and the coefficients associated with all other non-country variables remain basically unchanged.

32 French or German Treasuries are used to compute Euro denominated bond spreads, according to which of the two closest government bonds has the closer maturity to the one of the eurobond issue.

33 Spreads were computed as the difference between the seasoned BBB (Baa) corporate bond yields published by Moody's and the 5-year Treasury constant-maturity rate released by the Board of Governors of the Federal Reserve System.

slightly. BBB_SP has a positive coefficient, implying that each individual issue in our sample is directly affected by the overall "market mood" embedded in the BBB corporate bond spread.

The results for this alternative specification (Table 7, column (2)) are very similar to our base model (note that the SUBO dummy, which used to be only 10%-significant, now looks even weaker). The model was further refined in column (3), where all variables that were not statistically significant were sequentially removed (and the regression's R-square remained unchanged). This "reduced" model will be used as a basis for the simulations reported in Section 5 of this paper.

4.2. Robustness checks

Starting from the complete model based on BBB-spreads (column (2)), several robustness checks were carried out.

Separate sub-periods Separate regressions were run for bonds issued between 1991 and 1998 (3524 observations) and bonds issued between 1999 and 2003 (3708 observations),[34] to test for any temporal evolution in the relevant factors. Results are reported in columns (4a) and (4b). The adjusted R^2 increased from 0.81 in the first sub-period to 0.86 in the second one, indicating that the independent variables improved their explanatory power over the Nineties. Although some minor differences emerge, between the two sub-samples, regarding a few control variables, all rating dummies are statistically significant and the spread/rating statistical relationship, which is the focus of our analysis, remains strictly monotonic for the two sub-samples.

Banks vs. corporates The second check regards the relevance of the issuer type ("BANK") dummy. This simple dummy variable may not adequately reflect the gap between financial institutions and other firms if investors evaluate these two types of issuers differently. Therefore, two additional checks were performed: first, the dummy coefficients associated with the various rating buckets were estimated separately for banks and non-banks, to see whether a different steepness of the spread/rating relationship (rather than a difference in the average level) is found; second, separate regressions were run for eurobonds issued by banks and for those issued by non-financial firms. Results are reported in columns (5) and (6) of Table 7. As concerns column (5) (same model, different rating-bucket dummies), only some of the bank dummies are significantly different from their non-bank counterparts[35]; what is more, the difference between bank and non-bank spreads does not behave monotonically as rating buckets worsen. As concerns column (6) (different models), all rating dummies are statistically significant, explain a high portion of the spread and have monotonically increasing coefficients for both sub-samples.[36]

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[34] Separating recession years from expansion ones is difficult because issuers from different countries have different economic cycles. A simpler separation criterion, based on the number of issues, has therefore been adopted.

[35] Pairwise t-tests between bank and non-bank dummies for the same bucket have shown that the null hypothesis that the two be identical cannot be rejected without an error margin (p-value) of 48.3% for bucket 2, 0.3% for bucket 3, 0% for buckets 4 and 5; moreover, the hypothesis that the two intercepts for banks and non-banks (which represent the case of borrowers belonging to bucket 1) are identical cannot be rejected without a 76.6% error.

[36] Some differences exist between the two sub-samples when looking at the control variables. While AMOUNT and FEES appear statistically significant for the non-bank subsample, they seemingly have no impact on bank spreads; the opposite is true for PRIVATE and MATU. Finally, SUBO is strongly significant, with a positive coefficient, only for banks. As mentioned before, rating agencies tend to downgrade subordinated issues by one notch: seemingly, investors view this practice as fair (given the expected recovery rates) only for corporate bonds: as concerns banks, subscribers are relatively more pessimistic than rating agencies. This result can be explained in two alternative ways. First, investors find

These results suggest that no clear, monotonic difference emerges between the rating/spread relationship of banks and non-bank firms. A common scale of risk-weights per rating bucket should therefore be adopted for both banks and non-financial firms, while a separate treatment could be reasonable only for unrated exposures (as in the 1988 Accord).

