The timeliness of CDS spread changes in predicting corporate default, 2004-2008*

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Abstract: A Credit Default Swap (CDS) is a derivative that prices insurance against the default of its underlying bond. This paper tests the ability that CDS spreads have to predict default by addressing the question: how long before default does a significant change in the CDS spread occur? The sample analysed consists of 39 'default events' by Moody's rated corporate issuers from 2004 to 2008. Included in the sample are some of the systemic financial institutions of the 2008 credit crisis such as Lehman Brothers, GMAC, and Washington Mutual. The results are significant; CDS spreads are found to be powerful instruments for default prediction. Matching firm-adjusted CDS spreads in this sample increase substantially between 22 and 25 days prior to default, and these findings are robust to CDS index-adjustments. The magnitude and significance of the results are much larger for financial firms, most likely because of their increased exposure to default through leverage. Changes in spreads prior to default are also more significant during the credit crisis than in earlier periods.

JEL Classifications: G01, G10, G14

Keywords: credit risk, credit derivatives, credit default swaps, CDS spreads

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1. Introduction

The Credit Default Swap (CDS) market was 'hailed as a wonder of modern finance (Economist, 2008)' until 2007, when the notional outstanding value grew to $62.2 trillion (ISDA, 2007). Up from almost nil a decade ago and "roughly twice the size of the U.S. stock market", the CDS market far exceeded the $7.1 trillion mortgage market and $4.4 trillion U.S. Treasuries market (Time, 2008). A significant increase in defaults from just 19 to 106 Moody's-rated bonds from 2007 to 2008 has drawn attention to the CDS market and seen its value fall. This paper aims to examine the power of the CDS spread as an instrument for predicting default.

A credit spread is the difference in yield between securities, as a result of differing credit risk levels. A credit spread is usually quoted as the additional yield earned or paid above a benchmark, credit risk-free security. Credit risk is the risk that an issuer might default on a payment or go into liquidation, also known as default or counterparty risk (Reuters, 2003).

These financial risks inspired the development of credit default swaps (CDS's) in 1997 by JPMorgan Chase, designed to shift the risk of default to a third party. A CDS is a credit derivative contract between two counterparties where the buyer makes payments to the seller who in turn receives a payoff if the underlying financial instrument defaults. The spread of a CDS is what the buyer pays the seller as an annual percentage of the notional amount, until a credit event occurs or maturity is reached. CDS's have remained largely exempt from regulation due to the Commodity Futures Modernization Act 2000.

This lack of regulation has been blamed for the significant increase in defaults during 2008 by banks, brokers, insurers and mortgage agencies including Fannie Mae and Freddie Mac. In the words of Chris Cox, the chairman of the US Securities and Exchange Commission, the CDS market is "completely lacking in transparency and completely unregulated (Telegraph, 2008)". CDS losses affected Lehman Brothers, AIG, and Bear Stearns, among others. Leading up to the collapse of Bear Stearns the bank's CDS spread widened significantly, leading to a rush of buyers looking for protection against default. Markets have speculated that the widened spread restricted the banks access to wholesale capital, forcing the sale to JPMorgan in March 2008. However, others suggest the CDS surge was a symptom created by the hedging and speculation of informed investors. An example of the effect CDS exposure had on Lehman is provided below:

> *"The gross notional volume of CDS contracts written on Lehman is around $400bn. At the October 10 auction organized by the ISDA defaulted Lehman bonds secured a recovery value of 8.7 cents on the dollar. CDS protection sellers are thus called to pay out 91.3 cents of the insured face value to the protection buyers on October 21 (RGE Monitor, 2008)".*

2009 has seen both U.S. and European regulators attempting to stabilize the CDS market, and globally agreed standards administered by the International Swaps and Derivatives Association (ISDA) became effective in March of this year.

Given the severity of the 2008 credit crisis and its obvious connection with the CDS market, the question of interest is could it have been foreseen? The CDS spread seems to have the potential as a powerful instrument in predicting the defaults of 2008 and of the future. Blanco, Brennan and Marsh (2005) find the CDS market to be more efficient than both the stock and bond markets in pricing changes in risk. It is also likely that the CDS market is more efficient and liquid than changes to ratings when adjusting for new information, and in indicating the risk of default. Hull et al. (2004) suggest that CDS spreads are a better alternative to pure yield spreads as they imply a commitment to trade by the dealer and no assumption about a benchmark risk-free rate is required. If a relationship between the CDS spread and default probability can be established, it will have important implications for investors, risk managers, and regulators. Most importantly, this relationship has the potential to foresee and potentially avoid a similar situation to the credit crisis of 2008.

This paper will test CDS spreads as an instrument for predicting default by addressing the question: how long before default does a significant change in the CDS spread occur? Given the time frame from which default events are observed, 2004-2008, conclusions are also drawn on the behaviour and power of the CDS spread during periods of economic stability and crisis. A separate analysis is also performed on 'financial' and 'non-financial' firms as a form of industry analysis.

The remainder of the paper proceeds as follows. The next section contains a literature review. Section 3 outlines the research hypotheses, Section 4 introduces the data set, while Section 5 describes the research methodology and techniques. Section 6 contains the empirical findings, and Section 7 concludes.

2. Literature Review

Empirical literature on credit spreads focuses on three main areas: on the shape of the term structure across ratings categories, the components of corporate bond yield spreads, and the economic determinants of the level and changes in the level of corporate spreads (Bedendo et al., 2007). Existing models of default risk, which fit into two categories, are applied in each of these topical areas. Firstly, the structural approach proposed by Merton (1974) is based on a default boundary determined by credit quality. This model generally finds the term structure of high-quality firms to be upward sloping, and humped or downward sloping for lower-quality firms. The second approach is the reduced-form structural model (Jarrow and Turnbull (1995) among others), which is more flexible and 'easier to calibrate to observed credit spreads (Bedendo et al., 2007)'. This approach has no lower boundary on the assets or leverage of the firm and uses a 'hazard rate' to predict the default event.

2.1 Default prediction

Manning (2004) aims to test a finding of recent empirical work, that 'changing default expectations can explain only a fraction of the variability in credit spreads'. A sample of UK investment-grade bonds issued by industrial companies is related to default probabilities generated by the 'Bank of England's Merton model of corporate failure'. An error-correction method is used to capture the long and short-term relationship, and to avoid non-linear exploitation implied default probabilities are generated. This adapted model allows default to occur at any time, once a certain threshold has been reached, rather than only at maturity.

The study finds default probabilities to explain only a small portion of the variation in credit spreads for high quality corporate issues (8% for AAA/AA, 11% for A). It is found that macroeconomic factors such as liquidity conditions are of 'greater importance'. However for lower-rated investment-grade bonds, the probability of default is more important in determining credit spreads (explaining approximately 1/3 variability). Allowing for heterogeneity in ratings subgroups increases explanatory power to 28% and 50% respectively, confirming the importance of the non-linear model and consideration of macroeconomic factors (risk and liquidity premia). Some evidence is found that 'credit spreads respond more readily to changes in near-term default expectations' (one-year rather than five-year default probability), a point that motivates a study of the timeliness of credit spread changes in predicting default. These findings are thought to be a result of the more direct application of the Merton model which captures the non-linearity, crucial for companies closer to the default point.

Chou (2005) completes a study close to the relationship to be tested in this paper: the timeliness of credit spread changes and their ability to predict default. This article is a purely theoretical study analysing the information content of the distance-from-default regarding a firm's default risk. Merton's (1974) option pricing model is used to examine the relationships between the expected default probability of a firm and its distance-from-default (DD), and the relationship between credit spreads and DD. The KMV Corporation's 'DD' metric measures 'how many standard deviations a firm's asset value is away from its debt obligations' (where a higher measure means further from default). This article demonstrates that 'both expected default probability and credit spreads could be expressed by the analytical function of the DD'.

A further different approach to modelling default probabilities is proposed by Grass (2009); this paper develops a new procedure for extracting default probabilities from structural credit risk models based on 'virtual credit spreads (VCS)' and implements this approach using a simple Merton (1974) model of capital structure. 'VCS are derived as the impact of an increase in asset variance on the option value of debt and equity'. They 'yield a purer estimate of physical default probabilities' as they do not contain risk premia for default timing and recovery uncertainties. The properties of these VCS estimates, assuming a simple Merton model of capital structure, are compared to the expected default frequency from the Merton DD measure in a numerical analysis. The VCS estimates predict higher credit risk for safe firms and lower credit risk for firms with high volatility and leverage compare to the DD measure. The VCS estimates also require fewer parameter assumptions and are concluded to outperform the DD measure in predicting corporate default.

Before concluding the analysis of the attempts so far to model default prediction, it is necessary to mention research by Batterman and Sonola (2009). Their article focuses on three issues: how much of a warning do spread movements give prior to a firm failing, how to interpret specific trading levels in the context of varying macroeconomic/market conditions, and from an accounting perspective at what point does the change in spread become impossible to ignore in terms of imminent impairment. 17 US Fitch-rated defaults are studied; it is found that 'approximately one month prior to default, the median defaulted company experienced a 5 year CDS around 1,500 bps'. Also, 'half the defaulted companies in the study exhibited a spread greater than 99% of the rest of the universe during the nine months prior to default, a very strong signal'. These results show the significance of spread changes in predicting default.

2.2 Predicting ratings events with CDS spreads

Hull, Predescu and White (2004) analyse the relationship between credit default swap (CDS) spreads and bond yields, reaching conclusions on the benchmark risk-free rate used by participants in the credit derivatives market. The extent to which credit ratings announcements by Moody's are anticipated by participants in the credit default swap market is then tested. This paper expands on prior research by studying changes in CDS spreads, suggesting they are a better alternative to pure yields as they imply a commitment to trade by the dealer and no assumption about a benchmark risk-free rate is required. The data set covers 1998 to 2002 and 233,620 individual CDS quotes. The relationship between bond yields and CDS's is first established to determine an accurate benchmark risk-free rate used by the CDS market. An index for each rating category (above investment grade) is calculated so that an adjusted spread observation can be used, excluding macroeconomic effects. An event study is then performed to test changes in spreads from 90 days before to 10 days after an upgrade or downgrade, among other ratings events. Independent estimation periods of 30 days are then tested to examine the probability of a ratings announcement given changes in the spread.

There is a significant increase (at 1%) in the CDS spread well in advance of a downgrade event (30 days). Spreads increase by approximately 38bps in the 90 days before a downgrade, by 24bps before a review for downgrade, and by 29bps before a negative outlook. There are no significant changes in spreads during the 10 business days after any type of negative event. No significant results were found for positive events. The adjusted spread change is also found to contain useful information for estimating the probability of ratings events, mostly for the top quartile of changes.

