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JEL Classification : G13, G14

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The Relative Informational Efficiency of Stocks, Options and Credit Default Swaps

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In this study, we investigate the dynamics behind informed investors' trading decisions among European stock, options and credit default swap markets. This allows us to identify the predictive explanatory power of the unique information contained in each market with respect to future stock, CDS and option market movements. A lead-lag relation is found between the CDS market and the other markets in which changes in CDS spreads are able to consistently forecast changes in stock prices and equity options' implied volatilities pointing out how the fast growing CDS market seems to play a special role in the price discovery process. Moreover, in contrast to US results, the stock market is found to forecast changes in the other two markets suggesting that investors also prefer stock market involvement to exploit their information advantages and then move to CDS and option markets. Interestingly, those patterns have only emerged during the recent financial crisis, while before the crisis the option market was found to be of major importance in the price discovery process.

1. Introduction

A relatively new stream in the literature tries to explore the connections between the different equity, options and credit derivatives markets with respect to informed traders investment decisions. Acharya and Johnson (2007) study the phenomenon of insider trading in the credit derivatives markets. They find evidence of its existence especially when more banks are lending to an obligor. In fact, in case of an increase in credit risk, they show that credit default swap (CDS) spreads lead stock returns meaning that insiders (in this case the lending institutions) tend to exploit their (insider) knowledge causing a significant incremental information revelation in the CDS market. Following this line of reasoning, Cao et al. (2010) hypothesize that “if informed/insider trading is the common underpinning of price discovery in the option and CDS markets, then we should expect a contemporaneous link between CDS spreads and option-implied volatility (IV)”, considering that both CDS and options offer a low cost and effective protection against downside risk. Using a sample of US firms over a three years time span, they find their results being consistent with this main hypothesis. Similar results can be found in a contemporaneous study by Consigli (2007) who although uses a different approach applying the Merton model. The preference of informed traders for option markets over standard capital markets like stock or bond markets is also documented in previous studies such as Pan and Poteshman (2006) and Cao et al. (2005), which investigate the predictive power of option volume for future stock returns. In an earlier version of their paper, Cao et al. (2010) further explore the lead-lag relation among stock, option, and CDS markets. Their results are consistent with the preference of informed traders to first using both option and CDS markets to exploit their information, which subsequently diffuses into the stock market. They also examine the reasons why implied volatility is found to be a better explanatory variable for CDS spreads compared to historical volatility (HV) and other theoretical determinants. The results show that IV explains CDS spreads not only because it forecasts future volatility, but also because it captures a time-varying volatility risk premium. For an international sample of firms over the period 2000-2002, Norden and Weber (2009) find that first, stock returns lead CDS and bond spread changes while CDS spread changes are found to Granger cause bond spread changes for a higher number of firms than vice versa. Second, the CDS market is more sensitive to stock market than the bond market and this effect increases the lower the credit quality and the larger the bond issues. Finally, they

find that the CDS market contributes more to price discovery than the bond market although this effect seems stronger among US firms compared to European ones.

The aim of this European study covering the financial crisis period is to empirically investigate the relative informational efficiency of stock, options and credit default swaps. We try to answer this question by testing for a lead-lag relationship and exploring the price discovery process across all three markets. Inspired by Acharya and Johnson (2007), we run a two-step time series regression analysis using the seemingly unrelated regression (SUR) approach in the second step. Given that we are confronted with a relatively small cross-section and a long time-series, the SUR approach is more appropriate than conducting Panel-data analysis. A lead-lag relation is found between the CDS market and the other markets in which changes in CDS spreads are able to consistently forecast changes in stock prices and equity options' implied volatilities, pointing out how the fast growing CDS market seems to play a special role in the price discovery process. Moreover, in contrast to US results, the stock market is found to forecast changes in the other two markets suggesting that investors also prefer stock market involvement to exploit their information advantages and then move to CDS and option markets. Interestingly, these patterns have only emerged during the recent financial crisis, while before the crisis the option market was found to be of major importance in the price discovery process. Additionally, we find those relationships being substantially stronger for financial firms relative to non-financial firms as a result of the increased importance of financial firms in market participants' investment decisions during the crisis periods. With respect to informed/insider trading as the common underpinning of price discovery in the option and stock markets, we find that only for highly rated, most liquid and financial firms the option market is leading the stock market. For the most liquid firms and during the financial crisis, our results suggest that the option market is negatively influencing the CDS market, which is counterintuitive, and puzzling, but highlighting the unique characteristics of the recent crisis.

The remainder of the paper is organized as follows. In the next section we summarize the literature. In section 3 we describe the data and the methodology, section 4 explains the testing procedures and provides a discussion of the empirical results. Finally, section 5 concludes.

2. Literature

Two different market-implied proxies are typically used to measure the creditworthiness of a firm. First of all, credit bond spreads which are defined as “the increase in yield over comparable government debt (the benchmark) that corporate borrowers of different ratings have to pay” (Servaes and Tufano, 2006, p.12). This difference changes over time; although, as may sound obvious, the higher the rating of the issuer the lower the credit spread will be. Credit bond spreads have been the focus of many research studies whose main objective was to identify how much of these credit spreads could be explained by default components and by non-default ones. In particular Collin-Dufresne et al. (2001) apply a structural credit risk model to study the determinants of monthly credit spreads changes. They use a set of multiple variables like volatility, leverage, business climate proxies, yield curve slope etc. But they are only able to explain a maximum of 25 percent of the spreads changes (identified by the regression R^2). Through a Principal Component Analysis (PCA) they also discover how the residuals from their regression model are highly cross-correlated and mostly driven by a single common factor arguing that bonds seem to be trading in a highly segmented market. The results identify local demand/supply shocks, independent of both changes in firm credit risk and typical measures of liquidity, which are usually seen as main determinants of credit spreads, as the dominant component of credit spread changes. Moreover, Campbell and Taksler (2002) study and document the strong relationship between equity volatility and credit bond spreads arguing that it can be an explanatory variable as powerful as the company’s own credit ratings. In fact, from their results, both of the variables explain about one third of the variation in corporate bond yield spreads. They also find a longer-term explanatory relationship between bond spreads and idiosyncratic equity volatility. Cremers et al. (2008) continue on this field of research introducing equity implied volatility as explanatory variable with respect to credit spread changes together with implied volatility skew. They also perform a PCA reversing the findings of Collin-Dufresne et al. (2001). Furthermore, they find the existence of a spillover effect between option-market liquidity and short-maturity corporate bond market pointing out how individual option prices contain information on the likelihood of rating migrations.

