C HOW HAS CDO MARKET PRICING CHANGED DURING THE TURMOIL? EVIDENCE FROM CDS INDEX TRANCHES

The general repricing of credit risk which started in summer 2007 has highlighted significant problems in the valuation of collateralised debt obligations (CDOs). This special feature analyses the determinants of movements in CDS index tranche premia. The main finding is that the repricing of credit risk led to a heightened impact of risk aversion and liquidity measures on market prices. Overall, the results imply that even in the most liquid segment of the CDO market, market prices still contain a sizeable liquidity premium.[1]

INTRODUCTION

CDOs, which represent repackaged credit portfolios, can be classified into "bespoke" structures and index-based, i.e. standardised, instruments. In a bespoke CDO transaction, an investor can choose the CDO's underlying portfolio or the structure of cash flows. For most of these instruments, their specific features limit the development of an active market and so investors ordinarily hold these securities until maturity. Valuation therefore relies on theoretical pricing models. By contrast, in the standardised CDO segment the underlying credit portfolio is based on a credit index such as the iTraxx index of euro-denominated credit default swaps (CDSs). This standardisation and transparency has fostered active trading in index products. Therefore, market participants frequently use the market prices of these index-based CDOs, which are also known as CDS index tranches, as a basis for the valuation of many bespoke CDOs. Hence, CDS index tranches can be viewed as representing the "tip of the iceberg" of the entire CDO market segment.

This special feature applies regression analysis to investigate the fundamental factors explaining the variation of the market prices of iTraxx tranches. To explain the log differences of the tranche premia a variety of financial market variables are used, including proxies for overall credit risk, credit risk correlation, the risk-free interest rate and measures of market liquidity. Whether tranche premia are linked to a proxy for risk aversion is also tested. Furthermore, the analysis focuses on how the turmoil in credit markets which started in summer 2007 has affected the pricing of the index tranches. This leads to some preliminary conclusions on changes in CDO pricing more generally.

The market turmoil which started in summer 2007 has rekindled doubts concerning the validity of currently available CDO pricing models. Many market participants could not correctly price or measure the risks in instruments which are sensitive to credit risk correlation. These weaknesses in existing models provide an additional underpinning for the approach taken in this analysis, as it is not based on a specific pricing model, but instead tests the explanatory power of variables which should in theory influence market prices.

One of the main findings of the analysis is that declining risk appetite and heightened concerns about market liquidity, both of which have characterised investor behaviour since summer 2007, have provided a sizeable contribution to the observed strong increase in tranche premia.

The rest of this special feature is organised as follows. The first section briefly discusses the mechanics of CDS index tranches and the sample used. The second section describes market pricing during the turmoil. In the third section the potential determinants of tranche premia variation are discussed. The results of the empirical analysis are summarised in the fourth section. The last section offers some concluding remarks.

1 This special feature is a summary of the analysis in M. Scheicher (2008), "How has CDO market pricing changed during the turmoil? Evidence from CDS index tranches", ECB working paper, forthcoming.

THE MARKET FOR CDS INDEX TRANCHES

The iTraxx CDS index, which started trading in June 2004, provides the underlying asset for the corresponding tranches. These index CDSs essentially trade like CDSs on a single firm. In the event of a firm's default, the defaulted firm is removed from the index portfolio and the nominal value of the contract declines by 1/125 (0.8%). According to market information, trading activity is concentrated in the five-year maturity and therefore this horizon is the focus of the following analysis. In addition, the analysis focuses on the "on-the-run" series, which is rolled over every half year to the new index composition according to the current poll's ranking of firms.[2]

Given the present iTraxx index composition, the corresponding standardised CDO comprises instruments with varying degrees of exposure to the joint loss distribution of the 125 firms. These tranches therefore provide claims on the cash flows of the iTraxx CDS portfolio and in parallel serve as protection for a certain range of defaults in the portfolio. The equity tranche serves as the first level of protection against any defaults among the firms in the index and is therefore also called the "first loss piece". Specifically, the six iTraxx main index tranches are Equity (ranging from 0% to 3% of the joint loss distribution), Low Mezzanine (3% to 6%), Mid Mezzanine (6% to 9%), High Mezzanine (9% to 12%), Super Senior (12% to 22%) and High Super Senior (22% to 100%).