Similar results are found and methodology used in a study by Norden and Weber (2004), covering 2000-2002 and studying three major ratings agencies. This study incorporates additional variables such as the rating prior to the rating event, and previous rating events for the given bond. Galil and Soffer (2008) also support the relationships found by Hull et al. (2004) and Norden and Weber (2004). Data covering 2002-2006 is used for an event study similar to that of Hull et al. (2004), with additional consideration given to accompanying ratings announcements, which are found to affect results significantly. Galil and Soffer (2008) suggest that failure to consider accompanying ratings events when analysing the response of the CDS market may lead to an underestimation of the market response.

It is from these ratings-event studies that methodology is drawn, along with variables from the structural and reduced-form models of credit risk, for developing a model in which changes in CDS spreads can be used to predict default. Additionally, regression models developed by Malatesta and Thompson (1985) to investigate stock price reactions to corporate acquisitions are modified to test CDS spreads changes around default. Binder (1985) also uses multivariate regression models in event study analysis to test for abnormal returns. Although this paper uses the market model, the techniques by which regression analysis is applied to event studies are similar to those used in this research. The Constant-Mean model developed by MacKinlay (1997) for event study analysis is applied in this research to CDS spreads. MacKinlay states that although this is one of the more 'simple' models it often yields results similar to more sophisticated models, which are not always able to reduce error. This paper draws on methodology developed in a number of subject areas; given the emerging nature of the CDS market, and also to add robustness to findings.

The motivation for this study is clearly evident given the significance of the CDS market highlighted in the introduction, and the indication of the strength of the relationship between CDS spreads and default probability provided by Batterman and Sonola (2009).

3. <u>Hypotheses</u>

In order to address the topic proposed, namely the timeliness of CDS spread changes in predicting corporate default, two hypotheses are tested. These hypotheses answer the question: How long before default does a significant change in the CDS spread occur? Rejection implies that CDS spreads change significantly before, and therefore potentially can predict default:

Ho (1): The adjusted spread change in the 1, 3, and 6 months before default is not significantly different from zero.

Ho (2): The adjusted spread change in the 1, 3, and 6 months before default is not significantly different to the adjusted spread change during the estimation period (the 3-month period prior to the event window being tested).

To learn more about the behaviour of the CDS market, tests will also be performed to determine the direction of spread movement in the 1-month period after default. For this event study the 1 month prior to default is the estimation period.

For these hypotheses results during stable economic times (January 2004 - June 2007) are compared to the results found during times of economic instability or crisis (July 2007 - December 2008). These periods are selected based on changes in major US Index returns, US inflation rates, and US risk-free rates. Analysis of these two separate time periods will also provide insight into the development of the CDS market during the sample period. Sub-samples will also be constructed for financial and non-financial firms and the testing repeated as a form of industry analysis. The next section will discuss the data collection and analysis.

4. Data

4.1 Primary Data

Corporate bond default data is collected from Moody's Investors Service for all 'default events' occurring between January 1st, 2004 and December 31st, 2008. This implies that only Moody's-rated corporate entities are analysed in this study. Moody's rates over 12,000 corporate issuers and over 96,000 structured finance obligations (Moody's, 2009), however CDS data is not available for all defaulted companies. Each year Moody's provides a 'Compendium of Corporate Defaults' which describes each event, the date of the event, the security defaulted, and the type of default. Moody's also provides yearly excel data for 'Corporate Default and Recovery Rates', which has historical information as well as a sheet covering that year's defaults. Listed is the corporation's name, country, initial default type, whether it was a bond or loan, and whether or not it was included in the January 1st cohort of that particular year (see Moody's, 2009). The total number of default events included in the sample is as follows from 2004 to 2008: 41, 34, 33, 19, and 106. This gives a total number of 233 default events. With matching non-defaulted firms this gives a total potential sample size of 466 firms.

The credit default swap (CDS) data used in this analysis consists of a set of CDS spread quotes downloaded from both Bloomberg and DataStream. CDS spread quotes were downloaded for each default event to cover the period from 9 months (270 days) before the event to 1 month (30 days) after the event. Of the 233 Moodys-rated corporate default events that occurred from January 1, 2004 to December 31, 2008, 39 companies had sufficient CDS data for analysis. The first default event occurred on April 1, 2004 and the last on December 31, 2008. Of these 39, 11 companies CDS quotes were collected from Bloomberg and 28 from DataStream, no one data source contained all required data. Due to a lack of trade quotes, the mid quote is collected for all defaulted CDS spreads. The 5-year Senior CDS quotes are collected at a daily frequency, as this maturity is the most commonly traded (liquid). The final sample size of default events with corresponding CDS data is therefore 39. However, 3 of these events correspond to related company default events within 1 week, using the same CDS ticker, leaving an indicative sample size of 36, however the total 39 are analysed.

46 defaulted companies had CDS data avaliable, however 7 of these had prices that did not change throughout either the estimation period or event window so they were eliminated from the study. Where the data did not cover the shortest event window period of 1 month it has also been eliminated. Hypotheses corresponding to event windows of 1, 3, and 6 months prior to default (and 1 month after) are analysed, using an estimation period 3 months prior to the event window. Due to a lack of data availability for some time periods, the 6-month study will have a sample size of 37, the 3-month study 38, and the 1-month study 39. The 1-month post-default study has a sample size of 39 and a 1-month estimation period.

The 39 default events analysed are spread over the sample period as follows: 1 event in 2004, 9 events in 2005, 4 in 2006, 2 in 2007, and 23 in 2008. The markets corresponding to the CDS quotes are distributed as follows: Bulgaria (1), Canada (4), Germany (1), Iceland (3), Luxembourg (1), UK (1), and US (28). Of the CDS securities, 15 are quoted in Euros and 24 in United States Dollars, however because quotes are provided in basis points no currency conversion is necessary. The sample encompasses a broad range of industries including Banking (3), Finance (3), Industrial (24), Other Non-Bank (1), Public Utility (2), Real Estate Finance (1), Securities (2), Thrifts (2), and Transportation (1). Bond ratings for the defaulted firms 9 months prior to default range from Ca to Aa3, with an average rating of B1 (Moody's "Speculative Grade").

Matching firm data is then collected to construct adjusted returns. Again Moody's-rated bonds are used, and matching is completed as accurately as possible given the lack of CDS data. Firstly a non-defaulted firm within the same broad & specific (if possible) industry and same market (or similar) is identified. This is completed using the Moody's website. DataStream is then used to determine whether or not the firm's senior bond has a CDS spread available for the required time period (estimation and event window of defaulted match). If so, then the firm size (enterprise value) and credit rating 9 months prior to default are matched if possible, however this cannot be done in most cases as there are very few CDS-quoted companies.

4.2 Control Testing

Following the analysis of Hypothesis (Ho = null) (1) and (2), testing is completed to determine the significance of two control variables: CDS liquidity and firm size (enterprise value). Liquidity is measured using CDS daily bid-ask spreads collected from DataStream. Enterprise value is also collected from DataStream using the CDS's corresponding firm's equity ticker. Recovery values were not incorporated as they were based entirely on post-default information that cannot be used in predicting default.

4.3 Robustness Checks

The first robustness check involves construction of 'market economic condition' sub-samples, with data to determine these periods collected from the Federal Reserve website, Yahoo Finance and InflationData.com. Secondly, the sample is split into financial and non-financial industry sub-samples using information from Moody's. Finally the adjusted spread observation is also estimated using a CDS index. This method is not used as the primary method because the CDS index data begins in March 2007, which reduces the sample size significantly. The data for the Dow Jones 'CDX NA IG S8 SEN 5Y' (North American Investment Grade) and the ITRAXX 'EU S7 SEN 5Y' CDS indices are downloaded from DataStream. The Dow Jones CDX North American index is used for American & Canadian firms (markets) and the ITRAXX European index for European firms (markets).

4.4 Summary Statistics

Table 1 shows both the raw CDS prices quoted in basis points for each event and also daily changes (returns) in these prices, both unadjusted for matching firm movements. The table shows the two events which caused reduced sample sizes for some event windows; event 9 and 33 have fewer observations. The minimum spread is 26.5 and the maximum 17,700.1 basis points. Standard deviations range from just 4 to 4,247 basis points, indicating significant variations in volatility and or liquidity between spreads. The largest increase in spread on a given day is 7,753 basis points, and largest decrease 5,678 basis points.

Table 2 presents summary statistics for the average adjusted prices (ap) and average adjusted returns (ar), and the cumulated average adjusted prices (caap) and returns (caar), for each estimation and event window using matching firms. The variable descriptions are explained in the note to this table.

The highest adjusted CDS price, 2,262 basis points, is achieved during all three event windows, as it occurs in the final month before default. It is evident that maximum adjusted prices are much lower in the estimation periods than event windows. The largest daily increase in spread (return) occurs during the 6-month period, 274 basis points. The largest decrease occurs in this same period, highlighting the volatility of the spreads before default. The table shows that CDS spreads decrease post-default, as average prices decrease and returns are negative.

5. Methodology & Techniques

The methodology used in this research analysis is mostly an extension of that used by Hull et al. (2004), a study of the ability of the CDS market to predict ratings events, however in a different context. CDS data for defaulted and matching firms is collected as outlined in the data section. Event windows are then constructed for each event; four different event windows are tested as shown in figure 1. Reduced sample sizes were already required to achieve testing for these four periods. The 6-month event window has 37 firms, the 3-month event window 38 firms, and the 1-month before and after default event windows have 39 firms. Firstly adjusted CDS prices and returns are estimated using matching firms and average adjusted prices are calculated for each estimation period and event window. The price or return of the matching firm is simply subtracted from that of the defaulted firm. As mentioned in the data section, the CDS index does not cover the entire period required so could not be used. However, using matching firms has the advantage of partially controlling for industry effects. Cumulated adjusted prices and returns are then calculated for each estimation period and event window.

5.1 Hypothesis 1 Testing

Next the hypothesis testing is completed, firstly Ho (1), that the adjusted spread change in the 1, 3, and 6 months before default is not significantly different to zero. This test uses traditional event study methodology. The "adjusted spread change" is calculated as the adjusted spread price for day 0 minus the price for day -1, -3, or -6 months, and for event 4 the price on day +30 minus day +1. A test is then performed as to whether the mean adjusted spread change is equal to zero. A one sample t-test that the mean of these series is equal to zero provides t-statistics and p-values which indicate the direction of CDS price movement over the event window. Rejection of the test implies that price changes are significantly greater than zero, and the alternative hypothesis (Ha) p-values are used to determine whether the price increases or decreases in each event window.

A further test to determine the outcome of Ho (1) is then developed. Average adjusted daily CDS returns are calculated for each estimation period and event window. This produces a time series for these periods of adjusted spread returns. The same one-sample t-test is then completed to find whether the mean CDS spread return for each event window is equal to zero. If Ho can be rejected, then on average CDS returns are significantly greater than zero during the event window. Again, the direction of these returns is determined using the Ha results.