The second measure of a company’s creditworthiness available on capital markets is the so-called Credit Default Swap (CDS) spread. CDSs, as will be explained more extensively in the

following sections, represent the most common type of credit derivatives. They were designed to transfer the “risk of default” of a particular *reference entity* (underlying debt instrument debtor: a company or a sovereign entity) from a party which is seeking insurance protection (*protection buyer*) to the party that is willing to offer such a protection (*protection seller*) in exchange for a contractually determined fair premium (*CDS spread or premium*). Within a CDS not only the “risk of default” can be insured. There are several triggering events against which protection can be bought; namely default, bankruptcy, restructuring, repudiation or moratorium and obligation acceleration or default. Once one of these credit events takes place, the contract has to be settled either via a physical or a cash settlement, which was determined in the contract. One of the major features of CDSs, and also our main research focus, is the premium or spread. “The CDS spread is quoted as an annual premium, such as 1.00 percent or 100 basis points per annum, but it is actually paid in quarterly installments during the year” (Mengle, 2007, p.8). It should represent the fair value or price of the credit risk the institution (protection buyer) is subject to with respect to the debt instrument it is seeking to insure. The intense growth experienced by the credit derivatives market during the last decade gave researchers the opportunity to try to understand better what drives the pricing of credit risk (CDS spread). Continuing on the research path already mentioned in the previous paragraph, the relationship between CDS spreads and corporate bond spreads has been extensively examined. A theoretical arbitrage relation between the two which equals CDS spreads to the difference between bond yields and a reference risk-free rate is generally assumed. Following this research approach Blanco et al. (2005) consider 33 US and European investment grade firms and use the swap rate as the risk-free rate finding support to the theoretical relationship. They also find two forms of deviations from parity: for three companies CDS spreads result higher than bond spreads for long periods of time due to imperfections in contract specifications regarding CDS and errors in the CDS spread measurement. Moreover, they find that the CDS prices seem to lead credit bond spreads in the process of price discovery causing short-lived deviations from parity for all the rest of companies considered. These results point out how CDS spreads tend to respond more quickly to changes in credit conditions in the short-run. Similar results are provided by Longstaff et al. (2005) on a set of US firms using the Treasury rate as the risk-free rate. They identify how credit spreads seem to be composed of both default and non-default components. With respect to the non-default component, they discover how this seems to be particularly related to dimensions of individual corporate bond and market

wide liquidity (illiquidity) dimensions. This non-default component points out the significant difference between CDS spreads and corporate spreads. It can already be said that CDS spreads seem to be a more accurate and cleaner indicator of the firm's real creditworthiness or default risk. This is also confirmed in a study by Ericsson et al. (2009) who use a set of structural credit risk models to evaluate both the bond and the CDS spreads of a sample of US corporations. They point out how these models tend to underestimate the bond spreads but not the CDS spreads due to the importance of some omitted non-default risk components, in particular bond illiquidity, priced into bond spreads. In addition to this better default pricing capability, other advantages and benefits of the use of CDS spreads over bond spreads constitute the reason why CDS spreads have become in time the research focus of the credit risk pricing studies. New models and explanatory variables of CDS spreads have been investigated. Following the idea set out by Campbell and Taskler (2002), Benkert (2004) investigates the capability of both option implied volatility and historical volatility in explaining CDS spreads. Through the use of an international sample it becomes evident how option implied volatility is a more important factor in explaining the variation of credit default swap premia than historical volatility. Moreover, Ericsson et al. (2005) prove leverage, volatility and the risk free rate to be important determinants of the CDS spread as predicted by theory displaying an average explanatory power of 60 percent in regressions examining levels of CDS premia. Similar results are found in a study by Zhang et al. (2009) where they consider equity volatility risk and jump risk as explanatory variables. The authors are able to explain an average of 48 percent of the CDS spread changes considering volatility risk alone, confirming once more, the tight relationship between volatility and credit spreads considered as indicators of a company's risk. All of these studies are mainly based on US samples; Aunon-Nerin et al. (2002) instead follow the same line of reasoning using worldwide data but the majority of CDS quotes are still from US companies.

Based on Acharya and Johnson (2007), Berndt and Ostrovnaya (2008) investigate the impact of announcement of negative credit news on both credit default swap (CDS) and options market. The empirical finding shows that both the CDS and the option market react before prior to the announcement of negative credit news. But, options prices reveal information about such forthcoming adverse events at least as early as do credit spreads. They conclude that the options market trades on unsubstantiated rumors more than does the CDS market. In addition they find that

equity market does not react to abnormal movement in options but a strong incremental spillover is found from CDS to equity markets around adverse earnings releases.

Coudert and Gex (2008) use Vector Error Correction Model (VECM) and VAR model on major US and European firms sample to analyze the link between the CDS and the bond market. Conform to previous studies (Blanco et al. (2005), Zhu (2004)) they find that CDS lead bond market. In addition, they check the relationship between the CDS and the stock market using the same method, they find that the stock market has a lead over the CDS market. Coudert and Gex (2010) analyse the links between credit default swaps (CDSs) and bonds spreads, involving the crisis period. They find that the CDS market still leads the bond market for corporates and sovereigns. Moreover, the financial crisis seems to amplify the role of CDS market. Forte and Pena (2009) were the first who explore the dynamic between the three markets simultaneously: CDS, Stock and option market. Thus, they investigate the relationship between changes in credit spread measures related to: bond spreads, CDS spreads and stock market implied credit spreads (see Forte (2008) and Leland & Toft's (1996)). They apply a general VECM representation on sample of North American and European firms. The results indicate that stocks lead CDS and bonds more frequently than the other way round. It confirms the leading role of CDS with respect to bonds. They conclude that Stock market leads the price discovery process, followed by the CDS market. This is consistent with Norden and Weber (2009). In contrary, Meng et al. (2009) find that there is no a leading market. They examine the volatility transmission among the credit default swap (CDS), equity and bond markets using a multivariate GARCH model. They find an evidence of spillovers between the three markets, in other words, volatility of one market is transmitted to the other two markets.

Baba and Inada (2009) work on price discovery for four Japanese mega-banks' credit risk between subordinated credit default swaps (CDS) and subordinated bond spreads. They use the price discovery measures proposed by Gonzalo and Granger (1995) and Hasbrouck (1995). Their finding suggests that the two variables are co-integrated and CDS spread plays a more dominant role in price discovery than the bond spread. According to their results, the CDS spread has a significant effect on other financial market variables especially its own volatility and equity return. Furthermore, a significant volatility spillovers are detected from the CDS to bond spreads.