Moody's vs. S&P's Separate regressions using Moody's' ratings only (3714 observations) and S&P's ratings only (6218 observations) were estimated, to check for biases due to use of "average" ratings (using the average value of ratings coming from two different sources could produce misleading results if the agencies adopt significantly different criteria). Results are reported in columns (7) of Table 7: rating dummies are statistically significant (with the expected sign) for both sub-samples; besides, the spread/rating statistical relationship is very similar for the two scales.[37]

Issuer versus issue ratings In an attempt to keep our sample as wide as possible, we based our analysis on issue ratings (which are more easily found for our data source); however, issuer ratings also play an important role within the Basel II standard approach. Accordingly, for the available data (which are less than 50% of the original sample) our basic model was estimated again using a set of buckets based on issuer rating. The results (not reported to save space) show that the spread-rating relationship remains strong and monotonic; the SUBO dummy becomes statistically significant, and has a positive coefficient; this represents an expected finding because facilities' characteristics, such as subordination, are not embedded into issuer ratings.

National models A robustness check of the model in column (2) has been performed by running separate regressions for each G5 country. The results, not reported to save space, showed that the spread/rating relationship is similar (and always statistically significant) for bonds issued by corporations of different countries. In addition to that, most rating dummy coefficients show a monotonic pattern, indicating that spreads increase when ratings worsen.

Industry dummies The BANK dummy had to be dropped from the models in columns (1) and (2) because of its lack of statistical significance. However, one might object that it would turn out to be relevant when considered *inside a whole set of industry dummies*. This was done by including into model (2) a set of 23 dummy variables. The results (not reported) were the following: (1) 7 out of the 23 industry dummies turn out to be significant at the 5% level; (2) a joint LM test for the whole set of dummies leads to a F-statistic of 11.8, with a p-value close to zero; (3) the coefficients and statistical significance of the non-industry regressors remain approximately unchanged, as well as the regression's corrected R-square (79.6%); (4) the coefficient associated with the banking sector's dummy (7.07) continues not to be statistically different from zero at the 5% significance level.

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it more difficult to evaluate the expected recovery rate in the case of bank-issued subordinated bonds because of a lower degree of disclosure and of the financial nature of most banks' assets: the higher degree of uncertainty gets then translated into a higher required risk premium. Second, given the interest rate sensitivity of most banks' assets, it is more likely for banks than for non-financial firms that the same systematic factors determining insolvency also cause a decrease in the recovery rate. In such a case, the banks' default probability would be negatively correlated with the recovery, leading to an increase in expected losses. This adverse phenomenon would obviously be particularly exacerbated for subordinated bonds.

[37] Note that, to assess the effect of split ratings on our results, we also repeated our regression analysis after removing all split ratings (937 observations). The results (not reported) looked basically unchanged.

Granularity of the rating scale Throughout our estimates, we used only five dummy variables to summarise the rating spectrum shown by Table 2; this helped us make our results more robust and more consistent with the Basel Accord, where individual rating classes are grouped into larger "buckets". However, one might wonder whether our estimates would be affected by an increase in the "granularity" of the rating scale used: we therefore substituted our set of "compact" rating bucket-dummies with 21 rating dummies, describing all individual grades reported in Table 2. The results of model (2) did not show any significant change[38]: most control variables remained virtually unchanged, in terms of coefficients and statistical significance, while the R-square increases only marginally, from 79 to 81.4%.

Spread/rating relationship under tight market conditions One might expect that tight market conditions exert different effects on different rating classes, implying that the spread/rating relationship becomes steeper when market conditions are more strained. To check this, for each rating bucket we defined a new dummy variable which takes a value of one if BBB_SP is above its long-term average of 2.6%. In this enhanced model (not reported to save room), such dummies are statistically significant, but their coefficients are not monotonically increasing when moving towards worse rating buckets; we therefore preferred to stick to our basic model, where market conditions are simply accounted for by the BBB_SP variable.

