

## B WHAT EQUITY, CREDIT AND CREDIT DEFAULT SWAP MARKETS TELL US ABOUT THE RISK PROFILE OF BANKS

*Information from equity and credit market-based indicators of banks is commonly used for financial stability assessment. In this practice, it is often assumed that equity market-based indicators provide information on the markets' assessment of the outlook for, and the risks surrounding, future banking profitability. At the same time, for the credit-based indicators the prior assumption is that these provide information on the credit risk outlook for banks or the likelihood of bank failure. However, such indicators are likely to exhibit some co-movement owing to common drivers, such as the business cycle or interest rate changes. This special feature confirms that this is the case even for bank-specific (or idiosyncratic) equity and credit measures. In order to pin down the nature of the interaction between credit and equity markets and key macroeconomic drivers, a dynamic model is estimated, revealing a large role for a risk aversion driver, and a weaker one for changes in interest rates and oil prices. The analysis also finds that risk measures based on equity lead those stemming from the credit default swap (CDS) market.*

### INTRODUCTION

This special feature examines the information contained in equity and credit market-based indicators of banks which are commonly used for financial stability assessment in order to better understand what is driving them and to assess the complementarities that exist between them.<sup>1</sup> A common approach is to assume that equity market-based indicators reflect the markets' assessment of the outlook for and the risks surrounding the future trajectory of bank profits. For the credit-based indicators the prior assumption often made is that these embody the credit risk outlook for banks or the likelihood of bank failure. However, there are good reasons to believe that such indicators are likely to exhibit some co-movement owing to

common drivers, such as the business cycle or interest rate changes. Institution-specific factors are also likely to play a role in driving co-movement. For instance, a rise in the risk outlook for bank profits, reflected in a rise in the implied volatility of bank equity prices, will, all else being equal, increase the credit risk of banks as well. When this happens, typically a rise is also seen in the spreads on, for instance, subordinated bonds issued by banks. With these considerations in mind, two different aspects of the inter-relationship between a number of equity and credit-based indicators are examined. The first separates the common or systemic component of patterns in each indicator type for euro area large and complex banking groups (LCBGs) from the idiosyncratic components. Here, systemic components are common to all indicators, while the idiosyncratic components are institution-specific. This means, for example, if a bank had a weak business model, irrespective of general market conditions, it would be captured in the idiosyncratic component.

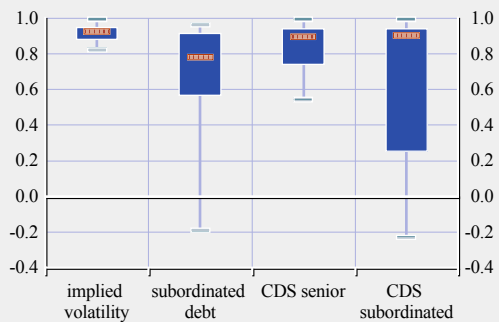
### SEPARATING SYSTEMIC FROM IDIOSYNCRATIC COMPONENTS OF EQUITY AND CREDIT RISK ACROSS LCBGs

Four different market-based measures are considered in this analysis: implied volatility extracted from equity call options,<sup>2</sup> subordinated debt spreads (ten-year horizon, or closest), and five-year credit default swap (CDS) senior and subordinated debt spreads. The measures of credit risk, the spreads on bonds and CDSs, are likely to exhibit differentiated degrees of liquidity, and as

- 1 See L. Norden and M. Weber (2004), "The comovement of credit default swap, bond and stock markets: An empirical analysis", CEPR Discussion Paper No. 4674, who find that the stock market generally leads the CDS market and bond markets and that the CDS market is more responsive to the stock market than the bond market. A. Berndt and A. Ostrovnaya (2008), "Do equity markets favor credit market news over options market news?", American Finance Association, 2008 New Orleans Meeting, also measure the joint contribution of the CDS and options markets to price discovery relative to the stock market.
- 2 This measure is calculated from a weighted average of the volatilities of the three call options closest to the at-the-money strike.

**Chart B.1 Dispersion of bilateral correlations between euro area large and complex banking groups across indicators**

(Apr. 2003 – Oct. 2007; minimum, maximum, interquartile distribution and median)



Sources: Bloomberg, Bondware and ECB calculations.