Most of the samples use in the studies mentioned above includes only US firms or US and European firms. Byström (2005) investigate on the behavior of iTraxx CDS Europe indexes. More precisely, he focus on the relationship between index spread changes and stock returns. Computing Pearson and Spearman rank correlations, he arrives to two main conclusions: The first indicates that the stock market tends to lead the CDS index market. While the second, shows a significant positive serial correlation in daily changes of iTraxx index. As an extension of this study, Alexander and Kaeck (2008) investigate the determinants of changes in the iTraxx Europe indices by applying a Markov switching model (Goldfeld and Quandt (1973) and Cosslett and Lee (1985)). The result between credit spreads and their determinants depends in particular on the volatility of the CDS market in normal market period (low volatility), the CDS spreads are more sensitive to stock returns than they are to stock volatility. While, during the instability period, the CDS spread depend to stock volatility. Furthermore, they find that theoretical determinants of structural credit risk models: interest rates, stock returns and implied volatility has a significant effect on CDS spreads. This result is consistent with Benkert (2004); Byström (2005) empirical studies. However, their sample does not include the 2007-2009 financial crisis. Avino et al. (2011) investigate the price discovery process in single-name credit spreads obtained from four markets: bonds, credit default swaps, equities and equity options on European data from January 2006 to July 2009. Using a VECM of changes in credit spreads, they find that, the equity market leads the other markets during tranquil periods, while, during the crisis, the option market lead the three other markets. This is confirmed by the strong volatility spillovers observed from the option market to the other markets. Even they include the crisis period, the sample include only 12 European non-financial companies.

In this study, we investigate lead-lag relation among the European Stock, option and Credit Default Swap markets. Our sample is composed of 91 financial and non-financial companies of investment- and non-investment grade over the period including the financial crisis.

3. Data and Methodology

3.1. Data

In our analysis, we use data related to the tree market: equity prices, option implied volatility and credit default swap spreads. The data was obtained from Thomson Reuters. The initial data set

consists of 163 European companies with daily observation from November 2003 to November 2010. After matching all the variables, the companies, the periods and dealing with missing data, we obtain a final sample of 91 companies from 15 July 2005 to 30 September 2010, and therefore, a total of 123 760 observations for each variable. We consider investment-grade and non-investment grade companies from financial and non-financial sectors.

CDS market

We extracted Senior CDSs with 5 year maturity, as they are the most liquid CDS contracts. We obtained data from Thomson Reuters data, coming from Credit Market Analysis (CMA), the history available data goes back to 01/01/2004. “CMA receives credit default swap (CDS) prices (“spreads”) from a range of market contributors. These contributors consist of both buy and sell side institutions active in the fixed income markets such as asset managers, hedge funds and banks. These active market participants provide CMA with both real-time and delayed prices of executed trades, firm or indicative bid/offers on a specific entities (e.g. company or emerging market), tenors, seniorities (ranking of the debt receiving moneys in case of default) and restructuring types. To ensure the highest level of accuracy CMA checks these prices against previous quotes and validates those using related securities and news. For less liquid entities where market activity is infrequent, CMA calculates the fair CDS spread using a proprietary issuer/sector curve model that derives an appropriate curve using known liquid CDS spreads, bond spreads and ratings data” (Thomson Reuters). We extract from this data base mid of bid/ask rates expressed in basis points. Additionally, the bid and ask rates are both used in the study to construct indicator of liquidity in the CDS market and thus make sub-samples analysis.

Option market

The relevant equity options data are also obtained from Thomson Reuters. In particular, for each firm and for both call and put options, an at-the-money implied volatility (IV) measure is retrieved. The implied volatility variable is the second most important element of our analysis. In fact, in order for a company to be included in the study, options trading volume has to be sufficiently high. In order to estimate a unique indicator of a firm’s equity options IV, an average of the call IV and put IV was calculated. This was done in order to reduce the possible noise contained in the data and obtain more accurate indicators with respect to option’s moneyness. The

measure of IV provided was the IV at-the-money (ATM) interpolated for a continuous series of options. According to Thomson Reuters definitions, the continuous series for calls or puts are calculated using the nearest expiry month options. Using MB Risk Management (MBRM) UNIVOPT – Universal Options Add In software together with the Black&Scholes and the Cox-Rubinstein Binomial Model, IV ATM interpolated is estimated taking into consideration “The nearest two options series at-the-money available: One above and one below the underlying price. For example if the underlying is 655 and the two closest ATM strikes are 650 and 700, the implied volatility of the 650 strike will be weighted 45/50 against the implied volatility 700 strike which is weighted 5/50” (Thomson Reuters Definitions).

Stocks market

Daily observations for Total Return Index (TRI) were also obtained from Thomson Reuters, assuming that dividends are re-invested to purchase additional units of an equity at the closing price applicable on the ex-dividend. Gross dividends are used where available and the calculation ignores tax and re-investment charges. Adjusted closing prices are used throughout to determine price index and hence return index. Since, the sample contains also United Kingdom companies; the prices were converted from pound GBP to euro currency using the actual exchange rate.

[Table 1]

Table 1 presents the cross-sectional summary statistics of the times series averages of variables using in the study during the period 15 July 2005 to 30 September 2010. It can be seen that on average firms in the sample have poorly performed with daily average stock return of -0.008 percent although the standard deviation shows a high value, 0.038 percent indicating that there is some heterogeneity between the various firms performance in the sample. Considering the fact that CDS spreads should be indicators of a firm’s creditworthiness, a high mean CDS spread (106 basis points) indicate that the sample also contains risky firms. While the standard deviation is, 92.01 basis points indicate that the sample firms display a different default risk; in fact, they range from a minimum value of 27 basis points to a maximum of 606 basis points. This is also

related to the sample considered since we investigate European companies which, as stated above, include investment-grade and non-investment grade. Considering the volatility measures, Implied Volatility and Historical Volatility takes more or less the same values for each summary statistic 33%. The heterogeneity between the companies observed through the standard deviation leads us to split our initial sample. Hence, we also provide a summary statistics for the sub samples using to check the robustness of the results in our analysis. The sample was divided according to: financial & non-financial sector, before & after the crisis, the credit worthiness and finally the CDS' market liquidity.

[Table 2 and Figure 1]

Table 2 report the cross-sectional summary statistics of the times series averages of variables for tow sub period: Before the crisis (from 15 July 2005 to 31 August 2007) and during & after the crisis (from 03 September 2007 to 30 September 2010). We considered crisis period started from 3 September 2007, because the most important negative events have occurred from that date onwards. The average CDS spread increased by 282% between the period before and after the crisis going from 40 to 152 basis points as illustrated in Figure 1. Given that CDS spread is one of risk measure, this increase in average spread shows that risk has grown significantly during the period of the financial crisis. Implied volatility which is another risk measure has also increased (much less than CDS spread) by 74% (from 23% to 40%) between the two periods. The table also shows an increase of the standard deviation between the two periods for both CDS spread and implied volatility, an increase of 201% and 129% respectively shows that the financial crisis has amplified the heterogeneity of the sample firms. In contrary, average of daily stock returns decrease after the crisis to -0.055% while the mean was 0.061% before the crisis.