Cumulated adjusted CDS returns are then constructed for each event window, and a one-sample t-test is run to determine whether these CAARs are significant. If the Ho that the mean CAAR is equal to zero can be rejected, then the direction of the return movement prior to default can be determined using the Ha results. If there are no significant changes in spread prior to default then a mean of zero is expected. These CAARs are then charted using the constant-mean method (MacKinlay, Campbell & Lo, 1997) to determine their significance. The following formulas are used;

SE = SQRT ((1/n^2) x sum of variances) *n = number of defaulted firms used in each event window*

Significance curve = (-) 1.96 x SQRT (observation #) x SE *SE = standard error*

A CAAR of greater magnitude (+ or -) than the significance curve indicates a significant result. These charts provide more detail about when the significant changes in CDS spreads are occurring, and are presented for each different event window.

5.2 Hypothesis 2 Testing

Testing is then completed to determine the outcome of Ho (2), that the adjusted spread change in the 1, 3, and 6 months before default (and 1 month after) is not significantly different to the average adjusted spread change during the estimation period. Here the Constant-Mean model (MacKinlay et al., 1997) is used in conjunction with the testing used for Ho (1) to provide robustness for the Ho (2) findings. Firstly changes in adjusted prices across estimation periods and event windows are constructed, and a two-sample t-test is run to test whether these mean changes are equal for the estimation and event windows. Again, the Ha results provide insight into which direction CDS prices are moving and the difference between estimation and event.

Next, regressions are run with average adjusted prices in the estimation periods and event windows (time series variables). These regressions help to determine the correlation structure or relationship between estimation period and event window CDS prices. This methodology is used by Malatesta & Thompson (1985) in analysing stock price reactions to acquisitions. The findings have two potential implications; no significant relationship may imply abnormality in prices prior to default. However, a strong positive relationship may also imply that CDS prices increase during the period prior to default by a factor of the estimation period prices, given by the coefficient. Ordinary least squares are used for all regression analysis in this research as the data is tested for heteroskedasticity and it is concluded that GARCH modelling is unnecessary.

The next set of tests for Ho (2) use adjusted CDS returns as used in Ho (1), rather than prices. The time series variables of adjusted CDS returns for each event and estimation period are firstly tested for mean equality. A two-sample t-test is used to determine whether the mean adjusted CDS return during the event window is greater than during the estimation period. Rejection of the hypothesis would support this expectation, with the Ha results indicating whether the returns increase or decrease prior, to and post, default. As completed for Ho (1), mean CAARs are then tested, but for mean equality for Ho (2). The expectation is that the mean CDS CAAR in the event window is greater than the mean in the estimation period. Finally, regressions are run again but using returns instead of prices, to test the relationship between both estimation and event window average adjusted returns, and CAARs. No controls are incorporated at this stage.

The proposed testing for Ho (2) is the next technique to be incorporated; the Constant-Mean model (MacKinlay, 1997) is used to test whether the mean adjusted spread change during the -1, 3, or 6 (and +1) month event window, minus the mean adjusted spread change during the estimation period, is significantly different from zero. The model estimates abnormal returns by calculating the mean adjusted spread change (return) during the corresponding estimation period for each different event window. Testing can then be performed as to whether the daily mean adjusted spread change during the event window, minus the mean adjusted spread change during the estimation period, is significantly different from zero. A time series of constant-mean abnormal returns can then be analysed. Some analysis is also completed with constant-mean adjusted prices in this case. Initially constant-mean analysis is completed with unadjusted returns, to truly see the results of the simple constant-mean model without market adjustment. However the final charts present matching-firm adjusted abnormal CDS returns. Significance is determined from the standard error of the returns during the estimation period. The formulas are outlined in Ho (1) for the CAAR chart construction.

Further robustness checks are also run for Ho (1) and (2); one-sample t-tests that the average constant-mean abnormal return is equal to zero are completed. If the constant-mean abnormal adjusted returns during the event window are greater than zero then the CDS spread is increasing significantly prior to default. Similarly, regressions are run to test the relationship (correlation) between the constant-mean adjusted prices in the event window and the adjusted prices during the estimation period, following on from the Ho (2) testing. Again, no relationship potentially indicates a significant change in spread prior to default. However if the event window price is significantly positively related to the estimation period price there may also be significant CDS spread increases prior to default.

5.3 Control Variable Testing

The next section of the results incorporates control variables where possible (without using panel data) into the testing completed so far. Incorporating control variables into these models is difficult however a liquidity measure is calculated and included in the regressions run as above for both adjusted CDS prices and returns. This is similar to the methodology used by Binder (1985), however because the market model is not used the results here reveal information about the correlation structure only. Liquidity is a focus because of the huge development in the CDS market over the sample period. An inspection of the data reveals poor liquidity for many CDS-quoted firms, and it follows that this is likely to affect the ability of the CDS spread to predict default, especially in a timely manner. The liquidity control variable is calculated as the log of the average spread over the entire estimation period and event window. A further liquidity control is estimated as the average spread as a percentage of the average 9-6 month estimation period price. Finally the log of the enterprise value is incorporated as a control variable to determine whether firm size has an impact on CDS spread behaviour.

5.4 Robustness Checks

Three main robustness checks are completed in this paper: firstly controlling for market economic conditions, followed by financial industry analysis, and finally using a CDS index to compute adjusted returns. Firstly the sample period is split to create sub-samples for default events that occurred during stable economic conditions (January 2004 - June 2007) and economic instability or 'crisis' (July 2007 -

December 2008). This provides insight into both the development of the CDS market over the entire sample period and also the behaviour of the market during the recent economic crisis. Tests of the mean CDS price during estimation and event windows are run as above, and also a constant-mean model is estimated. This provides conclusions for both Ho (1) and (2) for the two separate sub-samples.

To discover the specific behaviour of the CDS market around default events across major industry groups, the sample is split again to create sub-samples for financial and non-financial firms. The financial firms are isolated because 56% of defaulted firms in the total sample had traded CDS's, compared to 19% of non-financial firms. Financial firms also exhibit greater liquidity; the average bid-ask spread is 1.6% of the first estimation period price, compared to 2.2% for non-financial firms. Many of the financial firms in this study were also systemic in the 2008 credit crisis. The potential for TARP (Troubled Asset Relief Programme, US Government) funding in the financial sector may also have affected the responses of CDS prices to changes in risk. In this sample, only General Motors (GMAC) received TARP funding, but after the default event. For the industry analysis the constant-mean model is analysed, given that it produces the clearest results for prior testing.

The final and most important robustness check involves the reconstruction of adjusted spread prices and returns using the appropriate CDS indexes. This is important because it is the most accurate method for calculating adjusted returns, and had the CDS index been active for the entire sample period it would have been the method used throughout. Because index data begins in March 2007 the sample size for these tests is reduced to 23, as the data must cover 9 months prior to default. This leaves only those firms which defaulted in 2008. The data for the Dow Jones 'CDX NA IG S8 SEN 5Y' (North American Investment Grade) and the ITRAXX 'EU S7 SEN 5Y' CDS indices are downloaded from DataStream. The Dow Jones CDX North American index is used for American/Canadian firms (markets) and the ITRAXX European index for European firms.

The adjusted spread observation is constructed as with the matching firms, simply by subtracting the daily index price from the CDS price of the defaulted firm (or change in prices for returns). These new adjusted observations, as well as adjusted prices, are then used to complete testing of Ho (1) and (2). The means are tested relative to zero and to the estimation period. The cumulated adjusted returns are then tested for significance based on estimation period standard error using the constant-mean model.

Overall significance of these test results provides insight into the ability of the CDS market to predict default. Although no probability measure is constructed as such, if the CDS spread is increasing significantly before default then we can infer that the market is able to reflect changes in risk effectively. The testing of the two hypotheses and robustness checks will allow for conclusions to be drawn about the timeliness of CDS spread changes around corporate default events. The next section presents the findings from this research.

6. Research Findings

The findings from this research are mostly consistent with the hypothesised expectations, namely that a significant change in a firm's CDS spread does occur before default. The main research findings are presented as follows: firstly the results from Hypothesis 1 followed by Hypothesis 2 both with CDS prices and returns, and the results from the Constant-Mean model for Hypothesis 2. Next the findings incorporating control variables are presented, and finally robustness checks which include economic-period sub-samples, industry sub-samples, and testing using CDS indices.

6.1 Hypothesis 1: The adjusted spread change in the 1, 3, and 6 months before default is not significantly different from zero.

This methodology developed by Hull et al. (2004) tests the significance of CDS spread changes by first calculating an "adjusted spread change". This is calculated by subtracting an appropriate spread index, in this case the CDS price of a matching firm, and then calculating the change in this price from the beginning to the end of the event window. This is the first technique used in this research, and the aim is to determine whether the mean of the adjusted spread changes is significantly greater than zero. We expect this to be true for event windows before default and false for those after default. The results are presented below, where change0180 represents the average adjusted change in CDS spread price during the 180 day (6-month) event window, and so on.

6.1.1 Ho (1): Testing the mean value during the event window using adjusted CDS prices

The one-sample t-tests for each event window length test whether the mean change during the event window is equal to zero. Significant changes in CDS spread prices would cause rejection of this hypothesis. The direction of the change can be observed using the t-statistic value and alternative hypothesis (Ha) results.

The results for this test are very convincing, the t-statistics for the 6 month (180 days), 3 month (90 days), and 1 month (30 days) event windows are all significant (greater than 2) and positive. This indicates that the CDS spread price is significantly greater at the time of default than the beginning of the event window. This result is confirmed by the Ha results, which show that the mean change is significantly greater than 0 at 1% for 6 and 3 months before default, and 5% for 1 month before default. The most significant change occurs from 6 months prior to default (p-value 0.00), suggesting than increases in CDS spread prices are occurring as far as 6 months prior to bond default. For 1 month post-default, the CDS spread change is found to be negative with 10% significance. Because this analysis is completed with CDS prices in basis points, the standard errors and standard deviations are relatively high (compared to when returns are used).

The outcomes from the test for Ho (1) are consistent with expectations, next an alternative testing method for Ho (1) is developed using CDS spread changes.

6.1.2 Ho (1): Testing the mean value during the event window using adjusted CDS returns

As an alternative method for testing Ho (1), changes in adjusted CDS prices (i.e. returns) were calculated daily. An average change in adjusted CDS price is then calculated on a daily basis, whereby an increase in price corresponds to a positive change. Series are then constructed for each estimation period and event window, as a time-series of daily average adjusted CDS price changes. Table 4 shows the one-sample t tests for each estimation and event window, testing whether the mean value in each period is equal to zero. For example, avar96 is the average adjusted return (CDS price change) for all defaulted firms during the 9 to 6 months before default (a time series of values across this period).