CDSs are typically more liquid they may reflect the risk of default more closely.<sup>3</sup> Inspection of bank-level data reveals very strong positive correlations for all risk measures across institutions. In particular, pairwise correlations of banks' implied volatility exhibit the highest median of 0.92, while subordinated debt shows the lowest at 0.78 (see Chart B.1). However, it is evident that a few pairs of banks correlate even negatively in the cases of subordinated and CDS subordinated bond markets.

This high degree of co-movement is suggestive of important common driving factors across institutions, motivating a decomposition of the risk measures into idiosyncratic and systemic components.<sup>4</sup> The statistical approach used in this special feature to accomplish this separation is principal component analysis (PCA). This is a dimension-reduction technique which enables the variance of a multivariate dataset to be decomposed into a linear combination of a number of unobserved factors common to all of the variables, plus idiosyncratic components specific to each variable. The common factors or principal components are constructed and ordered such that the first one explains the largest portion of the sample covariance or correlation matrix, the second one explains the next largest portion, and so on. The principal components are, by construction, orthogonal.<sup>5</sup>

The risk measure of the  $i^{\text{th}}$  bank,  $x_{i,t}$  may be decomposed into systemic and idiosyncratic components as follows:

$$x_{i,t} = \lambda_i F_t + \varepsilon_{i,t}$$

where  $\lambda_i$  is a vector of loadings on the common (or systemic) factors  $F_t$ , and  $\varepsilon_{i,t}$  represents the bank-specific component.<sup>6</sup>

The first common factor explains a large share of the co-movement across banks for each market. For instance, the first principal component of the banks' implied volatility captures 92% of their joint variation, that of subordinated debt spreads captures 76%, while those of the CDS measures lie between the above bounds.<sup>7</sup> These systemic components appear to capture well movements

3 Bond spreads from the secondary market depend on the available number and specifics of the outstanding bonds, and this is related to the new bond issue activity of firms. By contrast, the CDS market is more standardised (in terms of tenor, notional amount, currency) and less dependent on primary bond market issuances. Also, CDSs are more flexible as only premia have to be paid. This is why CDS rates are less likely to be affected by market illiquidity, tax and other microstructure effects that can affect corporate bond spreads. Finally, CDS traders can easily go long or short in credit risk, while shorting of bonds is more difficult. See L. Norden and M. Weber (2004), op. cit., and A. Berndt, R. Douglas, D. Duffie, M. Ferguson and D. Schranz (2005), "Measuring default risk premia from default swap rates and EDFs", BIS Working Paper No. 173.

4 For a recent example, see C. Hawkesby, I.W. Marsh and I. Stevens (2007), "Comovements in the equity prices of large complex financial institutions", *Journal of Financial Stability*, No. 2.

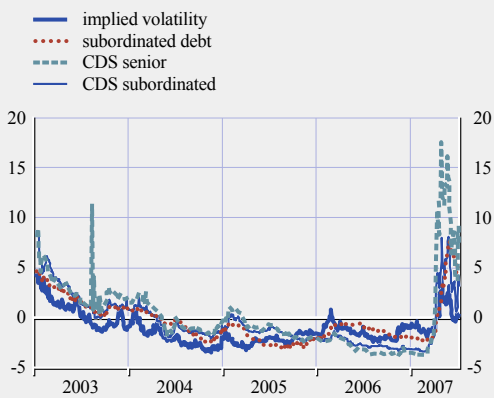
5 For an example of an application, see G. Connor and R. Korajczyk (1986), "Performance measurement with the arbitrage pricing theory: a new framework for analysis", *Journal of Financial Economics*, No. 15.

6 In this particular study, the convention is to take the principal components of the correlation matrix, rather than of the covariance one. In other words, variables have been normalised to have unit variance; otherwise a variable with large variance relative to the others would spuriously appear to have a higher correlation with the principal component.

7 The implied volatility series of fourteen banks for the period 2 September 2002 to 23 October 2007 were used. For subordinated debt spreads ten banks for the period 21 January 2003 to 16 November 2007 were used, for CDS senior debt spreads fifteen banks for the period 16 April 2003 to 24 October 2007 and for CDS subordinated debt spreads thirteen banks for the period 22 January 2003 to 24 October 2007. Only in the case of subordinated debt spreads does the second principal component show a weak statistical significance as depicted by the Jolliffe and Kaiser criteria. The Jolliffe criterion suggests cutting off once the percentage of joint variance explained reaches a certain threshold, for instance 80%, while the Kaiser criterion keeps eigenvalues greater than one if the correlation matrix has been employed.