[Table 3 and Figure 2]

Table 3 report the cross-sectional summary statistics of the times series averages of variables for the financial and non-financial sectors. CDS spread average is much higher for non-financial sector than financial sector, respectively 79 and 112 basis points. On the other hand, the implied volatility mean of the financial sector dominates the non-financial sector 40% against 32%. So, the non-financial sector is on average more risky than financial sector on the CDS market, while, the financial sector is the most risky on the on the option market. The CDS spread evolution over the entire period is shown in Figure 2. This shows that before the financial crisis, the financial sector is less risky than the other sector on the CDS market, while after the financial crisis; the difference between the average spreads of the two sectors is volatile and at some times the financial sector becomes more risky. The standard deviation of both CDS spread and implied volatility shows that the financial sample is more homogeneous compare to non-financial sample, it could be explained by the fact that non-financial sample include 74 firms while the second sample include only 17 firms.

[Table 4]

Table 4 report the cross-sectional summary statistics of the times series averages of variables for the three sub sample according to CDS market liquidity. The liquidity of the CDS market was proxied by the ratio of the bid-ask spread and the CDS mid point. We could see from the table that the most liquid market had higher values of CDS spread (149 basis points) and Implied volatility (35%), while, the medium one has lower values of these two variables (respectively 60 basis points and 31%). These result suggest that the most liquid market is the risky one, which is not intuitive but could be due to the crisis period effect.

[Table 5 and Figure 3]

Table 5 report the cross-sectional summary statistics of the times series averages of variables according to credit worthiness subdivisions. CDS spread average for the first group (the investment-grade companies) is more than three times higher than the average of the third group (46 basis points and 195 basis points respectively). Implied volatility is also higher for the worst companies 38% while it is 29% for the best companies. Figure 3 illustrates the evolution of the CDS spread for each of the three sub-samples over all study period. It highlights that increase in spreads after the crisis is much more important for the worst companies compare to other two groups. This shows that the financial crisis has a greater effect for the less creditworthy company.

3.2. Methodology

We want to examine how the price discovery process unfolds across European stock, option and CDS markets. In order to do this we apply a methodology similar to Acharya and Johnson (2007). Although we do not implement panel data regressions, but Seemingly Unrelated Regression SUR (Zeller, 1962) and then perform a cross-sectional t-test in order to verify the statistical significance of our average cross-sectional coefficient estimates. Using Panel data regression in our analysis will conduct us to inefficient result. Indeed, both fixed and random effect are based on assumption of large N and small T ($N \rightarrow \infty$ and T small), while our sample is characterized by large T and small N ($T \rightarrow \infty$ and N small). In this case it is more appropriate to use SUR regression. The methodology involves two steps; the first one allows extracting the residuals, which we are using in the second step as explanatory variables, thus, the model, can be estimated using SUR methodology.

In the first step, we regress the daily changes in CDS spreads, IV and stock returns over the three-times lagged values of CDS spread, IV changes and stock returns. To derive the CDS, option and stock market residual (respectively $r_{CDS,t}$, $r_{IV,t}$ and $r_{R,t}$), we estimate the following equations separately and for each company¹:

$$\Delta CDS_t = \alpha + \sum_{i=1}^3 \beta_i \Delta CDS_{t-i} + \sum_{i=1}^3 \gamma_i \Delta IV_{t-i} + \sum_{i=1}^3 \delta_i \Delta R_{t-i} + r_{CDS,t}$$

¹ Using Akaike's (1974) Information Criterion (AIC) and Schwarz's (1978) Bayesian Information Criterion (SBIC), the equation specification with three lags was found to be sufficient.

$$\Delta IV_t = \alpha + \sum_{i=1}^3 \beta_i \Delta CDS_{t-i} + \sum_{i=1}^3 \gamma_i IV_{t-i} + \sum_{i=1}^3 \delta_i \Delta R_{t-i} + r_{IV,t}$$

$$\Delta R_t = \alpha + \sum_{i=1}^3 \beta_i \Delta CDS_{t-i} + \sum_{i=1}^3 \gamma_i \Delta IV_{t-i} + \sum_{i=1}^3 \delta_i \Delta R_{t-i} + r_{R,t}$$

From these three regressions we obtain three vectors of residuals, which are then used as independent variables in the second step regression. We do this for up to three lags to absorb any lagged information transmission. The resulting residuals from each of the regressions can be interpreted as independent news from one market either not relevant or simply not appreciated by the other markets. These residuals should represent the amount of unique information contained in each market (option, stock and CDS market).

In the second step, changes in CDS spreads, IV and stock returns are regressed over the three lagged residuals. This allows us to investigate the predictive explanatory power of the unique information contained in each market with respect to future stock, CDS and option market movements.

$$R_{S,t} = \alpha_S + \beta_{S,CDS} r_{CDS,t-1} + \beta_{S,IV} r_{IV,t-1} + \beta_{S,S} r_{S,t-1} + \varepsilon_{S,t}$$

$$\Delta CDS_t = \alpha_{CDS} + \beta_{CDS,CDS} r_{CDS,t-1} + \beta_{CDS,IV} r_{IV,t-1} + \beta_{CDS,S} r_{S,t-1} + \varepsilon_{CDS,t}$$

$$\Delta IV_t = \alpha_{IV} + \beta_{IV,CDS} r_{CDS,t-1} + \beta_{IV,IV} r_{IV,t-1} + \beta_{IV,S} r_{S,t-1} + \varepsilon_{IV,t}$$

We use the SUR method to estimate the three equations independently. So, for each equation presented above, the SUR method estimates jointly the company-specific equations, taking into account the contemporaneous correlation of errors terms across equations. For each equation, the SUR method will consider the fact that:

$$E[\varepsilon_{i,t}, \varepsilon_{j,s}] = \delta_{i,j} \quad \text{For } t=s \text{ and } 0 \text{ otherwise.}$$

The method involves two steps, the first one consist to run OLS regression. The residuals produced by OLS estimation will be used to construct the variance matrix Σ , where the elements are given by the expression:

$$\hat{\sigma}_{ij} = \frac{1}{T} \hat{\varepsilon}_i' \varepsilon_j$$

The matrix obtained in the first step is used in the second step to run GLS estimation to obtain the coefficients:

$$\hat{\beta} = \left(X' (\hat{\Sigma}^{-1} \otimes I_T) X \right)^{-1} \left(X' (\hat{\Sigma}^{-1} \otimes I_T) y \right)$$

The cross-sectional average coefficient estimates (betas) and t-statistics (obtained through the cross-sectional t-test) are reported in Table 6. Note that if errors turn out to be uncorrelated or when the set of independent variables is the same, using SUR results in a standard OLS estimation in terms of efficiency.