Again, the tests reveal convincing results, showing that there are significant positive changes in CDS prices across all event windows tested. However, the t-statistic is greater than 2 only for the 6 month event window, suggesting that the most significant price changes occur 6 month prior to default. The Ha results are also most convincing for the 6 month event window, where the mean change in adjusted price is significantly greater than zero at 5% (0.02). The 3-month window gives a p-value of 0.04, and 1 month 0.08, however the t-statistics for these results are less than 2.

Table 4 also reports the mean CDS spread change for each period, the greatest change is evident during the one month before default, where the mean is a 27.39 basis point increase. It can also be seen that post default, there is an average decrease of 4 basis points in spread price daily. The estimation period mean changes are much lower, ranging from 2.9 to 6.2 basis point increases. The standard deviation and confidence intervals are relatively large, with standard deviation ranging from 16 to 104, showing that the CDS spreads are volatile. The other interesting result of this test is that each estimation period change is less significant than its corresponding event window. The 3 and 1 month estimation periods are not significant at 5%. This suggests that the increases in spread prices are greater during the event windows than all estimation periods. This hypothesis is tested further in the next section of the report. Finally, the change in spread price after default is found to be negative as expected, but insignificant.

The final test for Ho (1) uses cumulated average adjusted returns (spread price changes). These 'CAARs' are calculated for each defaulted company, so it is a static test not a time series analysis. If there is no significant change in spread price prior to default, these returns should be zero, and the CAAR should be insignificant. However, the test results in table 5 indicate what is expected, that again there is a significant increase in spread before default. All t-statistics are significant (greater than 2) and positive for pre-default spread changes. The Ha results are also convincing, with significantly positive CAARs for 6 and 3 months prior at 1% and 1 month prior at 5%. The decrease in spread price after default is significant only at 10%. Table 5 shows the mean CAAR across all firms is 1,643 basis points 6 months prior to default, 1,332 for 3 months prior and 850 one month prior. This implies that defaulted firms accumulate spread returns 8.5% greater than their non-defaulted match just one month prior to default.

A time series of these CAARs is presented in figures 2 to 5. The significance of these CAARs is calculated using the sum of variances for all defaulted firms across the corresponding estimation period for each test, which is input into the formulas explained in the footnote. Figures 2 to 5 show the cumulated average adjusted returns using matching firms. They are not constant-mean adjusted. The result show very significant increases in CDS spread prices as far as 90 days from default. Looking at the more short term CAARs, where SE tends to increase as it is based on prices over the previous estimation period, there are definite significant and positive CAARs 20 days from default. The CAAR after default is insignificant and only slightly negative. We now move on to test Ho (2) to determine exactly when the significant change in CDS spread is occurring, controlling for changes during the estimation period.

6.2 *Hypothesis 2: The adjusted spread change in the 1, 3, and 6 months before default is not significantly different to the average adjusted spread change during the estimation period (the 3-month period prior to the event window being tested).*

Hypothesis 2 is focused on comparing prices and returns during the event window with those during the corresponding estimation period. The results from these tests are first presented using CDS prices, and then using CDS price changes (returns) as for Ho (1).

6.2.1 Ho (2): Testing the equality of the event window and estimation period adjusted CDS prices

We now move on to the testing of Hypothesis 2, beginning with a test for mean equality between the changes in prices for all firms across the event window and estimation period. As for Ho (1) these variables are constructed as the price on the last day of the period minus the price on the first day, so it is a static test.[1]

To summarise the testing for Ho (2) using adjusted CDS prices, there are significant differences between changes in adjusted CDS spread prices during the estimation period and event window. The 6 month event is the most significantly different to the estimation period, and the 3 month event is also significant. It is evident that the significant changes have occurred before 1 month prior to default, as the changes in this period are no greater than from 4 to 1 month prior to default. The CDS spread price change is significantly lower 1 month post-default than 1 month before. Having determined the significant changes in CDS price during the 6 and 3 month event windows in particular, we now run similar tests using CDS price changes (returns).

6.2.2 Ho (2): Testing the equality of the event window and estimation period adjusted CDS returns

[1] Results are not reported.

A test of equality of means between adjusted CDS returns during the estimation period and event window was performed.[2] These variables are time series variables, which are the average adjusted returns, using matching firm returns, on each day of the given event/estimation period. The results are not as strong as when tests were completed using adjusted prices. Although the Ha that the mean difference between event and estimation period is significant at 10% for the 6 and 3 month events, this is not a convincing result. The t-statistics are also relatively low. The most significant result is for the one month post-default where there is a significantly lower average return than in the one month prior to default.

Similar tests were run using cumulated adjusted CDS returns for each defaulted firm. As for Ho (1), these are static variables, and the mean value is compared between event and estimation period. Table 6 presents these results. The t-statistics for the minus 6 and plus 1 month periods are significant, and p-values show that average CAARs are significantly greater during the event window for 6 and 3 months prior to default (at 1% and 5 % respectively). The results for 1 month prior again are insignificant, and 1 month post-default there is a significant decrease in CAAR relative to 1 month prior.

The final tests completed before moving on to use the final technique for Ho (2), the Constant-Mean model, are regressions of CAARs during the event and estimation periods. Table 7 shows a set of regressions testing this relationship using CAARs. The results show significant relationships for all estimation period CAARs in determining event window CAARs. As for the results using prices, this may indicate that there is a positive relationship in terms of magnitude; that the CAAR during the event window is positively related to the estimation period CAAR by the coefficient magnitude. However, the results may purely indicate the positive correlation structure between the variables. Again, p-values and t-statistics, as well as r-squared measures are all more significant and accurate for the 6 and 3 month events.

To summarise the findings of these initial tests of Ho (2), there are significant differences between both estimation period and event window prices and returns, with the results being more significant when using adjusted CDS prices. It appears from the results so far that a significant change in the CDS spread is occurring between 6 and 1 month prior to default, as the differences between the 4 to 1 month prior and 1 month event windows have been minimal. We now cover the Constant-Mean model testing, developed from MacKinlay (1997). This technique will help to determine exactly when the significant change in CDS spread is occurring prior to default.

6.2.3 Ho (2): Testing the equality of the event window and estimation period adjusted CDS returns (matching firm) with the Constant-Mean Model

[2] Results are not reported.

The Constant-Mean model explicitly addresses Ho (2); that the adjusted spread change in the 1, 3, and 6 months before default is not significantly different to the average adjusted spread change during the estimation period. Before presenting the traditional Constant-Mean model abnormal return charts, some of the testing completed for Ho (1) and (2) is also run using constant-mean adjusted returns. This is a form of robustness check, to determine the significance of the findings so far. The correlations for constant-mean (CM) adjusted returns and estimation period adjusted returns are relatively low.

Table 8 shows the Ho (1) test for whether the mean CM adjusted return is equal to zero during each event window. The results are less significant than those found using simple adjusted returns. The mean is significantly greater than zero, indicating positive abnormal returns, only at 10% for the 6 and 3 month windows. The strongest result is post default, where constant-mean returns are highly significantly negative.

Constant-Mean analysis is also completed with prices; table 9 shows the regression of event window constant-mean adjusted prices and estimation period adjusted prices. Here the mean adjusted price during the estimation period is subtracted from the daily adjusted prices during the event window, to give abnormal prices based on the CM model. The resulting abnormal prices are then regressed upon the estimation period adjusted returns to test whether dependence or correlation exists. These regressions essentially test for a correlation relationship between the estimation period prices, and the abnormal prices realised in the event window. Similar to the previous finding for Ho (2), there is a significant relationship between the 6 and 3 month estimation period and event window prices. This relationship implies that event window prices increase by a factor (coefficient) of estimation period prices. This is consistent with hypotheses expectations; a change in CDS spread does occur from estimation period to event window, even when adjusted for the constant-mean price.

We now move on to test Ho (2) using a more visual method; constant-mean (CM) charts with significance determined using standard error, as outlined in the CAR section for Ho (1). The standard error bars are calculated in the same way, using the estimation period sum of variances to calculate standard error and multiplying this by a factor of 1.96, and the observation number.

Figures 6 to 9 provide a very simple and accurate analysis of when significant changes in the CDS spreads of defaulted firms are occurring. Firstly the results are presented for CDS spread returns unadjusted for matching firm returns, resulting in simple constant-mean average abnormal returns without removing market movements as such. The results are highly significant, at similar points in time to the simple CAR charts presented in the Ho (1) section. CM market-unadjusted cumulated abnormal returns become significant approximately 90 days (3 months) from default and remain reasonably significant, before increasing dramatically in the final 40 days before default. The 3 month chart shows similar results, CM returns are significant immediately from 90 days, are remain positively significant apart from a period from -65 days to -40 days. As standard error estimation is based on the estimation periods, it changes for each event length, and therefore the significance varies from period to period. This is evident in the estimation of CM abnormal CARs for the 1 month prior to default. Here the returns appear less significantly increased, apart from between -20 and -16 days, and -1 day before default. Finally, it is clearly apparent that CDS returns become negative after default, however the magnitude of the unadjusted CM CAR here is not significant, except for day +30.

The first four CM charts (figures 6-9) provide an indication of the abnormal returns based on the constant-mean during the estimation period only, without adjusting for market movements. The next set of charts (figures 10-13) is more accurate in the sense that the matching-firm adjusted returns are first calculated, and these are used to estimate the constant-mean model as explained earlier. The resulting returns are therefore abnormal based on both market (matching-firm) movements, as well as average returns during the estimation period for a given defaulted firm. The standard error calculations remain the same for this version of the model. As the charts show, the results appear very similar in pattern; however they become less significant after the market/match adjustment. For the 6 month event window, CM CAARs are significant only permanently just over 20 days from default. This result is supported by the 3 month chart; however the 1 month chart shows significant CM CAARs only -20 to -16 and -1 day from default. Again the post-default CAAR is negative but not strongly significant.

These results suggest that there are significant abnormal returns 20 days from default, based on 6 and 3 month CAARs. However, based on 4 to 1 month prior returns, there is a less significant change 1 month from default. These results may be due to the fact that significant changes in CDS spread prices are occurring from 4 or 3 months prior to default, which means that when this period is used to estimate abnormal returns 1 month from default there is no significant change. This is consistent with the findings from the Ho (1) and (2) testing. The following control variable testing and robustness checks help to determine the accuracy of these findings so far. However, at this stage both Ho (1) and (2) have been rejected, implying that significant changes in the CDS spread do occur prior to default.

6.3 <u>Control Variable Testing</u>

Although we have been able to adjust for market or matching firm price movements, and average spread prices/returns during the estimation period, it is difficult to incorporate control variables into the testing used in this paper without venturing towards panel data. However when analysing the data set, and as a result of the difficulty with finding active CDS quotes, the lack of liquidity in the CDS market particularly before 2008 became apparent. Two liquidity variables were therefore constructed; firstly a common measure, the log of the average bid-ask spread during the entire estimation period and event window. Secondly, because of the different credit ratings analysed in this study, and therefore initial spread levels, the average spread as a percentage of the estimation period price is calculated to give a more comparable measure. The log of enterprise value has also been calculated, where

Enterprise Value is equal to Market Capitalization at fiscal yearend date + Preferred Stock + Minority Interest + Total Debt - Cash.