5. Implications for the adequacy of the Basel Committee's proposed risk weights

5.1. Simulated spreads

Once the credit spreads required by the eurobond market have been decomposed into their main drivers, we can use our reduced model (Table 7, column (2)) to simulate the spreads paid by a "standard" eurobond. This "simulated" bond has the following characteristics:

– it is issued by a group of ten managers (including co-managers, book-runners, etc.) for a gross fee of 100 basis points (these values are close to the sample averages shown in Table 3), is denominated in US dollars[39] and pays a 6% coupon rate;
– it has a 8-year maturity, and is issued at a time when BBB-rated bonds pay a spread of 2.6% over T-bonds (again, this mimics our sample averages; note, however that sensitivity analyses will be performed on this second array of parameters);
– like most issues in our sample, it is publicly issued and unregistered.

Table 8 shows the simulated spreads required on different "rating buckets". The standard eurobond described above is compared to some alternative cases, considering:

– shorter (5 years) and longer (10 years) maturities;
– a change in the currency in which the bond is denominated (euro vs. US dollar);
– different scenarios for the spread paid by BBB-rated bonds (ranging from 1.8 to 3.4%[40]).

[38] To save room, the results are not reported in the paper, although they are available from the authors upon request.
[39] As the coefficients of the two currency dummies (Table 7) suggest, euro-denominated bonds would lead to very similar results.
[40] This range amounts approximately to twice the variable's standard deviation.

Table 8
Estimated spreads per rating bucket—basis points

	AAA to AA−/ Aaa to Aa3	A+− to A−/ A1 to A3	BBB+ to BBB−/ Baa1 to Baa3	BB+ to BB−/ Ba1 to Ba3	Below BB−/Ba3
Base case	52.3	82.0	118.9	224.5	381.0
5-year maturity	49.4	79.1	116.0	221.5	378.1
10-year maturity	54.3	84.0	120.8	226.4	383.0
Euro-denominated	54.0	83.7	120.5	226.1	382.7
BBB-spread at 1.8%	29.9	59.6	96.5	202.0	358.6
BBB-spread at 3.4%	75.2	104.9	141.8	247.3	403.9

As can bee seen, spreads tend to remain mostly unchanged regardless of the working hypotheses used in our simulations. While maturity and currency exert a limited effect, changes in BBB-spreads induce a parallel shift in all values.

5.2. Capital requirements: theoretical framework

We now estimate the "optimal" bank capital associated with the "typical" spreads derived above. To do this, we follow a two-step procedure. In the first step, the typical spread of a bond falling into a given rating bucket is turned into a measure of the bond's risk based on Merton (1974); in the second step, two alternative ways are proposed, to use this risk measure to infer the optimal capital for a bank investing in this bond.

Step one uses Merton's model relating the equilibrium spread on a risky bond (s) with maturity T to the borrower's leverage (d) and asset volatility (σ_V):

$$s = -\frac{1}{T}\ln\left[N(x_2) + \frac{1}{d}\cdot N(-x_1)\right] \tag{2}$$

where, as in the Black–Scholes model:

$$x_1 = \frac{-\ln d + \frac{1}{2}\sigma_V^2 T}{\sigma_V\sqrt{T}}, \tag{2a}$$

$$x_2 = x_1 - \sigma_V\sqrt{T} \tag{2b}$$

and

$$d \equiv \frac{Be^{-rT}}{V} \tag{3}$$

where r denotes the risk-free rate (continuously compounded) for maturity T, V denotes the current value of the borrower's assets, and B denotes the value at maturity of the bond (which is thought to represent all the borrower's liabilities).

Based on this equilibrium relationship, and given the value of d for the borrower, one can compute the value for σ_V that is consistent with the "typical" spread for the ith rating bucket (s_i):

$$\sigma_V \;\Big|\; \frac{1}{T}\ln\left\{N\big[x_2(\sigma_V, d)\big] - \frac{1}{d}\cdot N\big[-x_1(\sigma_V, d)\big]\right\} = s_i. \tag{4}$$

Once σ_V is known, the volatility of the value of the bond (σ_i) can easily be derived based on the following formula (Merton, 1974):

$$\sigma_i = \sigma_V \frac{N(-x_1)}{N(x_2) + \frac{1}{d}N(-x_1)}. \tag{5}$$

In step 2, we consider a bank with a portfolio of assets (A) consisting entirely of loans/bonds like the one above. This means that $\sigma_A = \sigma_i$ also represents the bank's asset volatility. Optimal capital for this bank can now be estimated following two alternative lines of reasoning.