4. Empirical Testing

As already outlined in the introduction section, we want to investigate the price discovery process exploring the lead-lag relation among stock, options, and CDS markets. As mentioned before, the US results of Cao et al. (2010) are consistent with the preference of informed traders to first using both option and CDS markets to exploit their information which subsequently diffuses into the stock market. Another contemporaneous study worth mentioning, although, investigates the relationship among the CDS, the stock and the bond market for an international sample of firms over the period 2000-2002 (Norden and Weber (2009)). They find that first, stock returns lead CDS and bond spread changes while CDS spread changes are found to Granger cause bond spread changes for a higher number of firms than vice versa. Second, the CDS market is more sensitive to stock market than the bond market and this effect increases the lower the credit quality and the larger the bond issues. Finally, they find that the CDS market contributes more to price discovery than the bond market although this effect seems stronger among US firms compared to European ones.

Inspired by those results, we examine how the price discovery process unfolds across European stock, option and CDS markets. In order to do this we apply a methodology similar to the one used in Acharya and Johnson (2007). US results suggest that CDS spread and IV changes can forecast future stock returns and they report this as evidence for informed investors' preference

for the option and CDS markets to exploit their insider information compared to the stock market. In contrast, from Table 6 it is apparent that this preference for derivative markets does not entirely hold in European markets; in fact, neither innovation in the option market is able to predict future movements in stock or CDS markets. Both coefficients ($\beta_{S,IV}$ and $\beta_{CDS,IV}$) are not statistically significant.

[Tables 6]

However, the CDS market seems to play a leading role in the price discovery process. Changes in the CDS spread negatively influence the stock markets, suggesting that negative news about the creditworthiness of a firm (in line with an increase in the spread) lead to a drop of the stock price on the following day. Moreover considering the relationship between CDS and option markets, it was found in US studies that innovations in the options market can consistently forecast changes in the CDS spreads, but not the other way around. We report contrasting result considering the previously mentioned insignificant $\beta_{CDS,IV}$ and the positive and significant (at the 1 percent level) coefficient obtained with respect to the predictive power of the CDS market on changes in implied volatilities ($\beta_{IV,CDS}$). This confirms the strong relationship between the two markets already documented in previous studies and takes this one step further as we show that beyond displaying a contemporaneous link, the CDS market is also leading the price discovery process in the options market as evidence for the fact that informed investors tend to prefer the CDS market to the options market to exploit their informational advantage.

Finally, considering the stock market predictive power, we find that with respect to both the CDS and the option market the average coefficients ($\beta_{CDS,S}$ and $\beta_{IV,S}$) are found to be negative and statistically significant (at the 1 and 5 percent level) documenting how the stock market seems to also lead the price discovery process in the other two markets. With respect to the coefficient being negative, it can be seen that a 1 percent negative change in the stock return triggers a significant positive change in the CDS spread and IV over the next day. This phenomenon was “first discussed by Black (1976, p.177), who observed that the amplitude of relative price fluctuations (“volatility”) of a stock tends to increase when its price drops. This effect is particularly impor-

tant for option markets: option prices indeed reflect the fact that a negative volatility-return correlation induces a negative skew in the distribution of returns on longer time scales” (Bouchaud, Matacz and Potters, 2001, p.1). Considering the positive contemporaneous relationship already documented in previous studies between IV and CDS spreads and the fact that, as already stated, they are both measures of a firm’s riskiness, it is not surprising to find the same negative lead-lag relation between stock returns and CDS spreads. These results are also in line with Norden and Weber (2009) who find that European stock returns lead CDS and bond spread changes.

[Tables 7-9]

As a robustness check we subdivide our regression results into sub-samples according to sector (financial vs. non-financial), creditworthiness (proxied by level of CDS spread) and liquidity (proxied by the bid-ask spread relative to the CDS mid-point). Tables 7-9 report the results for the cross-sectional average coefficient estimates (betas) and their relative t-statistics (obtained through the implementation of the afore-mentioned cross-sectional t-test). The results in Table 7 suggest that the overall results are partly driven by the financial companies in the sample, but that the sub-sample results also differ. The results for financial firms are typically similar in terms of statistical significance, but always stronger in terms of economical significance. Interestingly, for financial firms, we find a volatility feedback effect from the option market to the stock market, suggesting that an increase in implied volatility predicts a drop in the underlying stock price. Table 8 looks at the lead-lag results from a company’s credit quality point of view using CDS spread levels to form the sub-samples. Again, both the CDS market and the stock market seem to lead the price discovery process in the options market across all groups which can be seen from statistically significant coefficient estimates (at the 1 percent level). Therefore, the findings are in line with Cao et al. (2010) and Acharya and Johnson (2007), suggesting the existence of two different groups of investors: a more sophisticated one which considers to enter the CDS market and a less sophisticated one which instead sticks with more traditional capital markets dynamics to exploit its knowledge. The reported results are also in line with what Norden and Weber (2009) find concerning the fact that the CDS market seems to be more sensitive

to the stock market as the credit quality of the reference entity decreases; in fact, looking at the average coefficients going from group 1 to group 3 the relationship becomes stronger. An interesting result emerges concerning the options and stock market dynamics as $\beta_{S,IV}$ becomes negative and significant at the 1 percent level moving from group 3 to group 1. This could be interpreted as a sign that for more solid firms investors tend to exploit their knowledge through opening positions in the options market. For those firms, despite the existence of a new competitive CDS market, the options market still plays an important role in the price discovery process. Finally, Table 9 summarizes the results looking at CDS market liquidity indicators, using the bid-ask spread relative to the CDS mid-point as a proxy for liquidity. Since the results are similar we only comment on the ones involving the options markets. As can be seen from Table 9, the stock market seems to be leading the price discovery process in both the option and CDS markets for the most actively traded group of firms. On the other hand, there is also evidence of some spillover effect of the CDS and option markets into the stock market. In line with the results regarding creditworthiness, the more liquid the derivatives markets are, the more investors tend to exploit their knowledge through opening positions in the options market, leading to significant coefficients $\beta_{S,IV}$ and $\beta_{CDS,IV}$. Finally, looking at the CDS and option market relationship, it can be seen that as the liquidity in the CDS market increases the connection between the two markets becomes stronger. The higher the liquidity of the CDS market, the tighter is the competition between the two markets and the more intertwined they become in the price discovery process.

[Tables 10]

Finally, we would like to separately analyze the price discovery process of the three markets before, during and after the financial crisis. Detailed results are presented in Table 10. A striking result is that our overall findings are very much driven by the dynamics that we observe during the financial crisis. Before the crisis and in line with most of the US studies, we observe that the options market is leading the CDS market and therefore, the options market plays the crucial role in the price discovery process. In this period, we do not observe different spillover effects. Most of the other dynamics that we observe and previously discussed emerge during the recent finan-

cial crisis. One exception is the negative coefficient $\beta_{CDS,IV}$, suggesting that the option market is negatively influencing the CDS market, which is counterintuitive and puzzling, highlighting the unique characteristics of the recent crisis.