**Chart B.2 Systemic risk depicted by principal components of equity and credit risk indicators of euro area large and complex banking groups**

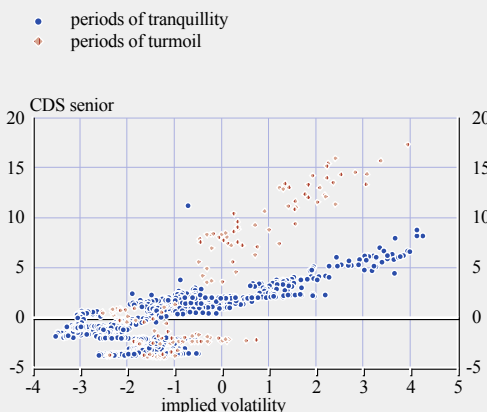
(Apr. 2003 – Oct. 2007)



Sources: Bloomberg, Bondware and ECB calculations.

**Chart B.3 Relationship between systemic implied volatility and CDS senior debt risk components**

(Apr. 2003 – Oct. 2007)



Sources: Bloomberg and ECB calculations.  
Note: Periods of turmoil are May 2005, May-June 2006, February-March 2007 and July 2007 onwards; other periods are periods of tranquility.

of systemic risk, in particular in periods of high uncertainty (see Chart B.2).

The systemic *content* of the variation of individual banks is similar across implied volatility and the CDS-based measures and very high, suggesting that euro area LCBGs appear highly sensitive to market movements.

The *association* of systemic equity and credit risk is easily seen in a scatter-plot (see Chart B.3).<sup>8</sup>

Even though significant diversity is observed in the nature of this relationship, episodes of financial turmoil, such as in May 2005, May-June 2006, February-March 2007 and especially from July 2007 onwards, are characterised by a higher correlation, in contrast to periods of relative market tranquillity when the relationship between equity and credit risk is less clear.

#### DO EURO AREA LARGE AND COMPLEX BANKING GROUPS TRANSMIT IDIOSYNCRATIC SHOCKS ACROSS MARKETS?

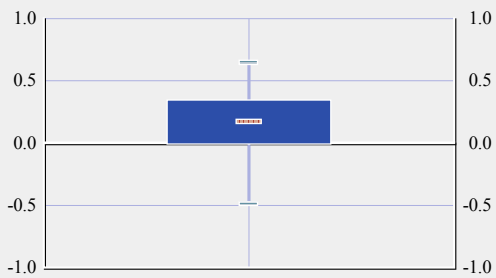
Even at the idiosyncratic level, there may be factors driving both equity and credit-based

measures. The economic rationale behind such a co-movement is straightforward: the payoff at maturity to the holder of a risky bond issued by a bank has the characteristics of a risk-free bond less the value of a put option on the bank's value. Hence, if equity volatility rises, so does the value of the put option, which reduces the expected payoff on the bond. This is reflected in a wider spread. This intuition comes from the Merton model that underpins the distance-to-default and expected default frequency approach. The extent to which idiosyncratic components across LCBGs show a degree of co-movement is pivotal for the assessment of systemic risk. If idiosyncratic components move in sync across markets, shocks in one market are reflected in movements in the other, meaning that uncertainty about the profitability outlook of a bank would intrinsically be related to its credit risk and thus the LCBGs serve as conduits for the transmission of shocks across markets – beyond the co-variation of systemic components.

<sup>8</sup> As the subordinated debt and CDS systemic components resemble each other fairly closely, CDS senior debt is chosen for the remainder to represent credit risk, as this measure embodies greater degrees of liquidity compared to corporate bonds and the data availability is richer.

**Chart B.4 Dispersion of coefficients in the relationship between idiosyncratic equity and credit risk components across euro area large and complex banking groups**

(Apr. 2003 – Oct. 2007; minimum, maximum, interquartile distribution and median)



Sources: Bloomberg and ECB calculations.