First, we assume that the optimal amount of capital is set according to a VaR (Value at Risk) framework. According to this perspective, and consistent with the IRB approach in the New Basel Accord, capital must prevent the bank from bankruptcy in a large fraction (say, 99.9%) of future scenarios. That is, we set the optimal capital ratio k^* so that the probability that at date T the bank's assets, A_T, will fall below the face value of its debt, D, is limited to p^*. Setting the risk horizon of the model (hence, the maturity of D) at one year, we compute:

$$k* \mid p(A_T < D) = N\left(-\frac{\ln[A/D] + \left(r_A - \frac{1}{2}\sigma_A^2\right)}{\sigma_A}\right) = p^* \tag{6}$$

where by definition[41]

$$k^* \equiv 1 - \frac{De^{-r}}{A} \tag{7}$$

and $r_A \equiv r + s_i - PD_i \cdot LGD_i$ denotes the expected rate of return on the bank's assets and is computed by subtracting from the contractual rate of return of the bond the expected loss per dollar (which in turn is given by the product between the borrower's PD and the bond's expected severity rate, LGD).

Alternatively, a "fair deposit insurance" capital standard can be defined. That is, the optimal capital requirement k^{**} can be set in a way that makes the insurance premium per dollar of deposits (π) fair. As shown by Merton (1977) and Flannery (1991), π represents the cost of a put written on the bank's assets (A) with strike equal to D. For a deposit guarantee with a one-year maturity, such a cost can be made fair by imposing that[42]:

$$\pi = N(h_2) - (1 - k^{**}) \cdot N(h_1) \tag{8}$$

where

$$h_1 = \frac{\ln[De^{-r}/A] - \frac{1}{2}\sigma_A^2}{\sigma_A}, \tag{8a}$$

$$h_2 = h_1 + \sigma_A. \tag{8b}$$

Summing up, this second approach (with deposit insurance) requires us to specify a value for π and to estimate the capital level which makes this fixed premium a fair one:

$$k^{**} \mid \pi = N(h_2) - (1 - k^{**}) \cdot N(h_1). \tag{9}$$

5.3. Capital requirements: empirical results

As mentioned above, step one of our procedure requires to set a value for the borrower's leverage (d) in order to be able to extract σ_V and σ_i from the "typical" spread s_i. This can be done by reference to the "median" leverage values for firms falling in different rating buckets,

[41] Note that, to avoid unnecessary complications, we are supposing that the bank's debt is perceived by depositors as virtually risk-free. If one were to add a spread to account for the risky nature of bank deposits when no insurance scheme is available, such a spread would indeed be very small and would not alter the empirical results of our model.

[42] See Eq. [6] in Merton (1977).

Table 9
Estimated capital requirements for rating buckets

Rating	Estimated capital requirements									
	Median leverage (S&P)	Typical spread in % (see Table 8)	Estimated σ_i	Typical r_A in % ($r + s_i$ - $PD_i \cdot LGD_i$)	Typical expected loss	VaR-based (k^*)	Insurance (k^{**}), $\pi = 0.1$ bp	Insurance (k^{**}), $\pi = 1$ bp	Insurance (k^{**}), $\pi = 10$ bp	Insurance premium consistent with k^* (see 6)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AAA, AA	20.0%	0.52	0.56%	5.49	0.03	1.24%	1.80%	1.34%	0.42%	0.015%
A	39.8%	0.82	1.54%	5.75	0.07	3.98%	5.35%	4.28%	2.74%	0.017%
BBB	45.6%	1.19	2.36%	6.04	0.15	6.15%	8.34%	6.81%	4.71%	0.023%
BB	57.2%	2.25	4.80%	6.63	0.62	12.54%	16.97%	14.32%	10.79%	0.035%
B	74.2%	3.81	9.06%	7.37	1.44	23.02%	30.63%	26.60%	21.28%	0.051%

as published by the main rating agencies. Column (1) of Table 9 shows the reference values disclosed by Standard & Poor's (Standard and Poor's, 2005).