5. Conclusions

The aim of this European study covering the financial crisis period is to empirically investigate the relative informational efficiency of stock, options and credit default swaps. We try to answer this question by testing for a lead-lag relationship and exploring the price discovery process across all three markets. Tracking the relatively recent field of research, which investigates the information content of equity options and CDS to predict returns on the underlying stock (see Cao et al. (2005 and 2010), Pan and Poteshman (2006), Acharya and Johnson (2007)), we perform another two step time-series regression analysis together with a cross-sectional t-test which, first, tries to identify the information advantage of each market with respect to the others and then uses this as explanatory variable for future changes in the other considered markets. Overall it can be concluded that investors seem to first prefer stock and CDS market involvement to exploit their informational advantages and then move to option markets. Therefore, the findings are suggesting the existence of two different groups of investors: a more sophisticated one which considers to enter the CDS market and a less sophisticated one which instead sticks with more traditional capital markets dynamics to exploit its knowledge.

In particular, a lead-lag relation is found between the CDS market and the other markets in which changes in CDS spreads are able to consistently forecast changes in stock prices and equity options' implied volatilities, pointing out how the fast growing CDS market seems to play a special role in the price discovery process. Moreover, in contrast to US results, the stock market is found to forecast changes in the other two markets suggesting that investors also prefer stock market involvement to exploit their information advantages and then move to CDS and option markets. Interestingly, these patterns have only emerged during the recent financial crisis, while before the crisis the option market was found to be of major importance in the price discovery process. Additionally, we find those relationships being substantially stronger for financial firms relative to non-financial firms as a result of the increased importance of financial firms in market participants' investment decisions during the crisis periods. With respect to informed/insider trading as the common underpinning of price discovery in the option and stock markets, we find

that only for highly rated, most liquid and financial firms the option market is leading the stock market. For most liquid firms and during the financial crisis, our results suggest that the option market is negatively influencing the CDS market, which is counterintuitive and puzzling, highlighting the unique characteristics of the recent crisis.

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Figure1. Daily CDS spread

Figure 1 presents daily Credit Default Swaps evolution over the period **15 July 2005 to 30 September 2010**; the solid line the cross sectional average of 91 firms in Basis point; the first quartile Q1 (25th [percentile](#)) in dotted line and the third quartile Q3 (75th percentile) in dash line were calculated on cross sectional data.

Figure2. Financial Vs. non financial CDS spread

Figure 2 shows the evolution of the CDS spread (BPS) of the financial and non-financial sector over the period **15 July 2005 to 30 September 2010**; The solid line represents the cross-sectional average of non-financial firms (74 firms) while dash line represents the cross-sectional average of financial firms (17 firms)

Figure3. Credit worthiness proxied by CDS spread

Figure 3 shows the evolution of the CDS spread according to the credit worthiness subdivision proxied by CDS spread (BPS) over the period **15 July 2005 to 30 September 2010**; Dash line (G1) represents cross-sectional average of best companies; The solid line (G2) represents cross-sectional average of medium quality companies while dot line (G3) represents the cross-sectional average of worst companies.

Table 1. Summary Statistics

For each variable, Table 1 reports the summary statistics of the time-series averages of the entire sample firms. CDS Spread is the daily five-year composite credit default swap spread; Historical Volatility is the 252-day historical volatility; Implied Volatility is the average of call and put implied volatilities at the money interpolated as available on Thomson Datastream; Firm Daily Stock Return is the daily average of firm continuously compounded stock returns; CDS Spread Changes and Implied Volatility Changes are the daily change in CDS spreads and IV of the average sample firm respectively. The sample period extends from 15 July 2005 to 30 September 2010.

	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread (BPS)	106.01	70.74	92.01	27.12	605.84	54.05	128.73
Historical volatility	33.41%	32.24%	7.99%	20.58%	59.08%	27.05	39.82%
Implied volatility	33.09%	31.79%	7.44%	14.99%	53.53%	27.78%	39.07%
Stock returns (daily)	-0.008%	-0.003%	0.038%	-0.189%	0.059%	-0.028%	0.015%
CDS spread change	6.32%	4.78%	9.01%	-33.25%	44.06%	3.04%	6.94%
Implied volatility change	0.006%	0.006%	0.006%	-0.020	0.022%	0.002%	0.009%

Table 2. Before Vs. during and after the crisis

For each variable, Table 2 reports the summary statistics of the time-series averages of the two sub-samples firms: Before the crisis from 15 July 2005 to 31 August 2007 (panel 1) and during & after the crisis from 03 September 2007 to 30 September 2010 (panel 2). CDS Spread is the daily five-year composite credit default swap spread; Historical Volatility is the 252-day historical volatility; Implied Volatility is the average of call and put implied volatilities at the money interpolated as available on Thomson Datastream; Firm Daily Stock Return is the daily average of firm continuously compounded stock returns; CDS Spread Changes and Implied Volatility Changes are the daily change in CDS spreads and IV of the average sub-samples firms respectively.

Panel 1. Before the crisis : 15/07/2005 to 31/08/2007							
	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread	39.77	28.03	44.91	5.79	290.98	15.88	44.52
Historical volatility	21.62%	20.62%	4.91%	14.06%	47.48%	18.60%	23.54%
Implied volatility	23.41%	22.97%	4.73%	10.64%	47.73%	21.07%	25.52%
Stock returns (daily)	0.061%	0.061%	0.050%	-0.040%	0.245%	0.028%	0.085%
CDS spread change	0.98%	0.95%	10.75%	-63.18%	54.60%	-0.56%	2.94%
Implied volatility change	0.017%	0.016%	0.011%	-0.027%	0.048%	0.010%	0.025%
Panel 2. During & after the crisis: 03/09/2007 to 30/09/2010							
	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread	151.82	100.74	135.22	40.24	873.41	72.37	183.28
Historical volatility	41.61%	38.69%	12.02%	25.12%	88.64%	32.05%	49.53%
Implied volatility	39.79%	37.79%	10.83%	18.00%	77.29%	31.10%	48.35%
Stock returns (daily)	-0.055%	-0.046%	0.056%	-0.319%	0.039%	-0.084%	-0.018%
CDS spread change	10.02%	7.29%	12.11%	-26.86%	62.30%	5.01%	10.77%
Implied volatility change	-0.001%	-0.001%	0.007%	-0.022%	0.021%	-0.006%	0.003%

Table 3. Financial Vs. non financial firms

For each variable, Table 3 reports the summary statistics of the time-series averages of the two panels: Non financial sector (panel 1) and Financial sector (panel 2). CDS Spread is the daily five-year composite credit default swap spread; Historical Volatility is the 252-day historical volatility; Implied Volatility is the average of call and put implied volatilities at the money interpolated as available on Thomson Datastream; Firm Daily Stock Return is the daily average of firm continuously compounded stock returns; CDS Spread Changes and Implied Volatility Changes are the daily change in CDS spreads and IV of the average sub-samples firms respectively. The sample period extends from 15 July 2005 to 30 September 2010.