These variables can be incorporated into the testing of Ho (1) and (2) using regression. Firstly regression analysis with CDS prices and control variables is completed, testing whether the relationship between estimation period and event window prices is affected by these factors.[3] Log of EV is found to be significant for the 6 month event window at 10%, and average spread as a % of price is significant at 10% for the 1 month window only. These results suggest that these control variables do not affect the results found so far in a significant way.

Next the same control variable analysis as above is completed with CDS spread returns. The correlation results are again mixed, although log of EV again appears to have the highest correlation with CDS spread returns, being 0.22 for 6 months and 0.50 for the 1 month estimation period.

As for CDS prices, regressions are run to test the significance of the control variables to the relationship analysed in Ho (1) and (2). These variables are insignificant in the relationship between estimation period and event window returns, expect for the average spread as a % of price being significant at 10% for the 3 month period. In conclusion, the control variables are found to be insignificant in this study, despite the varying liquidity amongst CDS quotes and across time as the CDS market has developed.

6.4 Robustness Checks

6.4.1 Market Economic Condition (Time Period) Sub-Samples

Different market condition sub-samples were constructed based on a number of factors including Treasury and Swap rates, stock indices, and US inflation, to develop a sample for those firms which defaulted during more 'stable' economic conditions and times of economic 'crisis'. The resulting periods are January 2004 to June 2007 and July 2007 to December 2008. The defaulted firms were split into two sub-samples based on which of these two periods they defaulted in. There remains 14-16 firms in the 'stable' period, as two have data available only for 3 and 1 month periods before default, and 23 in the 'crisis' period (all defaulted in 2008).

The first test completed with these sub-samples is the Ho (1) test that the mean changes in adjusted CDS spread prices over the event window is equal to zero. The results (not reported) clearly show that the findings are more significant during the 'crisis' period.

The alternative test completed with these sub-samples is the main test for Ho (2), using the Constant-Mean model to calculate abnormal returns, which are then cumulated and tested for significance. Figures 14-17 present these results and provide very interesting findings. Significant returns are evident

[3] Results are not reported.

for those firms defaulted in 2008 only, during the economic downturn, shown by the purple line. The pattern evident in CDS spread changes prior to default in 2008 is very similar to that found when using the entire sample. In fact, those firms that defaulted prior to 2008 experience significant negative returns in CDS spread 6 months prior to default, which is inconsistent with the expectations outlined in the hypotheses section. Although some increases in spread are observed for these firms in the 3 and 1 month periods, they are insignificant and of considerably lower magnitude than the firms which defaulted in the 'crisis' period. Post-default returns show similar results; the 2008 defaults are significantly negative, but not the defaults during the more stable period.

The findings from the market economic condition sub-samples provide very interesting results. One potential explanation for this phenomenon is that the CDS market was not fully developed until mid 2007; meaning it would not be pricing risk accurately or be liquid enough to predict default events. A further possibility is that the market was blown out by the 2008 credit crisis, and CDS prices grew to extraordinary levels. An example of this is the GMAC spread which grew to 17700 basis points, or 170% above the risk free rate. Either way the findings previously reported in this study are only robust for those firms which defaulted during the credit crisis, and the results have actually been magnified for these firms as the smaller changes in earlier-defaulted firms have been removed. The next robustness check tests the results using industry sub-samples.

6.4.2 Industry Sub-Samples

As a method of controlling for major industry effects, the defaulted-firm sample set is split into two groups using the data from 2004 to 2008; financial firms and non-financial firms. The motivation for these classifications arose from the dramatic spread levels achieved by defaulted systemic financial institutions such as Lehman Brothers and Washington Mutual. The only firm to receive TARP funding was GMAC; therefore analysis on firms receiving this funding is not worthwhile (ProPublica website, 2009). There were 12 firms in the financial sub-sample and 25-27 in the non-financial sub-sample. Industries grouped to be financial were: Non-US Banks, Finance- Captive, Securities Holding Companies, Securities Companies, Thrifts (S&L), Mortgage Finance, and REIT's. The remaining industries were placed in the 'non-financial' sub-sample.

This robustness check also reveals very significant and interesting results. The Constant-Mean model is chosen for this testing, as it has been the most useful model for testing the significance of CDS spread changes. As shown on figures 18 through 21, financial firm CDS spread changes are much more significant than non-financial changes. For the 6 month event window, financial firms (note these all also defaulted in 2008), have significant abnormal CAARs from 95 days onwards, except for a 10 day period around 60 days from default. Non-financial abnormal CAARs are significant only in the last 20 days before default, and by a very small magnitude.

The results are similar for the 3 month period, although abnormal financial CAARs are definitely significant and positive 28 days prior to default. The rise and fall of these CAARs before -60days may be a correction in prices, or may be due to other events. The non-financial CAARs become significant only after the financial CAARs approximately 25 days from default. The 1 month period confirms the results, with CAARs moving along the significance line from 25 days before default, and strongly significant 4 days prior. Non-financial firm CDS spread abnormal returns are insignificant during this period. For 1 month post default, again the financial firms have more significant abnormal CAARs than the non-financial firms which again produce insignificant results. These results imply interesting conclusions about the behaviour of the CDS market. There are clearly very different behaviours of CDS spread within industries, and the market has changed significantly over the sample period in this study.

6.4.3 Adjusted Returns using a CDS Index

Unfortunately for this paper, there was not a market index available for the entire sample period with which adjusted returns could be constructed. However, advantages of using matching firm are that industry effects are partially controlled for, and the assumption that all companies have the same sensitivity to the associated index is not necessary. As the final robustness check adjusted returns are calculated using the appropriate CDS index for the period that it is available, from March 2007. This results in a sample of 23 firms, all of which defaulted in 2008 (the index must be available from 9 month before default). Because the sample consists of both European and American firms, data for two indices were collected; the Dow Jones 'CDX NA IG S8 SEN 5Y' (North American Investment Grade) and the ITRAXX 'EU S7 SEN 5Y'. The appropriate index is subtracted from the defaulted-firm CDS price based on the firm's country or market base (the closest possible). The European CDS index is used for 4 firms, and the American for the remaining 19 firms. Now the assumption that all firms have the same sensitivity to their matching index is required.

A series of tests are performed with these new adjusted prices and returns.[4] These findings affect the robustness of the previously reported results; however both Ho (1) and (2) can be rejected for the 6 and 3 month period prior to default, implying that a significant change in CDS spread does occur before default.

6.5 Comparison of Findings with Reviewed Literature

Although this is the first empirical study to address the actual timeliness of CDS spread changes around default; as highlighted in the literature review there are many areas of academic research relevant to the findings in this paper. Firstly, the findings are consistent with Farnsworth and Li (2007), who find lower rated bonds to be more sensitive to systematic shocks. Although no comparison has been made among bonds of different rating categories here, the average rating of bonds which defaulted in

[4] Results are not reported.

2008, when the most significant changes in CDS spreads occurred, is a "Speculative Grade" of Ba2. The results are also consistent with Davies (2008) where conditioning upon inflationary stages is found to increase the explanatory power of CDS spreads. This is shown in the 'market economic condition' sub-samples, where it is found that significant changes in CDS spread were much greater during the economic crisis of 2008 when inflation was very volatile.

This pattern found with the 'economic condition' sub-samples may be consistent with the findings of Huang and Huang (2003) that only 20% of spread changes are caused by credit risk and the remainder by systematic factors. This may explain the vast difference between results for pre- and mid-'crisis' defaults. The hugely significant increases in CDS spread during the 'crisis' period may be due to wider systematic factors, hence why the results are so different to the more 'stable' economic period. Manning (2004) also finds that default probabilities explain a small portion of the variation in credit spreads, but only for investment grade bonds. However, by controlling for matching firm or CDS index returns, these systematic factors should have been removed from the analysis. It is interesting that the significance of spread changes greatly reduced when the CDS index is used to calculate adjusted returns. This partially supports the findings of Huang and Huang, and Manning, however significant changes still remained. It seems that the behaviour of the CDS market in 2008 was unlike any other time in history.

Manning however does note that default probability is more important for lower grade bonds, and perhaps this is why the CDS returns of defaulted bonds found in this study persist over the market, as the average rating is 'speculative'. The results here are inconsistent with Manning's finding that liquidity is significant in determining credit spreads, this is not the case in the regressions completed with this sample. However, this could be because of the time period analysed by Manning and the average market spread at that time (i.e. not a 'crisis' period). It is important to note here that in order to incorporate many of the determinants of CDS spreads outlined in the literature review into this 'default prediction' testing as control variables, panel data analysis is required.

As mentioned in the literature review, little if any academic research has actually modelled default prediction using CDS spreads. Grass (2009) and Chou (2005) begin to develop these models for predicting default; however do not discuss the timeliness of CDS spread changes in terms of prediction. However, the models used in the article by Batterman and Sonola (2009) are consistent with the findings from this research. The results cover the economic 'crisis' period, and find that defaulted CDS spreads are greater than 99% of the non-defaulted CDS universe during the 9 months prior to default. Significant changes in this paper occurred from 6 and 3 months before default, however the conclusions about the ability of the CDS market to predict default are consistent.

Finally, Hull et al. (2004) provide the basis for the models used in this paper for testing the hypothesis in question. Although the topic is very different, Hull studies the ability of the CDS market to predict ratings events; the conclusions drawn about CDS spreads as an instrument are consistent with this research. Hull et al. find CDS spreads to be a significant instrument in predicting ratings events, and this research has confirmed this ability in predicting default. Having discussed the findings from this research, the next section of the report draws conclusions, highlights implications, and suggests areas for further research.

7. Conclusions

This paper has analysed the question: how long before default does a significant change in CDS spread occur? Firstly, both Hypothesis (Ho) 1 and 2 can be rejected for 3 and 6 month periods prior to default, with rejection implying that a significant change in CDS spread does occur. This conclusion can be drawn for Ho (1) based on the significant change in CDS price over these event windows above matching non-defaulted firms. The mean adjusted return and cumulated adjusted return during these periods is also significantly greater than zero. Based on matching firm data the significant change in CDS CAAR (cumulated average adjusted/abnormal return) occurs as far as 90 days from default, with definitive significance 55 days from default, for the 6 month event window. The 3 month event window shows significant positive CAARs 45 days before default. The 1 month period prior to default also produces significant and positive CAARs; however these 1 month results are not robust.