Collectively, the six tranches represent the entire capital structure of the CDS index portfolio and can be interpreted as options on the joint loss distribution. In total, the six tranches cover all the possible losses arising from defaults in the CDS index portfolio. In parallel, all cash flows from the CDS index portfolio are paid out, starting from the senior tranches and ending with the equity tranche. Tranche trading takes place in the over-the-counter market among banks and brokers. Because the instruments are constructed like synthetic single-tranche CDOs, investors can buy or sell all tranches individually.

Tranche premia are very sensitive to the default correlation between the firms in the portfolio because this correlation directly influences the distribution of risk in the capital structure. In particular, tranche premia depend on the joint loss distribution of the underlying portfolio and, given all other parameters, the default correlation determines the shape of this distribution. As the default correlation changes, the corresponding movement in the shape of the joint loss distribution is directly transmitted to the relative allocation of portfolio credit risk between equity, mezzanine and senior tranches.

A rise in the credit correlation represents a scenario of increasing systematic and therefore decreasing firm-specific risk in the credit portfolio. Thus, it can be interpreted as increasing risk of a general downturn in the economy rather than the default of a particular firm or a sector. In this scenario, the probability mass moves from the centre to the tails of the joint loss distribution of the iTraxx portfolio. These fatter tails of the loss distribution imply that the likelihood of the realisation of few as well as many credit events increases. Under this scenario, the overall shape of the joint loss distribution leads to a decline in the equity premium, because the buyer of the equity tranche is not required to make a payment in the absence of defaults. This mechanism explains why market participants equate buying an equity tranche with a long position in credit correlation: rising correlation lowers the equity tranche premium and therefore raises the mark-to-market value of the position. As regards the mezzanine segment of the CDO capital structure, there is generally no unambiguous effect of the correlation on tranche premia.

2 For more details and references see ECB (2006), "The information content of CDS index tranches for financial stability analysis", *Financial Stability Review*, December 2006.

THE BEHAVIOUR OF CDS INDEX TRANCHE PREMIA DURING THE TURMOIL

Two snapshots of the iTraxx tranche premia for 29 January 2008 and 23 January 2007 are shown in Table C.1. All premia are expressed in basis points. This premium is the amount which the investor in a specific tranche (the "protection seller") receives from the protection buyer as compensation for covering the losses tied to that tranche.

At the end of January 2008, the iTraxx index traded around 70 basis points. This means that it cost around €70,000 annually to obtain insurance for a portfolio of €10 million of European investment-grade corporate debt. In contrast, one year earlier, with the premium at 23 basis points it cost less than this amount for the same insurance.

There are large differences in individual tranche premia due to differences in their inherent sensitivity to portfolio credit risk. At the end of January 2008, for instance, the tranche providing exposure to the 12% to 22% segment of the loss distribution paid 59.5 basis points annually; the 9-12% tranche paid 117 basis points and the equity tranche 1,243 basis points. Thus, for taking on the first loss piece of the capital structure of the default insurance for the iTraxx portfolio, the equity investor would have been compensated with an expected annual payment of around 12.5% of the notional amount.

After market participants started their reassessment of the pricing of credit risk in the summer of 2007, investment-grade premia jumped upwards over a short period of time, leading to large mark-to-market losses. All tranche premia widened significantly, although the severity of the changes differed across the capital structure. Table C.1 shows that between 23 January 2007 and 29 January 2008, equity tranche premia rose from 750 basis points to 1,243 basis points, whereas the premium on the 12-22% tranche rose from 2.25 basis points to around 60 basis points. A similar sharp increase was observed for the 22-100% tranche where the premium increased from around 1 basis point to around 20 basis points.