The analysis in this special feature rests on a general fixed-effects panel model:

$$cdsresid_{i,t} = c_i D_i + \beta IVresid_{i,t} + \varepsilon_{i,t}$$

where for the  $i^{\text{th}}$  bank,  $cdsresid_{i,t}$  is the idiosyncratic (or residual) component of the CDS senior debt spread,  $D_i$  allows the intercept to be bank specific, and  $IVresid_{i,t}$  is the idiosyncratic component of implied volatility of call options. The estimations suggest that the relationship between the idiosyncratic components across banks is weakly positive – the coefficient of  $\beta$  being 0.149 – and significant at the level of 1%. The fact that the association is positive but small suggests that each indicator provides marginal information that is not provided by the other. In other words, these findings would suggest that there is useful information in the idiosyncratic components extending beyond the Merton-type relationship. It would also suggest that it is better to consider patterns in several market-based indicators collectively in order to form a reliable assessment rather than focusing on one of them to the exclusion of the others.

Because restricting the coefficient  $\beta$  to be equal across banks could mask heterogeneity across banks, a model allowing this coefficient to vary across banks – thus fine-tuning fixed effects to take account of this heterogeneity – is also estimated:

$$cdsresid_{i,t} = c_i D_i + \beta_i (D_i * IVresid_{i,t}) + \varepsilon_{i,t}$$

Not surprisingly, there appears to be a varying degree of association across the banks (see Chart B.4).

Even though for the majority of the banks the association of the idiosyncratic components across markets is positive, strong and significant, a sample of banks exhibiting different results stands out. Specifically, for four out of thirteen euro area LCBGs considered in this analysis a statistically insignificant relationship between the idiosyncratic components is found at the level of 1%.<sup>9</sup> Out of the nine banks with significant association, seven show a positive relationship. The geographical and size specificity of the four banks exhibiting insignificant association suggests that, even though these banks operate globally, some geographical or size factor may underlie this result. It could also be of relevance that these banks exhibited very high debt-to-equity ratios during 2006 and 2007.

Overall, it is evident that for euro area LCBGs there is a significantly positive association between idiosyncratic equity and credit risks.

#### THE DYNAMICS OF THE SYSTEMIC RISK COMPONENTS AND THEIR INTERACTION WITH MARKET DRIVERS

Both systemic and idiosyncratic linkages across markets imply channels of transmission of shocks across markets. Identifying the nature of the causality would appear important, not the least as it could shed some light on whether the credit cycle may be reinforced through these channels. For instance, the relationship between the two types of risk may reflect the “pecking order” of cash-flow payouts that would create a natural delay in the transmission from equity-based to credit-based risk. An adverse shock to profits would result in lenders being affected last, as shareholders experience a direct hit through lower dividends. Hence, it seems intuitive that profitability strains will

<sup>9</sup> The standard errors are corrected for panel-specific autocorrelation and panel-level heteroscedasticity.

show up first in the equity-based indicators, as shareholders are subordinate to all other stakeholders in a firm.

The analysis at the systemic level is technically simpler for this investigation. In addition, the interaction with market drivers can be modelled explicitly at the systemic level. It also seems appropriate to exclude from the analysis the episode of financial turmoil that started in July 2007, as this very exceptional period is characterised by unusual drivers and possibly also dynamics (see Chart B.2).<sup>10</sup>

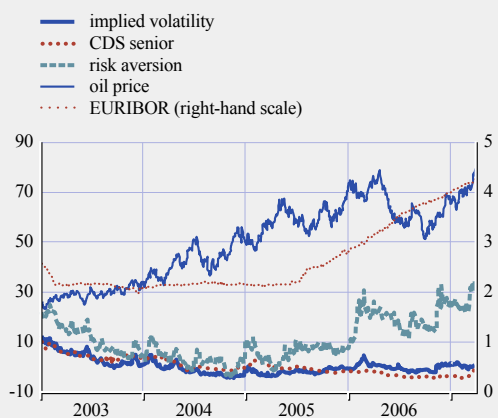
In order to motivate the analysis, a “reduced-form” (as opposed to “structural” market factors) model of the joint dynamics of the implied volatility and CDS senior debt systemic components alone is first investigated. As tests reveal that both indicators, at a daily frequency, exhibit non-stationary behaviour, and that a cointegrating relationship, which is significant at the level of 5%, exists between them, a vector error correction model (VECM) is used to model the dynamics.<sup>11</sup> Bearing in mind the possible problems of such reduced-form misspecification, the results indeed suggest that an increase in systemic implied-volatility-based risk results in a subsequent and persistent widening in the CDS-based systemic risk measure.<sup>12</sup>