Panel 1. Non financial sector							
	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread	112.30	70.69	100.27	27.12	605.84	52.01	145.35
Historical volatility	31.56%	30.23%	7.06%	20.58%	50.56%	25.70%	36.53%
Implied volatility	31.59%	29.72%	6.96%	14.99%	47.88%	26.71%	36.75%
Stock returns (daily)	0.000%	0.003%	0.031%	-0.103%	0.059%	-0.022%	0.019%
CDS spread change	6.12%	4.17%	9.95%	-33.25%	44.06%	2.72%	5.87%
Implied volatility change	0.004%	0.005%	0.005%	-0.020%	0.021%	0.002%	0.007%
Panel 2. Financial sector							
	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread	78.62	70.74	27.72	44.20	138.91	57.57	88.03
Historical volatility	41.46%	40.72%	6.86%	30.54%	59.08%	37.59%	45.28%
Implied volatility	39.65%	39.52%	5.85%	29.22%	53.53%	37.57%	41.04%
Stock returns (daily)	-0.041%	-0.035%	0.048%	-0.189%	0.026%	-0.063%	-0.007%
CDS spread change	7.22%	6.96%	2.12%	3.61%	12.45%	6.20%	8.27%
Implied volatility change	0.012%	0.012%	0.006%	0.002%	0.022%	0.008%	0.015%

Table 4. CDS volume as proxy of liquidity

For each variable, Table 4 reports the summary statistics of the time-series averages for the three sub sample according to CDS market liquidity subdivision. CDS Spread is the daily five-year composite credit default swap spread; Historical Volatility is the 252-day historical volatility; Implied Volatility is the average of call and put implied volatilities at the money interpolated as available on Thomson Datastream; Firm Daily Stock Return is the daily average of firm continuously compounded stock returns; CDS Spread Changes and Implied Volatility Changes are the daily change in CDS spreads and IV of the average sub-samples firms respectively. The sample period extends from 15 July 2005 to 30 September 2010.

Panel 1. The most liquid market							
	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread	148.64	119.81	121.61	47.71	605.84	70.03	164.44
Historical volatility	34.53%	34.96%	6.65%	23.67%	45.46%	28.63%	40.36%
Implied volatility	35.31%	36.71%	6.46%	24.20%	46.56%	29.37%	40.11%
Stock returns (daily)	-0.008%	-0.001%	0.038%	-0.103%	0.058%	-0.032%	0.018%
CDS spread change	9.02%	5.53%	12.02%	-9.42%	44.06%	2.60%	10.09%
Implied volatility change	0.006%	0.006%	0.005%	-0.009%	0.021%	0.004%	0.009%
Panel 2. The medium liquid market							
	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread	60.33	53.51	30.84	29.23	194.76	44.06	65.27
Historical volatility	31.87%	31.68%	6.52%	22.48%	46.10%	25.60%	37.08%
Implied volatility	31.39%	29.70%	6.04%	18.76%	44.68%	27.23%	36.23%
Stock returns (daily)	-0.003%	-0.004%	0.032%	-0.081%	0.059%	-0.024%	0.023%
CDS spread change	5.06%	4.22%	3.29%	2.04%	19.50%	3.39%	6.35%
Implied volatility change	0.008%	0.007%	0.006%	-0.001%	0.022%	0.003%	0.012%
Panel 3. The less liquid market							
	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread	108.97	81.64	79.20	27.12	357.88	56.89	135.37
Historical volatility	33.81%	31.55%	10.20%	20.58%	59.08%	25.79%	42.35%
Implied volatility	32.59%	31.84%	9.09%	14.99%	53.53%	25.46%	38.39%
Stock returns (daily)	-0.011%	-0.005%	0.045%	-0.189%	0.054%	-0.026%	0.011%
CDS spread change	4.94%	4.82%	9.10%	-33.25%	26.24%	3.49%	7.05%
Implied volatility change	0.004%	0.004%	0.006%	-0.020%	0.020%	0.002%	0.007%

Table 5. credit worthiness proxied by CDS spread

For each variable, Table 5 reports the summary statistics of the time-series averages according firms credit worthiness subdivision proxied by CDS spread (BPS). CDS Spread is the daily five-year composite credit default swap spread; Historical Volatility is the 252-day historical volatility; Implied Volatility is the average of call and put implied volatilities at the money interpolated as available on Thomson Datastream; Firm Daily Stock Return is the daily average of firm continuously compounded stock returns; CDS Spread Changes and Implied Volatility Changes are the daily change in CDS spreads and IV of the average sub-samples firms respectively. The sample period extends from 15 July 2005 to 30 September 2010.

Panel 1. The best compagnies							
	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread	46.12	45.15	8.24	27.12	57.05	43.29	53.36
Historical volatility	28.38%	27.17%	5.52%	20.58%	46.10%	25.07%	29.75%
Implied volatility	28.67%	28.01%	5.46%	18.76%	44.68%	25.77%	30.39%
Stock returns (daily)	0.003%	0.005%	0.031%	-0.081%	0.059%	-0.012%	0.020%
CDS spread change	3.96%	3.59%	2.07%	1.62%	11.69%	2.66%	4.21%
Implied volatility change	0.005%	0.004%	0.005%	-0.002%	0.004%	0.002%	0.006%
Panel 2. The medium quality companies							
	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread	73.87	69.79	12.80	57.52	97.18	63.83	86.43
Historical volatility	33.38%	31.94%	8.40%	21.94%	59.08%	28.43%	39.41%
Implied volatility	32.63%	31.63%	7.72%	14.99%	53.53%	27.49%	37.64%
Stock returns (daily)	-0.017%	-0.008%	0.044%	-0.189%	0.046%	-0.032%	0.007%
CDS spread change	5.02%	5.16%	2.88%	-3.99%	12.45%	3.33%	6.47%
Implied volatility change	0.007%	0.005%	0.006%	-0.002%	0.021%	0.003%	0.012%
Panel 3. The worst companies							
	Mean	Median	STDEV	Min	Max	Q1	Q3
CDS spread	195.08	156.91	111.17	113.02	605.84	128.73	200.46
Historical volatility	38.30%	37.67%	6.64%	24.11%	50.56%	33.98%	42.87%
Implied volatility	37.82%	38.99%	6.08%	24.69%	47.88%	33.42%	41.64%
Stock returns (daily)	-0.009%	-0.003%	0.038%	-0.103%	0.058%	-0.032%	0.016%
CDS spread change	9.87%	6.29%	14.53%	-33.25%	44.06%	4.33%	17.89%
Implied volatility change	0.006%	0.007%	0.007%	-0.020%	0.021%	0.005%	0.009%

Table 6. Lead-Lag Analysis of changes of the CDS Spreads, Implied Volatilities and Stock Returns

Entire Sample

Cross-sectional average coefficients and t statistics (in parentheses) of lead-lag time series SUR regressions of changes of the CDS spread, implied volatility and the stock return for the entire sample. Newey and West (1987) standard errors are used to compute t-statistics. (***) indicates statistical significance at the 1 percent level, (**) at the 5 percent level and (*) at the 10 percent level. The regression equations and the coefficients are defined in equations (8)-(10). The sample period extends from 15 July 2005 to 30 September 2010.