Table C.1 Tranche premia for iTraxx Europe Main five-year on 23 January 2007 and 29 January 2008

(basis points)

Instrument	23 Jan. 2007	29 Jan. 2008
iTraxx Main IG Index	*23.00*	*70.00*
Equity 0-3%	750.00	1,243.00
Mezzanine 1, 3-6%	40.00	294.00
Mezzanine 2, 6-9%	12.00	188.00
Senior 9-12%	6.00	117.00
Super senior 1, 12-22%	2.25	59.50
Super senior 2, 22-100%	0.95	19.50

Sources: JPMorgan Chase & Co. and ECB calculations.

These movements imply that investors became seriously concerned about losses hitting even the higher components of the capital structure of the iTraxx index tranches. Tail risk plays a large role in determining the values of senior and super-senior tranches.[3] Hence the pattern of price changes in the less risky parts of the CDO capital structure over the last year can be interpreted as representing a reassessment of the weight of large, low-probability loss events.

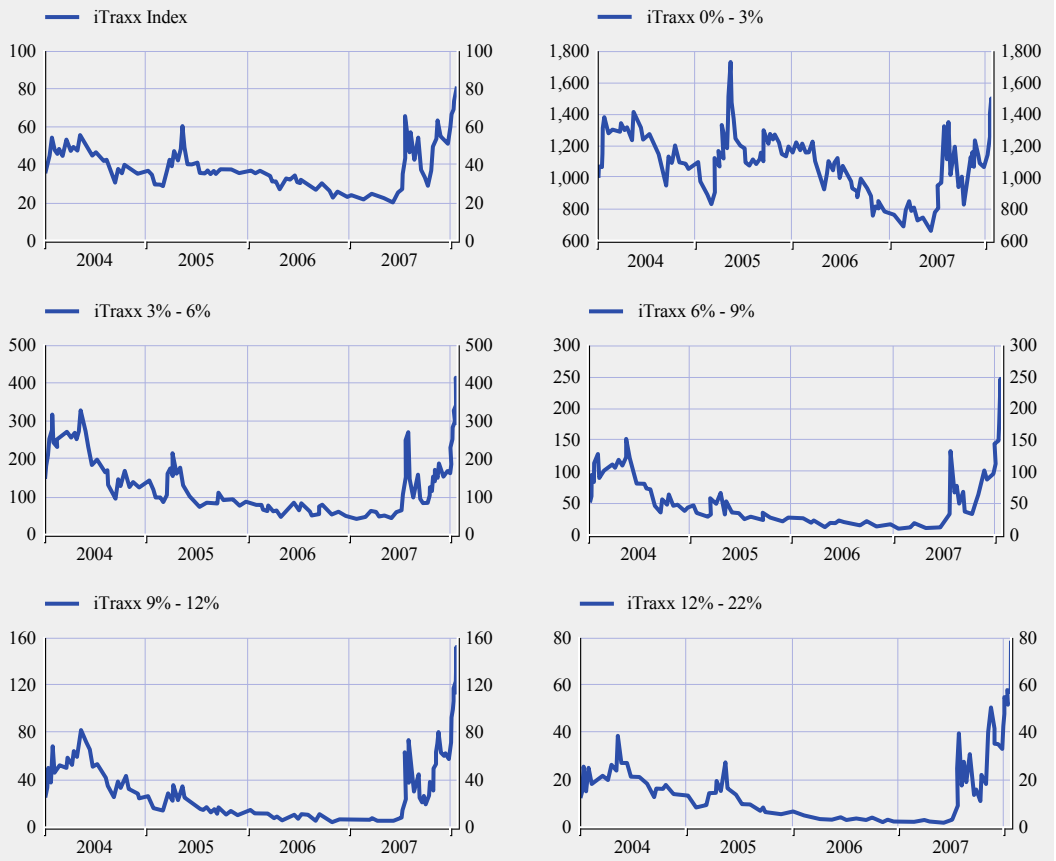
The sharp spike in the second half of 2007 is also visible in Chart C.1, which plots the time series of the index and the corresponding five tranches since the start of trading in the first half of 2004.[4] The chart also shows that the market turmoil which started in summer 2007 had a much more severe impact on market prices (with the exception of the equity tranche) than the May 2005 period of high volatility, when the downgrading of the US automobile companies Ford and General Motors triggered substantial turbulence in the credit market.