Ho (2) testing also allowed for confident hypothesis rejection, implying a significant difference between CDS spread prices and returns during the event window over the estimation period. Using matching firms, mean price changes are significantly greater during the 6 and 3 month event windows than in their corresponding estimation periods. Regressions show significant positive relationships between the estimation and event windows for these same time frames, indicating positive correlation and an increase in prices during the event window relative to the estimation period. Similar results are achieved using CDS spread returns, and CAARs, in a time series test of mean equality.

The Constant-Mean model charts proved to be the most informative in terms of identifying the exact point in time in which significant changes in CDS spreads occur prior to default. Firstly, testing completed for Ho (1) and (2) is repeated and the significant results confirmed for the 6 and 3 month event windows using adjusted constant-mean abnormal returns. Constant-mean CAARs unadjusted for market movements (matching firms) are significant 50 days from default in the 6 month period, and 42 in the 3 month period. However, controlling for matching firm movements and estimation period mean returns means that the CDS CAARs are significant just 22 days from default in the 6 month period, and 25 in the 3 month period. Based on the results before robustness checks there are significant increases in a firms CDS spread between 22 and 25 days prior to default, after adjusting for mean returns and matching firm movements.

Attempts to control for liquidity and enterprise value in these tests do not produce consistent results. Despite the obvious variations in CDS liquidity between defaulted firms, and especially across time as the market has developed, liquidity is not significant in the relationship between estimation period and event window prices or returns. Enterprise value is also insignificant.

The robustness checks completed in this paper produce very interesting results. Firstly, analysis of separate 'stable' and 'crisis' market economic condition sub-samples finds that a large portion of the significant changes in CDS spreads found in the full sample occur during the economic crisis alone. Using the Constant-Mean model, CDS spread CAARs are significantly negative for firms that defaulted during the 'stable' period. Firms that defaulted in the period of economic 'crisis' exhibit highly significant CAARs up to 90 days from default, and consistently 50 days from default in the 6 month period. CAARs are significantly positive 27 days from default for 'crisis' defaults, but insignificant for 'stable' defaults in the 3 month period. The 1 month period is more significant than in prior testing for the 'crisis' defaults, with significant CAARs from -23 to -6 days. These results imply that only the firms that defaulted from 2007 to 2008, during the economic crisis, exhibit significant changes in CDS spreads prior to default.

The second robustness check splits the sample into financial and non-financial sub-samples as a form of industry analysis. These classification choices are motivated by the impact on the economy of certain financial institutions during 2008, and interestingly all financial-firm defaults in this sample occurred during 2008. The financial firms produce much more significant constant-mean CAARs than the non-financial firms in all event windows. During the 6 month period, financial firms CAARs are significant from -95 to -65 and again from -55 to the day of default. Non-financial firms are minimally significant only a few days before default. The 3 month period shows greater magnitude in financial firm CAARs again, from as far as 90 days out. The one month results are less significant. The reason for these dramatic differences between financial and non-financial firms may be a result of the higher leverage levels of financial firms. This not only increases exposure to default, but also the pressure to hedge using the CDS market. The Depository Trust and Clearing Corp made public its count of $72 billion worth of outstanding CDS contracts referencing Lehman in an attempt to manage the wider liquidity impacts of its failure (1 month after default) (BIS website, 2009).

The final robustness test, the calculation of adjusted returns using a CDS index, highlights the difference between matching firm and market movements. However, this sample includes only those firms which defaulted during 2008, when the CDS index was active. Simple CAARs are constructed and show significant CDS returns between -22 and -10 days before default in the 6 month period, and similar results for the 3 month period. There are no significant results in the 1 month period.

In summary, based on adjusted returns using matching firms, there are significant changes in the CDS spread from 25 to 22 days prior to default onwards, cumulating abnormal returns for 6 and 3 months respectively. These findings are robust to constant-mean adjustment. However, further robustness checks reveal that the significance of these results is apparent (and magnified) only in the sample of firms that defaulted during the economic crisis of 2008. Also, the magnitude and significance of these results is much larger for financial compared to non-financial firms. CDS spreads are found to decrease post-default, however not always significantly.

Before moving to the implications of this research, it is important to discuss the main assumptions made in the process. Firstly, using four overlapping event windows implies at each stage that the estimation period is 'untainted' by the default event, or other events for that matter. Secondly, the Constant-Mean model assumes that a bonds CDS price has a constant-mean over time (MacKinlay, 1997). It is also important to keep in mind that this sample includes a range of credit ratings (9 months prior to default), from Ca to Aa3, therefore no control is given to the differing levels of default and recovery rates that exist. Some assumption is also made about significant CDS price changes prior to default implying prediction ability. However, the suggestions for further research will expand on this idea.

The implications of these results are that firstly, the CDS spread has been confirmed as an instrument that can be used to predict, or at least foresee, default. A significant change occurs is the CDS spread CAAR of defaulted firms in this study between 25 and 22 days prior to default. This in turn implies that the holder of the underlying bond of this CDS can partially avoid the losses associated with default by observing movements in the CDS market. The best strategy would be to sell the bond before 30 days prior to default, assuming that there is the liquidity to do so. There are much wider and larger implications than those for bondholders however. The systemic impact of the default of some of the financial firms in this study, such as Lehman Brothers, has been described as "Massive global wealth destruction (Bloomberg, 2009)". The CDS market may, if not be a tool used to avoid these failures, at least foresee their occurrence and reduce the widespread losses felt as a result.

Investors are now able to use the CDS market as a risk-monitoring device, knowing that historically significant changes have occurred in CDS spreads prior to default. This significant market behaviour also has implications for risk managers, who now have a tool confirmed to price changes in default risk accurately. As indicated in the introduction, regulations for the CDS market are being reviewed by ISDA. The matter of interest here will most likely be control of the market, as although it has proved to be an instrument for anticipating default, the huge CDS levels realised during 2008 also have negative effects of the same magnitude for the counterparty that has sold the contract. Regulators may also be able to use the CDS market to monitor systemically important financial institutions.

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Figure 1: Estimation periods and event windows analysed

	-270 days (9 months)	-180 days (6 months)	-120 days (4 months)	-90 days (3 months)	-30 days (1 month)	0	30 days (1 month)
Event 1	Est. Period	Event Window					
Event 2		Estimation Period		Event Window			
Event 3			Estimation Period		Event Window		
Event 4					Est. Period		Event Window

Note: Both months and days are referred to in the testing and results hence the explanation for each. All estimation (Est.) periods are three months long, except for the one month post default event where it is 1 month long.

Figure 2: CAAR from default -6 months to day of default

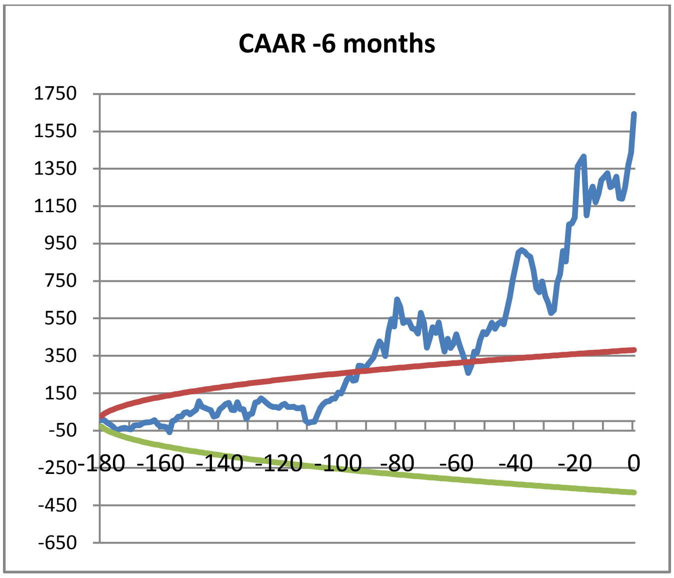


Figure 3: CAAR from default -3 months to day of default

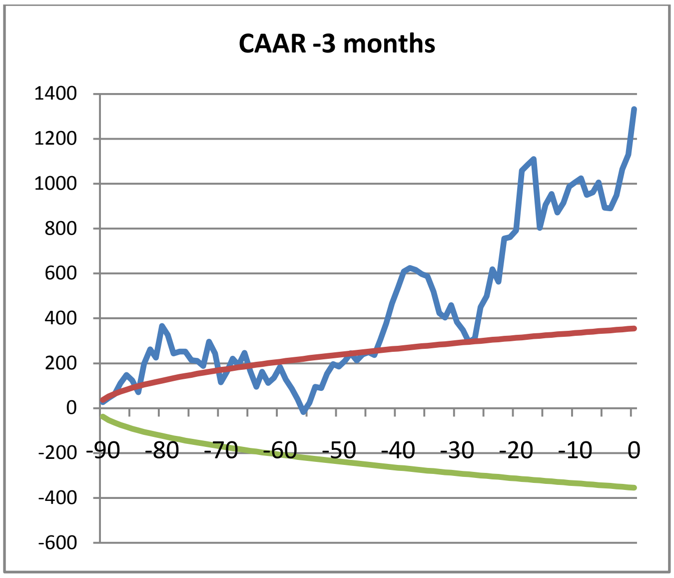


Figure 4: CAAR from default -1 months to day of default

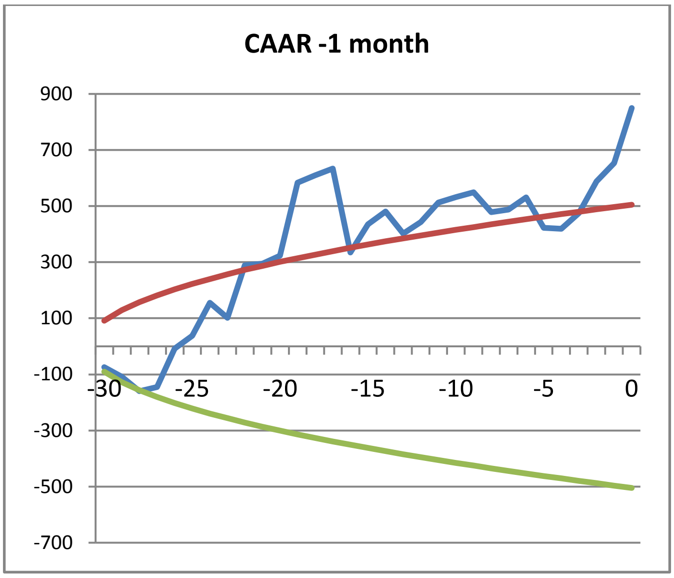
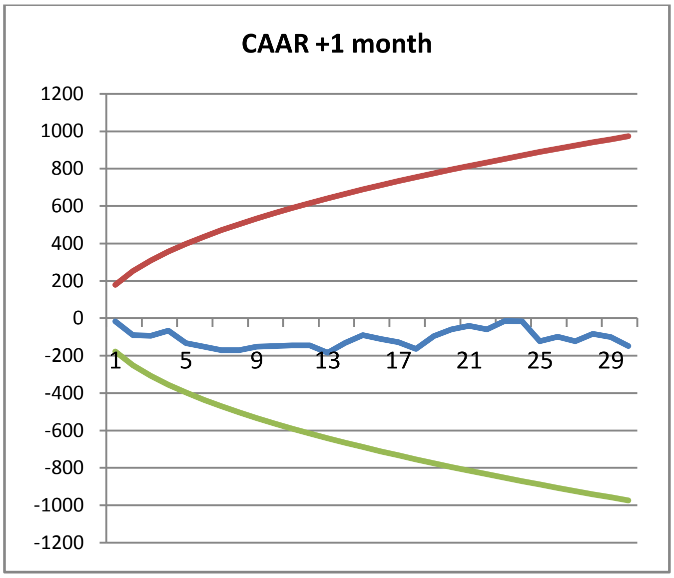


Figure 5: CAAR from day of default to default +1 month



Note: These charts show cumulated average adjusted returns for all four event windows. Significance curves are calculated using the following formulas from the constant-mean model; SE = SQRT ((1/n^2) x sum of variances), Significance curve = (-) 1.96 x SQRT (observation #) x SE. Vertical axis: CAAR in basis points, Horizontal axis: time in days around default.