The reduced-form model is enhanced with “market drivers” – the natural candidates being the three-month EURIBOR interest rate (measuring the cost of funds), a measure of investors’ risk aversion already developed and presented in earlier issues of the FSR (capturing the cycle as seen from the supply of funds side) and oil prices (a proxy of supply-side drivers) (see Chart B.5).<sup>13</sup>

Simple correlation measures of the five variables indicate that the relationship with risk aversion is greatest for implied volatility, while for both interest rates and oil prices it is higher with credit risk (see Table B.1).

**Chart B.5 Systemic risk measures of euro area large and complex banking groups and their market drivers**

(Apr. 2003 – July 2007)



Sources: Bloomberg, Chicago Board Options Exchange (CBOE), UBS, JPMorgan Chase & Co., Lehman Brothers, Westpac, Dresdner Kleinwort, Bank of America and ECB calculations.

In order to capture the dynamic interdependence of the equity and credit market measures with their risk drivers, a dynamic model was estimated. Like the systemic risk measures, drivers are also non-stationary, and cointegrating relationships are again detected; therefore the VECM specification is applied again. The structural model explains more of the variation in the credit market (31%) than in the equity market (7%), in line with the reduced-form model, but capturing more of the variation.

<sup>10</sup> The sample period for this part of the analysis is from 16 April 2003 to 13 July 2007.

<sup>11</sup> This model has been estimated with five-day lags, one less than the optimal number of lags determined by the Akaike Information criterion for the corresponding VAR representation. Moreover, since the data are not trending, the restricted constant case has been fitted. The outlier point for CDS spreads on 1 December 2003 has been excluded.

<sup>12</sup> Much of the variation in the credit market (but less of that in the equity-based options) is explained by the model: about 2% of the variation in the equity market is explained and 10% in the credit market.

<sup>13</sup> The risk aversion measure used is that of ECB (2007), “Measuring investors’ risk appetite”, *Financial Stability Review*, June. This measure is shown to drive financial market liquidity in ECB (2007), “Measuring financial market liquidity and risk aversion interdependence”, *Financial Stability Review*, December.



**Table B.1 Correlation of systemic equity and credit risk with risk drivers at various frequencies**

(Apr. 2003 – July 2007)

		Risk aversion	EURIBOR	Oil price
Daily	Implied volatility	0.484	-0.078	-0.532
	CDS senior	-0.182	-0.684	-0.837
Weekly	Implied volatility	0.482	-0.079	-0.532
	CDS senior	-0.202	-0.700	-0.846
Monthly	Implied volatility	0.483	-0.086	-0.538
	CDS senior	-0.243	-0.733	-0.859

Sources: Bloomberg, Chicago Board Options Exchange (CBOE), UBS, JPMorgan Chase & Co., Lehman Brothers, Westpac, Dresdner Kleinwort, Bank of America and ECB calculations.

**Table B.2 Summary of short-term dynamics of the VECM model**

(Apr. 2003 – July 2007)

Explanatory variables	Dependent variable in each equation				
	Implied vol.	CDS senior	Risk aversion	EURIBOR	Oil price
Implied vol.	4	10	-	-	-
CDS senior	-	6	-	-	-
Risk aversion	5	-	10	8	10
EURIBOR	8	-	-	5	-
Oil price	-	-	-	-	-

Sources: Bloomberg, Chicago Board Options Exchange (CBOE), UBS, JPMorgan Chase & Co., Lehman Brothers, Westpac, Dresdner Kleinwort, Bank of America and ECB calculations.  
Note: An entry denotes the highest lag with short-term coefficients of the VECM being significant at the 5% level.

Regarding the variables' short-run interdependencies, the measure of risk aversion appears to be a significant driver of the equity-based systemic measure, which itself is a driver of movements in CDS spreads. All in all, a shock in risk aversion translates into important rises in equity risk, with impacts being persistent as they last for at least five days (see Table B.2).