3 See J. Coval, J. Jurek and E. Stafford (2007), "Economic catastrophe bonds", Harvard Business School Working Paper No 07-102.

4 The super senior 22-100% tranche is not included.

Chart C.1 Time series of iTraxx index and tranche premia

(basis points)



Sources: JPMorgan Chase & Co. and ECB calculations.

THE DETERMINANTS OF CDS INDEX TRANCHES

In the literature on the modelling of credit spreads, econometric analysis of the explanatory factors of credit spreads has been used by many authors, starting with Collin-Dufresne et al.[5] The advantage of this approach is that it can use a much wider set of explanatory factors such as, for example, liquidity factors or proxies for risk aversion. Furthermore, it is not constrained by the specification of a particular theoretical model, but rather provides a data-based approximation to such a theoretical model.

The analysis in this special feature includes factors which serve as inputs in pricing models, namely proxies for credit risk and for the movement of the risk-free interest rate. The main components of a CDO pricing model are a specification of the firm-level default process, the default co-movement and assumptions about the dynamics of the risk-free interest rate.[6] In addition, some other factors, which previous research has found to be significant determinants of credit spreads, are included. Furthermore, the analysis focuses on how the impact of the pricing factors changed after the start of the market turmoil in July 2007.

5 See P. Collin-Dufresne, R. Goldstein and J. S. Martin (2001), "The determinants of credit spread changes", *Journal of Finance*, 56, 2177-2207.

6 See, for example, F. Longstaff and A. Rajan (2006), "An empirical analysis of the pricing of Collateralized Debt Obligations", NBER Working Paper No 12210, for an empirical study of the performance of theoretical pricing models.

Overall the following eight factors are used:

The CDS index

The level of the CDS index determines the expected loss and hence the central tendency of the joint loss distribution. Therefore, the log changes of the iTraxx index time series are included.

The credit risk correlation

The credit risk correlation determines the shape of the joint loss distribution. As discussed earlier, tranche premia are very sensitive to the credit correlation between the firms in the portfolio because this correlation directly influences the distribution of risk across the tranches.

The implied base correlation of the iTraxx equity tranche is used to measure credit risk correlation. This measure is the simplest estimate of the homogeneous asset value correlation in the index portfolio. Furthermore, the base correlation is also the market standard for expressing default co-movement in CDO portfolios.[7] To avoid potential endogeneity problems in the econometric specification the lagged correlation change is used.

The risk-free interest rate

Changes in the risk-free interest rate are in general negatively related to credit spreads, and whether the same linkage also holds for tranche premia is tested. The theoretical explanation within the Merton (1974)[8] framework for a negative relationship proceeds as follows: first, a rising risk-free interest rate decreases the present value of the expected future cash flows, i.e. the price of a put option on the value of the firm decreases. Second, a rising risk-free interest rate tends to raise the expected growth rate of the firm value and hence a higher firm value becomes more likely. In turn, this implies a lower price of the put option on the firm value. Hence, both effects of increasing risk-free interest rates decrease the costs of insurance against default, i.e. the price of the put option on the firm value, which implies a smaller credit spread.