Entire sample	
$\beta_{S,CDS}$	-7.9 E-05 (-4.03)***
$\beta_{S,IV}$	-0.00 (-1.53)
$\beta_{CDS,S}$	-11.00 (-5.64)***
$\beta_{CDS,IV}$	-0.01 (-0.59)
$\beta_{IV,S}$	-2.37 (-2.96)**
$\beta_{IV,CDS}$	0.01 (5.29)***

Table 7. Lead-Lag Analysis of changes of the CDS Spreads, Implied Volatilities and Stock Returns

Financial Vs non- Financial sector subsamples

Cross-sectional average coefficients and t statistics (in parentheses) of lead-lag time series SUR regressions of changes of the CDS spread, implied volatility and the stock return for each of the sub-groups. Newey and West (1987) standard errors are used to compute t-statistics. (***) indicates statistical significance at the 1 percent level, (**) at the 5 percent level and (*) at the 10 percent level. The regression equations and the coefficients are defined in equations (8)-(10). The sample period extends from 15 July 2005 to 30 September 2010.

	Financial / non- Financial Sector	
	Financial	Non-financial
$\beta_{S,CDS}$	-1.2 E-04 (-5.70)***	-7.0 E-05 (-3.64)***
$\beta_{S,IV}$	- 2.7 E-04 (-3.60)***	- 1.1 E-04 (-1.15)
$\beta_{CDS,S}$	-8.88 (-8.05)***	-11.49 (-5.49)***
$\beta_{CDS,IV}$	-0.01 (-1.28)	-0.01 (-0.49)
$\beta_{IV,S}$	-7.47 (-5.96)***	-1.20 (-2.04)*
$\beta_{IV,CDS}$	0.01 (6.41)***	0.01 (5.05)***

Table 8. Lead-Lag Analysis of Changes of the CDS Spreads, Implied Volatility, and Stock Return

Credit worthiness sub samples proxied by CDS spread

Cross-sectional average coefficients and t statistics (in parentheses) of lead-lag time series SUR regressions of changes of the CDS spread, implied volatility and the stock return for each of the sub-groups. Newey and West (1987) standard errors are used to compute t-statistics. (***) indicates statistical significance at the 1 percent level, (**) at the 5 percent level and (*) at the 10 percent level. The regression equations and the coefficients are defined in equations (8)-(10). The sample period extends from 15 July 2005 to 30 September 2010.

	Credit worthiness		
	Group1 best	Group2	Group3 worse
$\beta_{S,CDS}$	-8.5 E-05 (-3.54)***	-9.9 E-05 (-4.52)***	-5.3 E-05 (-5.66)***
$\beta_{S,IV}$	-3.6 E-04 (-2.91)***	-1.4 E-04 (-1.79)*	7.4 E-04 (1.38)
$\beta_{CDS,S}$	-4.45 (-3.69)***	-4.41 (-4.17)***	-23.71 (-9.70)***
$\beta_{CDS,IV}$	-0.01 (-1.16)	0.00 (0.21)	-0.02 (-0.73)
$\beta_{IV,S}$	-1.25 (-1.99)*	-4.15 (-3.92)***	-1.74 (-2.87)***
$\beta_{IV,CDS}$	0.01 (5.36)***	0.01 (6.06)***	0.01 (4.65)***

Table 9. Lead-Lag Analysis of Changes of the CDS Spreads, Implied Volatility, and Stock Return

Liquidity sub samples

Cross-sectional average coefficients and t statistics (in parentheses) of lead-lag time series SUR regressions of changes of the CDS spread, implied volatility and the stock return for each of the sub-groups. Newey and West (1987) standard errors are used to compute t-statistics. (***) indicates statistical significance at the 1 percent level, (**) at the 5 percent level and (*) at the 10 percent level. The regression equations and the coefficients are defined in equations (8)-(10). The sample period extends from 15 July 2005 to 30 September 2010.

	Liquidity		
	G1 +liquid	G2	G3 -liquid
$\beta_{S,CDS}$	-1.1 E-04 (-5.84)***	-2.3 E-05 (-1.00)	-1.0 E-04 (-6.81)***
$\beta_{S,IV}$	-7.9 E-05 (-1.90)*	-3.7 E-04 (-3.10)***	2.5 E-05 (0.27)
$\beta_{CDS,S}$	-15.72 (-6.88)***	-2.26 (-2.74)***	-14.89 (-7.23)***
$\beta_{CDS,IV}$	-0.04 (-3.02)***	-0.00 (-0.28)	0.02 (0.87)
$\beta_{IV,S}$	-1.08 (-2.07)**	-1.58 (-2.14)**	-4.40 (-4.35)***
$\beta_{IV,CDS}$	0.01 (6.35)***	0.01 (5.45)***	0.01 (4.21)***

Table 10. Lead-Lag Analysis of Changes of the CDS Spreads, Implied Volatility, and Stock Return

Before/ During & after crisis sub sample

Cross-sectional average coefficients and t statistics (in parentheses) of lead-lag time series SUR regressions of changes of the CDS spread, implied volatility and the stock return for each of the sub-groups. Newey and West (1987) standard errors are used to compute t-statistics. (***) indicates statistical significance at the 1 percent level, (**) at the 5 percent level and (*) at the 10 percent level. The regression equations and the coefficients are defined in equations (8)-(10). The first sample period extends from 15/07/2005 to 30/08/2007 and the second sample period extends from 03/09/2007 to 30/09/2010.

	Sub period	
	Before the crisis	During & after the crisis
$\beta_{S,CDS}$	7.3 E-05 (1.37)	-1.1 E-04 (-4.90)***
$\beta_{S,IV}$	-6.4 E-05 (-0.63)	-1.3 E-04 (-1.30)
$\beta_{CDS,S}$	-2.13 (-1.49)	-15.00 (-6.09)***
$\beta_{CDS,IV}$	0.04 (2.58)**	-0.03 (-1.68)*
$\beta_{IV,S}$	0.00 (0.34)	-0.03 (-3.71)***
$\beta_{IV,CDS}$	9.5 E-06 (0.09)	1.3 E-04 (5.66)***