As in the reduced-form specification, credit risk is quite responsive to shifts in equity risk, even after ten days, and the relationship is positive for almost all of the lags. Conversely, no significant effect appears to run from credit to equity risk. These findings certainly mirror the aforementioned pecking order of cash-flow payouts, which suggests that when a profitability shock occurs strains will first appear in the equity risk measures and only gradually transmit to the credit-based risk ones.

There is mixed evidence on the effect of interest rates on the equity-based measure, and no indication of a significant effect on the credit risk in the short run. In the immediate aftermath of a rise in oil prices, the equity risk measure responds positively, but the effect is only significant at the 10% level.<sup>14</sup>

The long-term behaviour of the variables reveals important and intuitive structural relationships. The Johansen test for cointegration suggests that

two equilibrium relationships among the five variables exist in the long run (see Table B.3).<sup>15</sup> The coefficients of the cointegrating vectors imply that, in the long run, increases in risk aversion are associated either with an increase in equity risk or credit risk or both. In the context of the "market" as a whole, this result would seem obvious – the measure of risk aversion being itself the main common component in the movements across several markets.

The second stationary long-run equilibrium suggests that higher interest rates are associated with lower systemic credit risk among LCBGs. This result stands in contrast to general results documenting a negative relationship between movements in interest rates and credit spreads in the short run and no clear behaviour in the

<sup>14</sup> When extending the sample until the end of September 2007 to include data from the recent turmoil, risk aversion drives equity risk in a much more persistent manner and even the credit market directly; oil prices also appear to explain some variation in implied volatility in the immediate aftermath of a shock. These inspections confirm the expectation that during stress points risk is driven by shocks in variables that would not otherwise affect it so significantly.

<sup>15</sup> Both the trace and maximum eigenvalue tests reject the null of rank being equal to 1 at the 1% level, while the maximum eigenvalue test does not reject the null of rank being equal to 2 at the 1% level. The tests were carried out with twelve lags, as that was indicated to be optimal by the log-likelihood criterion, provided the maximum lag is again twelve, and a restricted constant. The lag lengths that minimise the Akaike and Bayesian Information Criteria are three and two respectively.

**Table B.3 Long-term relationship between equity risk, credit risk, risk aversion, three-month EURIBOR rates and oil prices**

(Apr. 2003 – July 2007)

	First	Second
Implied volatility	-0.0224	0.0063
CDS senior debt spreads	-0.0229	-0.0286
Risk aversion	0.0674	0.0462
EURIBOR	0.0003	-0.0010
Oil price	0.0296	0.0034

Sources: Bloomberg, Chicago Board Options Exchange (CBOE), UBS, JPMorgan Chase & Co., Lehman Brothers, Westpac, Dresdner Kleinwort, Bank of America and ECB calculations.  
Note: The darkest grey shade refers to significance at 1%, medium dark to significance at 5%, light grey to 10% and unshaded refers to insignificance at any level.

long term.<sup>16</sup> It suggests, however, that the maturity transformation function of this group of banks is important, as higher interest rates reduce risk.

## CONCLUDING REMARKS

A decomposition of commonly used equity and credit-based risk measures for euro area LCBGs into systemic and idiosyncratic components confirms previous findings that systemic components show substantial co-movement. Looking at the drivers of these common factors reveals that risk aversion is a significant driver of equity risk, with the impact transmitting to credit risk in a rather persistent manner. Interest rates and oil prices are found to have a weak association, at least in the short term. The results confirm a long-run relationship between risk aversion (a summary market measure) and the two LCBG-specific risk measures. Indeed, a general rise in the level of risk aversion is associated with increased levels of implied volatility and credit spreads in the long term.

This special feature also reveals that there is still a significant, weakly positive co-movement between the idiosyncratic components of credit and equity risk for the majority of euro area LCBGs. The fact that the association is positive but small suggests that each indicator provides marginal information that is not provided by the other. In other words, these findings would suggest that there is useful information in the

idiosyncratic components extending beyond the Merton-type relationship.

All in all, the findings indicate that great care should be exercised in interpreting patterns in market-based indicators as part of a financial stability assessment. Analysing patterns in many indicators should be done first and foremost for cross-checking of the interpretation, but also for assessing how different events shape the risk profile of banks.

<sup>16</sup> See M. Lin and J. Curtillet (2007), "Another look at the relation between credit spreads and interest rates", *Journal of Fixed Income*.