Figure 6: Constant-Mean CAR, default -6 months to day 0

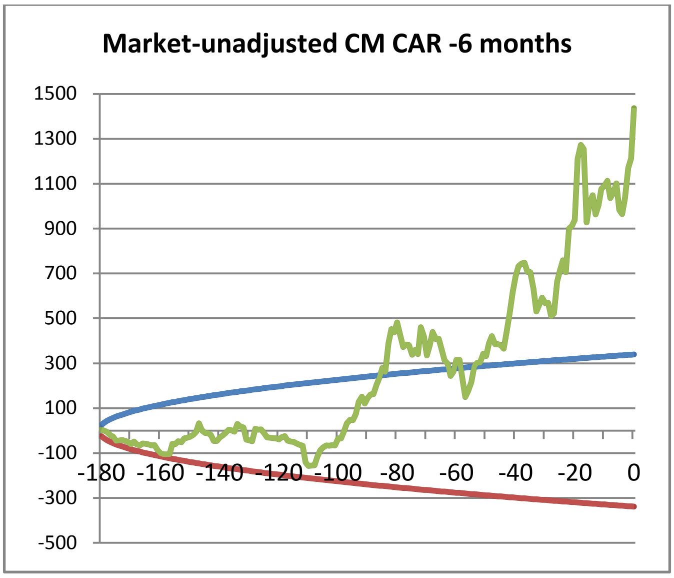


Figure 7: Constant-Mean CAR, default -3 months to day 0

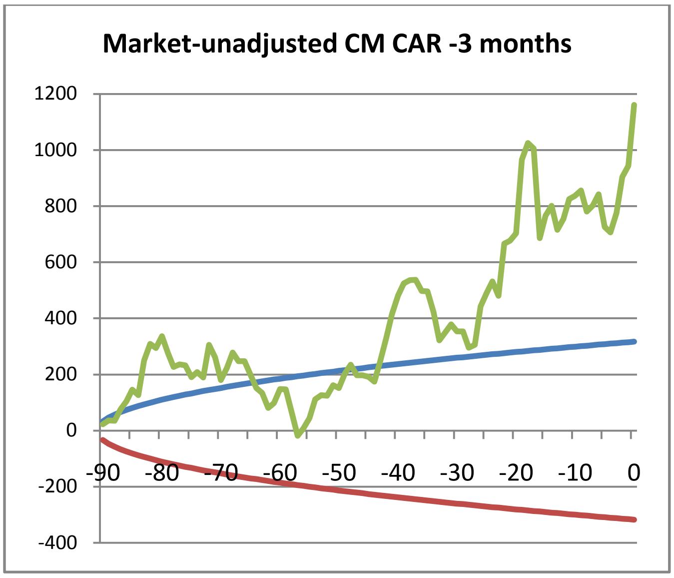


Figure 8: Constant-Mean CAR, default -1 month to day 0

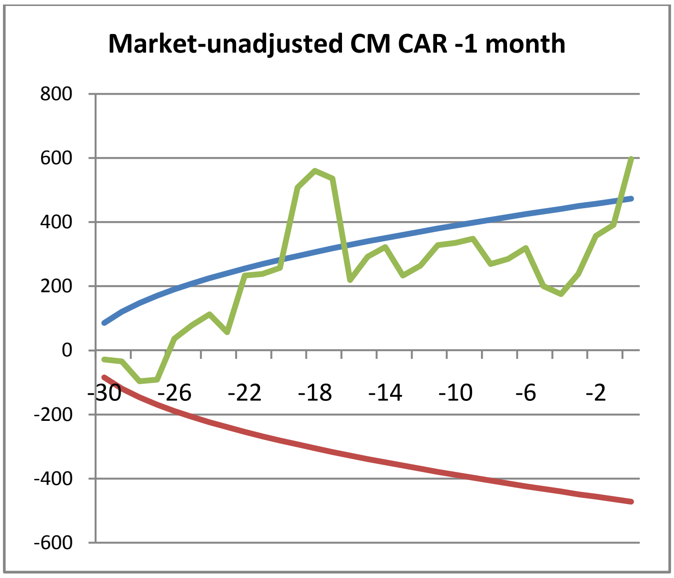
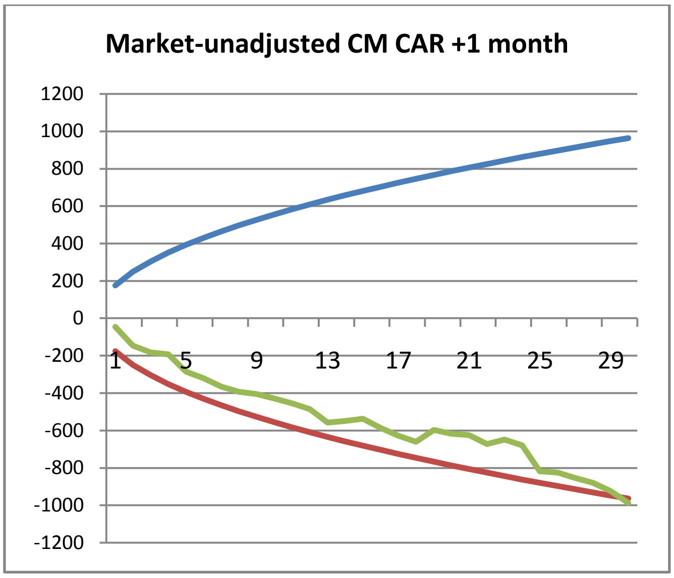


Figure 9: Constant-Mean CAR, default +1 month to day 0



Note: These charts show constant-mean (CM) cumulated average abnormal returns (CAR) for all four event windows. Significance curves are calculated using the following formulas from the constant-mean model; SE = SQRT ((1/n^2) x sum of variances), Significance curve = (-) 1.96 x SQRT (observation #) x SE. Vertical axis: CM CAR in basis points, Horizontal axis: time in days around default.