Based on those values and the "typical spreads" s_i (see Table 8, base case, reported also in Table 9, column (2)), we use Eqs. (4) and (5) to derive volatility estimates (σ_i) for bonds falling into different rating classes (Table 9, column (3)). Note that the values for r and T are the same used in Table 8 to generate typical spreads ($r = 5\%$; $T = 8$ years).

We now move to step two, starting with the case where capital standards are set based on a VaR framework. If the bank's default probability p is limited to 0.1% (as in the internal ratings approach proposed in the New Basel Capital Accord), then Eq. (6) leads to the capital requirements (k^*) shown in Table 9, column (6).

Note that, in Eq. (6), the expected rate of return r_A on the assets of a bank investing in class i bonds (Table 9, column (4)) has been computed as $r + s_i - PD_i \cdot LGD_i$. The expected loss term ($PD_i \cdot LGD_i$) is in turn based on a constant 50% LGD (different values would not change our results significantly), while the one-year PDs associated with different rating buckets are taken from Table 10 (based on estimates by Standard and Poor's[43]). Here, for a eight-year bond, issued by a class i borrower, the average one-year PD_i is computed as $1 - (1 - PD_{8,i})^{1/8}$, where $PD_{8,i}$ is the cumulative 8-year default probability for class i.

To implement the alternative (fair insurance) approach (Eq. (9)), we have to specify a value for the deposit insurance premium π. Such premiums vary greatly across countries and over time; moreover, as shown in Pennacchi (1987), the theoretical values for those premiums can significantly differ from the actual ones. Hence, instead of setting a unique, arbitrary value, we prefer to explore alternative solutions, using values for π of 0.1, 1, 10 basis points.[44] Results for k^{**} based on these three values are reported in columns (7)–(9) of Table 9.

Three main results emerge from the table:

(1) The optimal capital levels increase as ratings worsen, and such an increase is steeper than the one proposed by the Basel standardised approach;

[43] Our last rating bucket is based on the default rates for the CCC+/Caa1 rating class because no data is available from S&P's for other rating classes in the bucket.

[44] Note that 0.1 bp approximately corresponds to the average annual assessment rate charged in 2005 by the US FDIC. However, such a value is very low when compared to other historical values; moreover, the assessment rate for US banks can vary within a large (0 to 27 bp) bracket.

Table 10
Estimated PDs for 8-year bonds (source: S&P Creditstats)

	Cumulative %	Average %
Rating classes		
AAA	0.4	0.0
AA+	0.5	0.0
AA	0.4	0.1
AA−	1.0	0.1
A+	0.9	0.1
A	0.8	0.1
A−	1.5	0.2
BBB+	2.2	0.2
BBB	2.3	0.3
BBB−	5.5	0.6
BB+	7.9	0.9
BB	10.7	1.0
BB−	18.6	1.9
B+	22.8	2.3
B	29.8	3.1
B−	33.7	3.2
CCC	44.8	4.9
Rating buckets		
AAA to AA−/ Aaa to Aa3	0.5	0.1
A+− to A−/ A1 to A3	1.0	0.1
BBB+ to BBB−/ Baa1 to Baa3	2.9	0.3
BB+ to BB−/ Ba1 to Ba3	12.0	1.2
Below BB−/Ba3	28.2	2.9

Source: Standard and Poor's (2001).