In the empirical application, the five-year euro swap rate is used as the risk-free interest rate because the tranche contracts have a maturity of five years and interest rate swaps are commonly seen as the market participants' preferred measure of the risk-free interest rate.[9]

The slope of the term structure

There is at least one linkage between the slope of the risk-free term structure and credit spreads: the slope of the term structure reflects the assessment of market participants about the economic climate because of the linkages between the term structure and investors' portfolio decisions. If investors expect the business climate to improve, they will shift some of their assets from short-maturity instruments into long-term bonds. This change in the portfolio composition will increase the short rate relative to the long rate, leading to a flatter slope of the term structure. A poorer macroeconomic outlook may lower demand for CDO investments, because investors may react to the increased likelihood of a general downturn by moving towards less risky assets such as government bonds.

In the empirical application, the slope of the term structure is defined as the difference between the ten-year and the one-year euro swap rates.

Risk aversion

As Eckner (2007) shows,[10] the tranche premia compensate investors not only for pure expected loss but also for systematic risk or jump risk. Hence, the market price of the tranches may change due to changes in investors' risk aversion, even if the underlying fundamentals (i.e. pricing under the "statistical measure") are unchanged.

7 See, for example, A. Elizalde (2005), "Credit risk models IV: Understanding and pricing CDOs", CEMFI working paper.
8 R. Merton (1974), "On the pricing of corporate debt: The risk structure of interest rates", *Journal of Finance*, 29, 449-470.
9 See F. Longstaff, S. Mithal and E. Neis (2005), "Corporate yield spreads: default risk or liquidity? New evidence from the credit default swap market", *Journal of Finance*, 60, 2213-2253.
10 A. Eckner (2007), "Risk premia in structured credit derivatives", Stanford University working paper.

The JP Morgan G-10 Risk aversion index is used in the empirical application. This index aggregates implied volatilities and measures for flight to quality into a single measure of the market participants' risk appetite.

Swap spread

As a proxy for the liquidity risk premium in financial markets the swap spread, i.e. the yield differential between a ten-year interest rate swap and the benchmark German government bond with similar maturity is used. The swap spread contains a liquidity risk premium because it is affected by the funding operations of banks in the interbank market.[11] In addition it also contains a small default risk premium as the banks active in this market may have a non-zero default probability.

Liquidity proxy

Longstaff et al. (2005) show that the non-default component in credit spreads is significantly positively related to average bid-ask spreads. Hence the second measure of market liquidity is the average bid-ask spread across five of the six tranches.[12] This measure should reflect common patterns in the market liquidity of the tranches.

Yen exchange rate

In the period from 2000 onwards, many market participants used trading strategies called "carry trades". Such strategies rely on borrowing in a low-interest rate currency and investing the proceeds in higher-yielding assets. Specifically, the yen was commonly used as a funding currency. Thus, it is of interest to explore if movements in the JPY/EUR exchange rate affected the prices of tranches through effects on the cost of financing.

The sample comprises daily data from 23 September 2004 to 29 January 2008. The estimation is conducted with ordinary least squares analysis for each tranche separately. The dependent variable is defined as the log change in the tranche premium. Specifications with and without an interaction dummy for the turmoil period starting in July 2007 are evaluated.

Chart C.2 plots the time series of the levels of the explanatory variables. It illustrates a sharp upward movement in the bid-ask spread starting in summer 2007, which may indicate liquidity problems in the tranche market. An increase in the swap spread is also visible. The bid-ask spread also shows a temporary increase during the May 2005 market turmoil, whereas the swap spread reacted much less. The variation of the risk aversion measure showed a pronounced trend up to the summer of 2007.