(2) A remarkable degree of consistency appears across the two approaches (VaR vs. fair deposit insurance), and capital ratios—as expected—tend to be lower when a more costly (hence, effective) insurance scheme is available;
(3) The values for capital when a VaR-based approach is used are lower than insurance-based ones if π is 0.1 or 1 basis points but are higher if π is 10 basis points. The implication is that capital set at a probability of default equal to 0.1% would require a fair insurance premium of between 1 and 10 basis points. Actually, those insurance premiums can be computed using Eq. (9) and are shown in the last column of Table 9: as expected, they turn out to be between 1 and 10 basis points (more precisely, in a range between 1.5 and 5.1).

5.4. *Confidence intervals*

As noted above, the risk-weighing curves reported in Table 10 look steeper than the one adopted by the Basel Committee. However, they are based on the point estimates of the coefficients reported in Table 7. One therefore must check whether this greater steepness survives, once the volatility in coefficient estimates is accounted for.

To do so, we "shocked" the estimates of the rating dummies' coefficients reported in Table 7 (column (3)), by adding and subtracting twice their standard errors. For example, the coefficient associated with bucket 1 (i.e. the constant term: −181.58) was both increased and decreased by

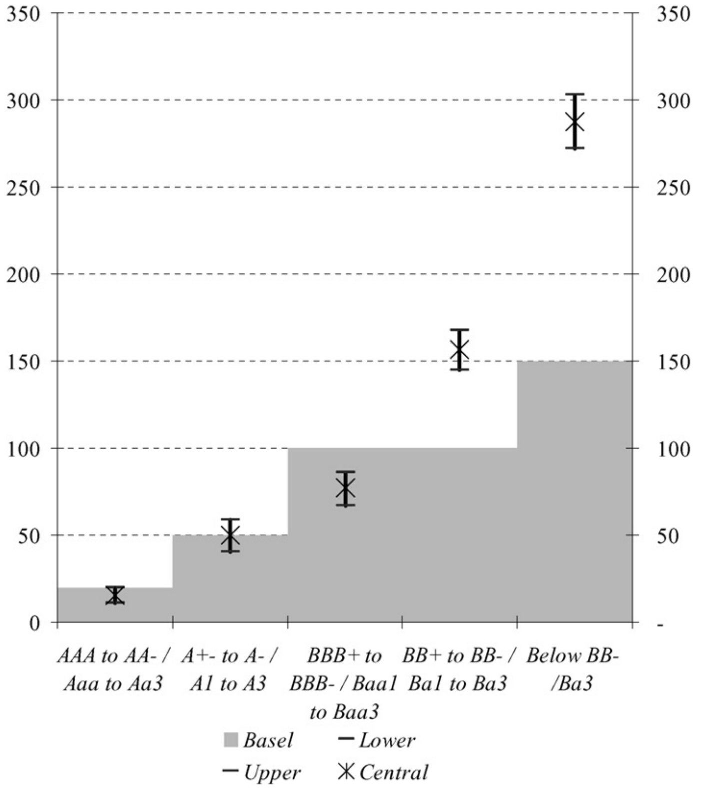

Fig. 1. Confidence intervals for our rating buckets risk weights.

twice 9.65, getting two values of −162.28 and −200.88 respectively. The same was done for the other rating buckets.[45]

Those two sets of "shocked" values were then used to generate two alternative sets of risk weights ("upper" and "lower"), as shown in Fig. 1. To keep things simple, we limited ourselves to the former approach used in Table 9 (that is, the VaR-based approach); hence the "central" values in Fig. 1 coincide with column (6) in Table 9; however, results would not change dramatically if one were to use columns (7)–(9) as a starting point. The grey steps on the background show the values adopted by the Basel Committee. The figure shows that:

– the risk-weights associated to adjacent buckets remain different from each other even when one considers confidence intervals instead of point estimates;
– in the case of the best two rating buckets, our "confidence brackets" overlap with the values (20% and 50%, respectively) indicated by the Basel Committee, suggesting that the difference between our estimates and the regulatory weights may not be statistically significant;

[45] For each bucket from 2 to 5, both the constant term and the rating bucket's coefficient were used; accordingly, the standard errors used to shock the central estimate were computed based on the (heteroscedasticity-adjusted) variances and covariance of the constant term and the rating bucket's coefficient.