EMPIRICAL RESULTS

From the regression analysis, five results emerge.[13]

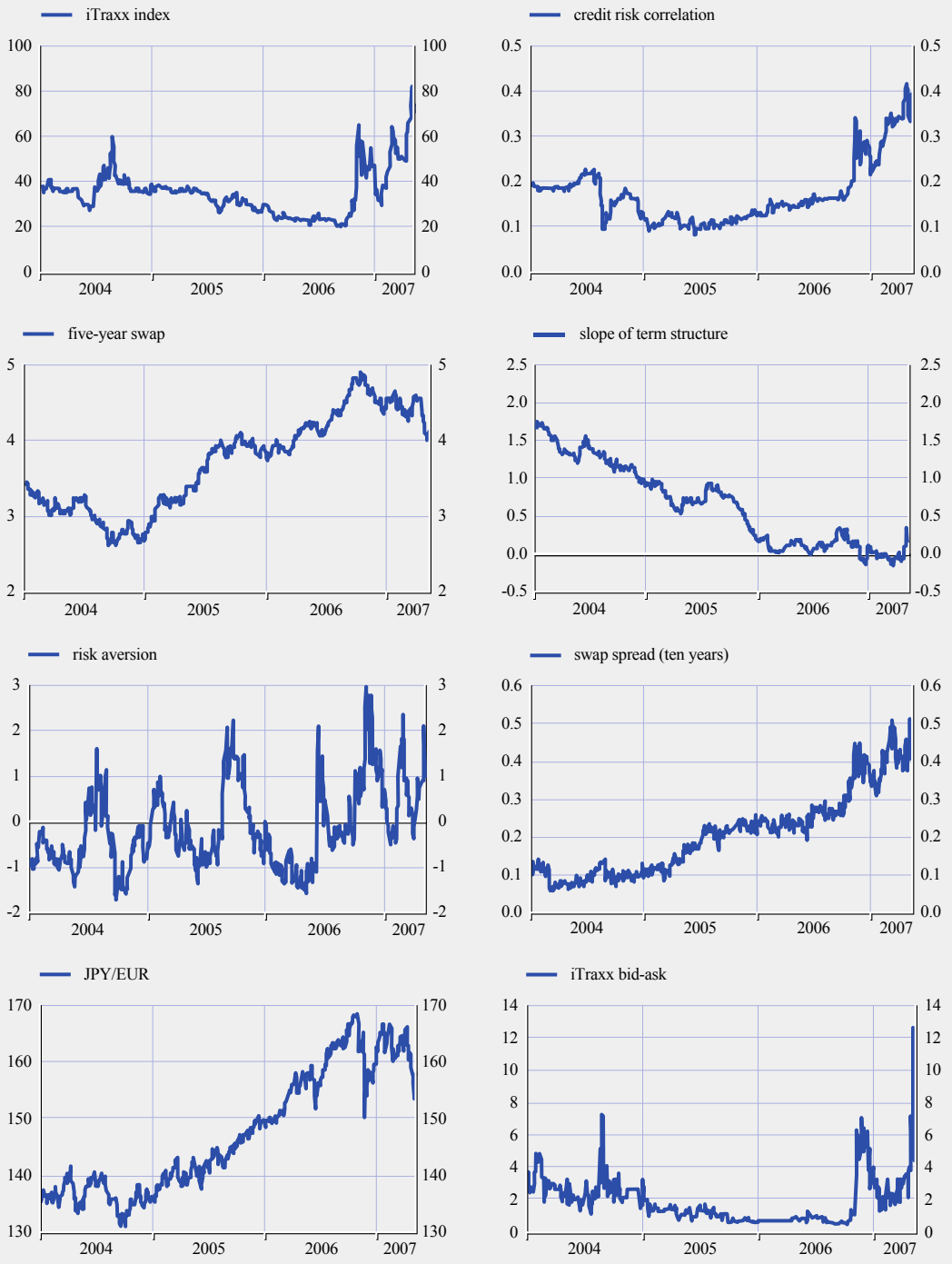
First, the CDS index has a large impact on the variation of all tranche premia. As hypothesised, the change in the index CDS premium enters the equations with a positive coefficient. A rise in this proxy for the expected loss in the underlying portfolio raises the tranche premia. In the iTraxx sample, the coefficient of the index change clearly increases with the subordination, with the biggest effect observed for the 6-9% tranche.