– however, this is not true for the last three buckets, where our confidence brackets do not cross the edge of the grey areas representing Basel's choices;
– as concerns the 100% regulatory weight, there is evidence that it overstates the riskiness of BBB-rated exposures, while seriously understating the risk of BB-rated issues, for which a 150% risk weight might be more appropriate;
– risk looks seriously understated also in the case of exposures below BB: although our coefficient estimates look comparatively more volatile than for low-risk grades, they indicate that a risk weight of at least 250% would be more consistent with market spreads.

6. Conclusions

The Standardised Approach of the New Basel Capital Accord was designed as a deliberately simplified framework, to increase its applicability to a wide array of financial institutions. Its simplicity, though making it less risk-sensitive than the internal ratings-based approaches, is by no means a shortcoming: actually, it represents a huge advantage, ensuring that this approach can be implemented effectively in a broad range of circumstances.

While embracing this simplified framework, this study has examined the ability of the Basel Committee's risk-weights to adequately reflect the risk-rating relationship. Issuance spreads on 7232 eurobonds issued during 1991–2003 have been used in order to estimate the average spread per rating bucket and evaluate the risk-rating relationship. Three main results emerged from the empirical analysis. First, the spread/rating relation is strongly significant, with spreads increasing when ratings worsen. Second, the estimated spreads per rating bucket indicate a steeper risk/rating relation than the one implied in the new risk-weights approved by the Basel Committee. Finally, while eurobonds issued by banks have a better average rating than those issued by non-financial companies, no statistically significant difference emerges in the spread/rating relationship of banks and non-financial firms. This indicates that the distinction between bank and corporate loans has no economic justification once external ratings are accounted for.[46]

Following these empirical findings, three main revisions should be considered in the future to the standardised approach risk-weights. First, no distinction should be present between rated banks and non-financial companies; a more favourable weight for banks should be kept only for unrated entities. Second, the risk-weights per rating bucket should be adjusted in order to reflect the steeper relationship between risk and rating. Third, five rating buckets should be considered rather than the four currently proposed by the Basel Committee.[47] Namely, the third bucket

[46] One might even argue that, for a given rating class, banks tend to show *higher* default frequencies than non-financial corporations, at least in the US This was shown by Ammer and Packer (2000), by means of a probit model based on Moody's data, in which rating and vintage effects are separately accounted for: their results (see Table 4 in the paper) quantify in 2.14% the expected default frequency for banks, as opposed to 1.37% for non-financial corporations. This result was recalled by the Basel Committee itself, in its 2000 survey on rating sources (Basel Committee on Banking Supervision, 2000); however, Cantor and Falkenstein (2001), working on data for speculative-grade issuers, have shown that the gap between banks' and non-banks' historical default rates appears significant only if one assumes that default probabilities stay constant over time. When a more sophisticated framework is adopted (where default probabilities fluctuate over time because of short-term shocks, like the Savings & Loans crisis), no clear proof emerges that banks are to be considered more risky than non-financial firms in the same rating class. However, none of the above-mentioned studies ever hinted that banks should be considered *less* risky, as in the Committee's standardised approach.

[47] Note that the real steepness of the rating-risk relationship might be somewhat understated, as risky issuers may be more likely to issue in good times. As concerns our sample, however, the relative incidence of junk issues seems to be

including rating classes from BBB+ to BB− (from Baa1 to Ba3 in the Moody's' scale) should be split into two different levels.

Such revisions would make the standardised approach much closer to the markets' sentiment, thereby bridging a potentially dangerous gap between the first and the third "pillar" of the new regulatory architecture.

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influenced only marginally by the "tightness" of the market: although the correlation coefficient between the incidence of speculative issues on the total and the BBB_SP variable is slightly negative (−13%), it is not statistically different from zero; besides, the relative importance of junk issues remains unchanged at 7% both before January 2001 (when BBB_SP averages 219 b.p.) and afterwards (as the average BBB spread jumps to an average of 373 bp).

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