Second, the sign of the coefficient of credit correlation is negative for the first four tranches and positive for the highest tranche in the sample, namely the 12-22% tranche.[14] Hence, the relationship between tranche premia indeed depends on the subordination of the respective tranche.

Third, the five-year swap rate, the slope of the swap curve and the yen exchange rate do not have significant effects on tranche premia. In the overall regression, the risk aversion proxy also has only weak positive effects, mainly on the pricing of the equity tranche (albeit with a t-statistic of only 1.34).

11 Y. Huang and S. Neftci (2003), "What drives swap spreads, credit or liquidity?", ISMA Center Working Papers in Finance, 2003(5).
12 The super senior 22-100% tranche is not included.
13 The tables can be found in Scheicher (2008), op. cit.
14 The super senior 22-100% tranche is not included.

Chart C.2 Time series of explanatory variables



Sources: JPMorgan Chase & Co. and ECB calculations.

Fourth, there are significant liquidity effects in tranche premia. The average bid-ask spread and the swap spread have statistically significant positive effects, with the former significant for all except the 6-9% tranche and the latter significant for all except the equity tranche. Hence, an increase in one of the proxies for liquidity raises all tranche premia.

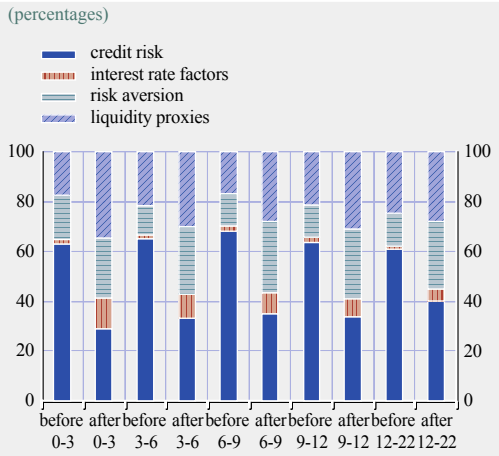
Fifth, the explanatory power of the market-based factors indicates a good fit of the regression model. The R-squared values of the iTraxx dataset are around 30% with the highest explanatory power for the 12-22% tranche.

After the overall regression analysis, the impact of the credit market turmoil on tranche premia is analysed. Understanding the specific factors and their role in driving the variation is important because changes in the weight of credit and non-credit-related elements may have different implications for the understanding of market pricing. For instance, indications about a declining risk appetite (i.e. risk preferences) provide a different signal of market perceptions than forecasts of rising future expected losses (i.e. statistical measures of risk).

To study the impact of the credit market turmoil on the pricing of standardised CDOs, this special feature focuses on changes in the weights of the pricing factors. For this purpose, the relative contribution of the R-squared goodness of fit measures of the block-wise regressions of the iTraxx tranche premia are compared. The four blocks are credit risk (index and base correlation), interest rate factors (level and slope), risk aversion (JPMorgan index) and liquidity risk (swap spread, bid-ask, yen). Chart C.3 shows the results of this analysis for two sample periods: August 2004 to July 2007 ("before") and July 2007 to January 2008 ("after").

The chart clearly shows the shift in the relative explanatory power among the four categories. The weights of risk aversion (as captured by the JPMorgan index) and liquidity risk both increased, whereas the role of credit risk declined in relative terms. For example, in the case of the 6-9% tranche, credit risk accounted for more than 60% before the turmoil and for less than 40% after the start of the turmoil. Simultaneously, the contribution of risk aversion changed from less than 20% to more than 30%.

Chart C.3 R^2 of block-wise regressions on iTraxx tranche premia



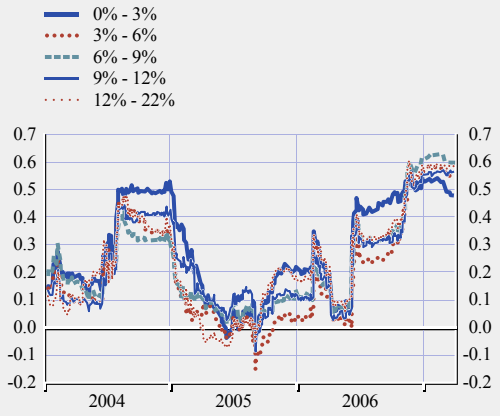
Sources: JPMorgan Chase & Co. and ECB calculations.
Note: The chart plots the relative contribution of the R-squared goodness of fit measures of the block-wise regressions of the five iTraxx tranche premia. The four blocks are credit risk (index and base correlation), interest rate factors (level and slope), risk aversion (JP Morgan index) and liquidity risk (swap spread, bid-ask, yen). The sample periods are August 2004 to July 2007 ("before") and July 2007 to January 2008 ("after").

To analyse further how the individual explanatory power of risk aversion and liquidity risk changed over time, rolling bivariate correlations based on a moving window of 120 daily observations are estimated (see Charts C.4 and C.5).[15]

Across all tranches, there was a sharp increase in the linkages between risk aversion, liquidity risk and the tranche premia after summer 2007. In relative terms, the impact of risk aversion on tranche premia rose by more than the impact of liquidity risk on tranche premia. This difference between risk aversion and liquidity risk is observed for all tranches. Among the five tranches, the 12-22% tranche shows the strongest correlation with the bid-ask spread, and the

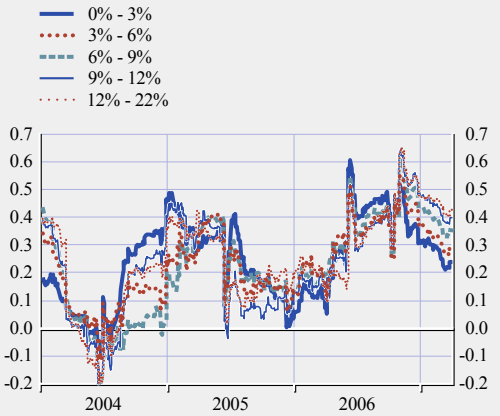
15 Correlations are used because in a bivariate regression the R^2 measure equals the squared correlation coefficient.

Chart C.4 Rolling correlations of iTraxx tranche premia and risk aversion measure



Sources: JPMorgan Chase & Co. and ECB calculations.
Note: The chart plots the rolling bivariate correlations based on a moving window of 120 daily observations. The sample is January 2005 to January 2008.

Chart C.5 Rolling correlations of iTraxx tranche premia and liquidity measure



Sources: JPMorgan Chase & Co. and ECB calculations.
Note: The chart plots the rolling bivariate correlations based on a moving window of 120 daily observations. The sample is January 2005 to January 2008.

6-9% tranche has the strongest correlation with the risk aversion proxy. Furthermore, the impact of liquidity risk saw a slight decline in the last weeks of the sample period.

The two charts also show that the more recently observed relationships differ from those observed during the market turmoil in May 2005. In particular, the role of the risk aversion component exceeded that observed in 2005.

All in all, these findings imply that the declining risk appetite and heightened concerns about market liquidity which investors have shown since last summer have provided a sizeable contribution to the observed strong increase in tranche premia.

CONCLUDING REMARKS

This special feature has analysed the determinants of the daily movement in CDS index tranche premia. By means of regression analysis the reaction of the market prices of iTraxx tranches to market-based variables such as proxies for credit risk, liquidity risk, risk aversion and interest rate risk were estimated.

The main finding is that the repricing of credit risk led to a heightened impact of risk aversion and liquidity measures on market prices. Hence, the strong increase in iTraxx tranche premia after the summer of 2007 can in part be explained by declining risk appetite and heightened aversion to liquidity risk of investors.

Overall, the results imply that even in the most liquid segment of the CDO market, market prices still contain a sizeable liquidity premium. This means that commonly used CDO pricing models do not capture a major determinant of market prices.