Figure 10: Constant-Mean CAAR, default -6 months to day 0

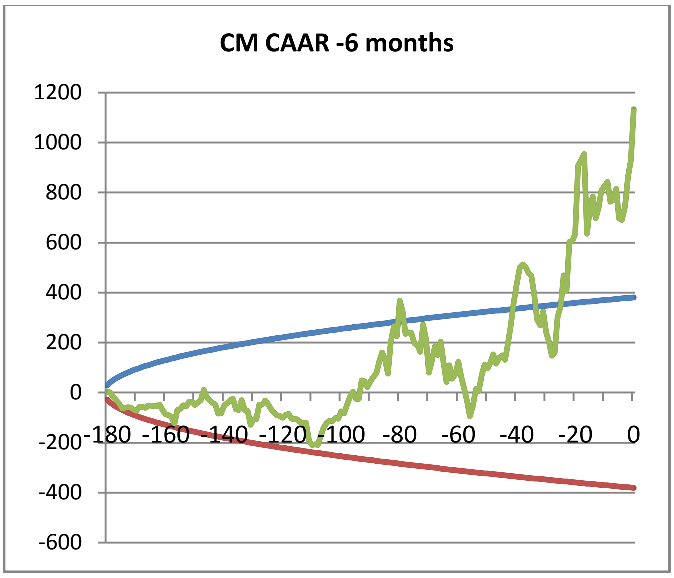


Figure 11: Constant-Mean CAAR, default -3 months to day 0

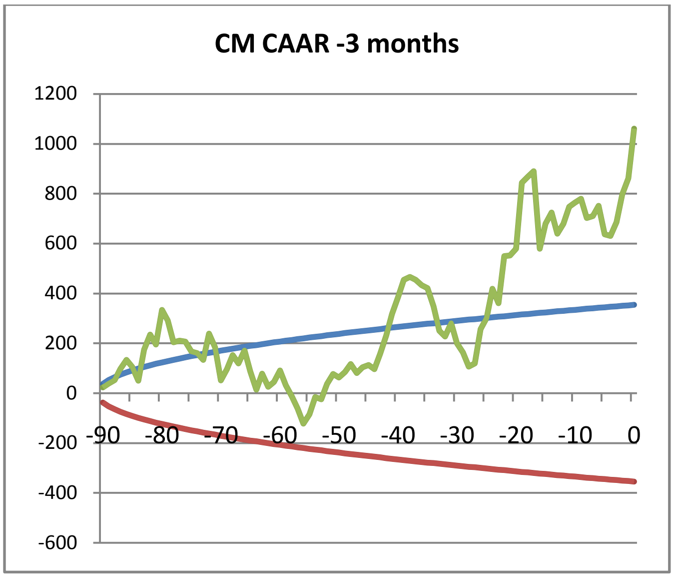


Figure 12: Constant-Mean CAAR, default -6 months to day 0

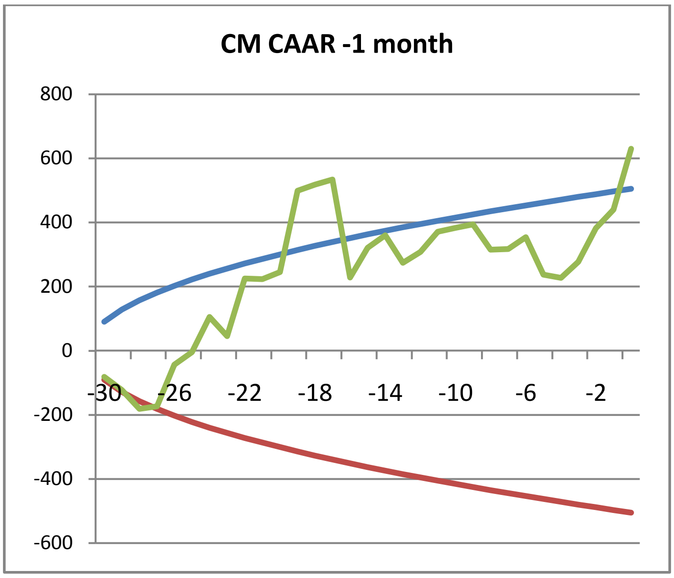
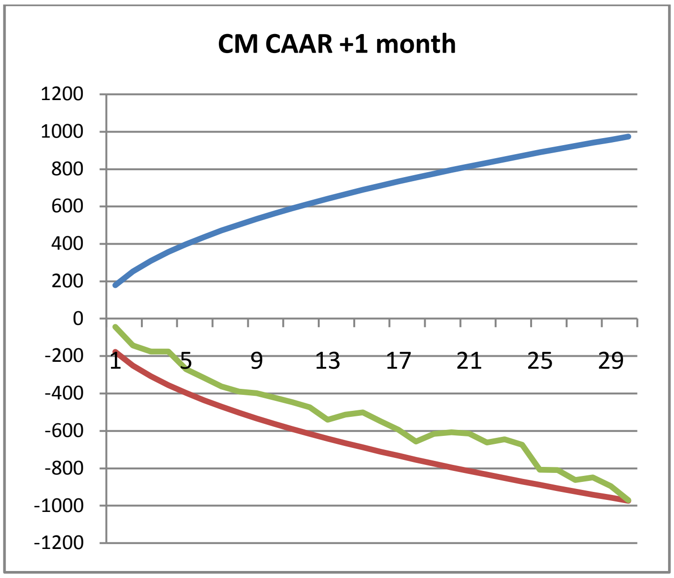


Figure 13: Constant-Mean CAAR, default -3 months to day 0



Note: These charts show constant-mean (CM) cumulated average abnormal adjusted returns (CAAR) for all four event windows. Significance curves are calculated using the following formulas from the constant-mean model; SE = SQRT ((1/n^2) x sum of variances), Significance curve = (-) 1.96 x SQRT (observation #) x SE. Vertical axis: CM CAAR in basis points, Horizontal axis: time in days around default.

Figure 14: Constant-Mean CAAR, default -6 months to day 0

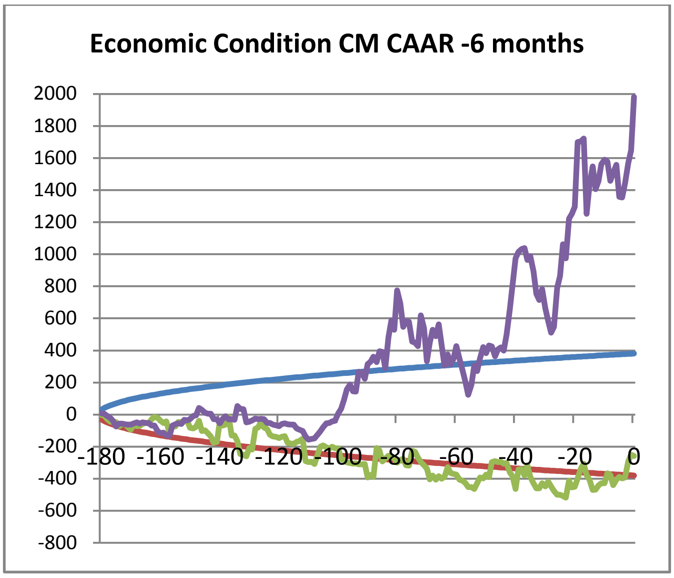


Figure 15: Constant-Mean CAAR, default -3 months to day 0

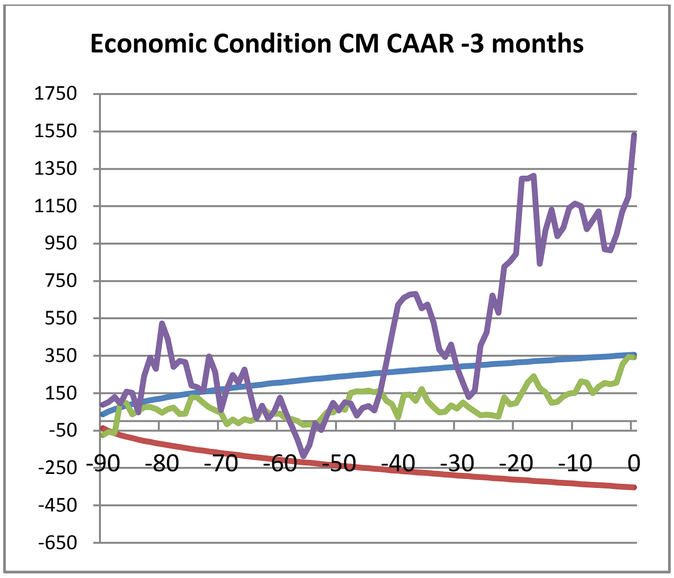


Figure 16: Constant-Mean CAAR, default -6 months to day 0

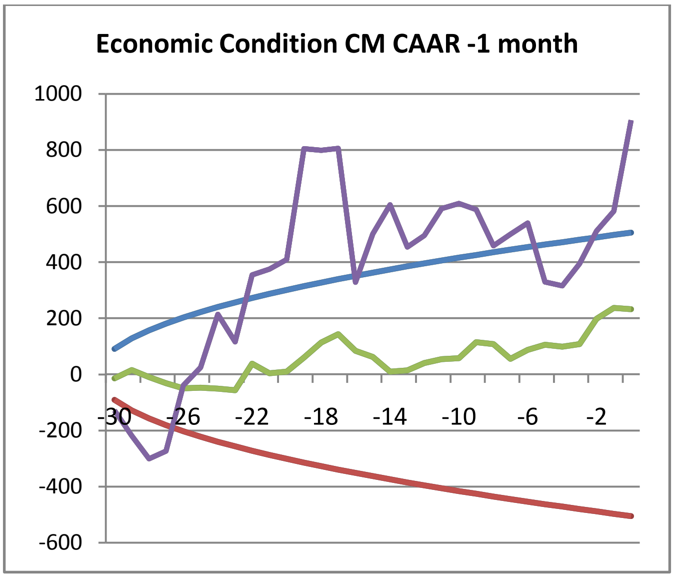
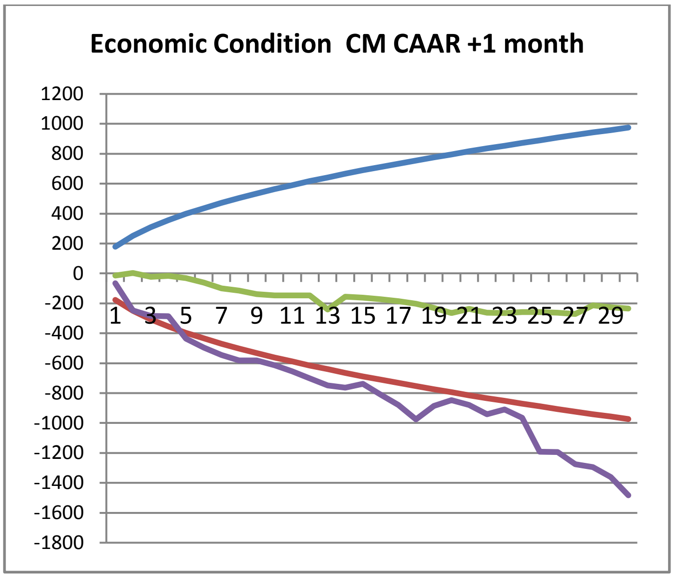


Figure 17: Constant-Mean CAAR, default -3 months to day 0



‘Economic Crisis’ sub-sample ‘Stable-economy’ sub-sample

Note: These charts show constant-mean (CM) cumulated average abnormal adjusted returns (CAAR) for all four event windows for both sub-samples. Vertical axis: CM CAAR in basis points, Horizontal axis: time in days around default.

Figure 18: Constant-Mean CAAR, default -6 months to day 0

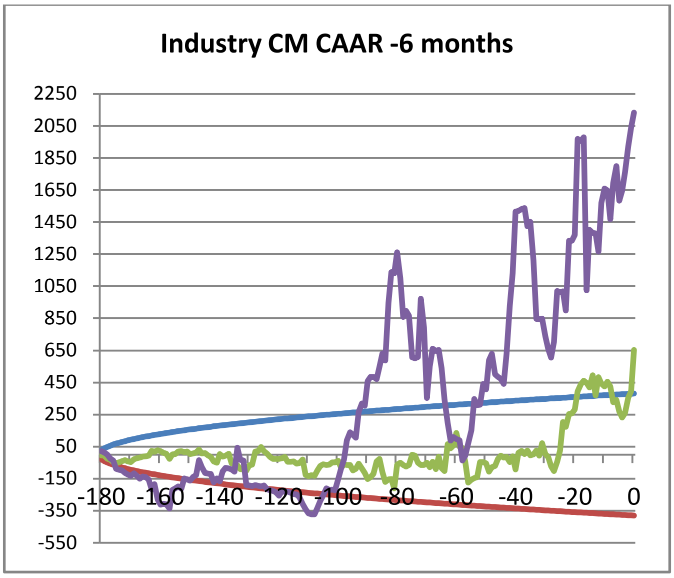


Figure 19: Constant-Mean CAAR, default -3 months to day 0

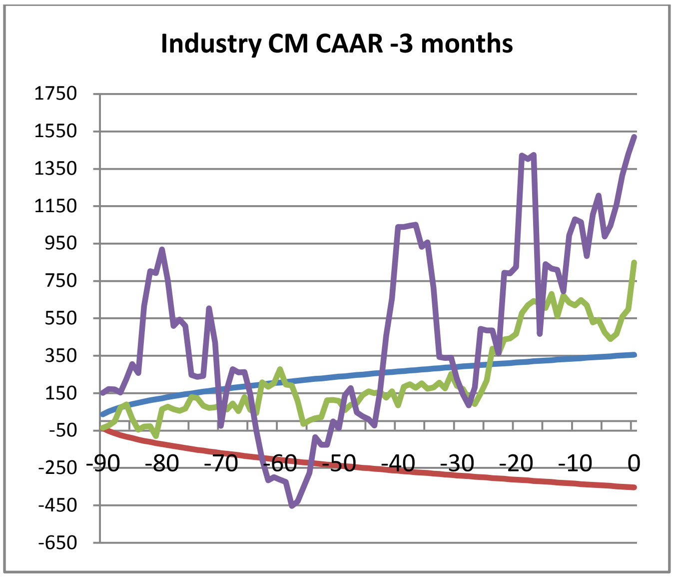


Figure 20: Constant-Mean CAAR, default -6 months to day 0

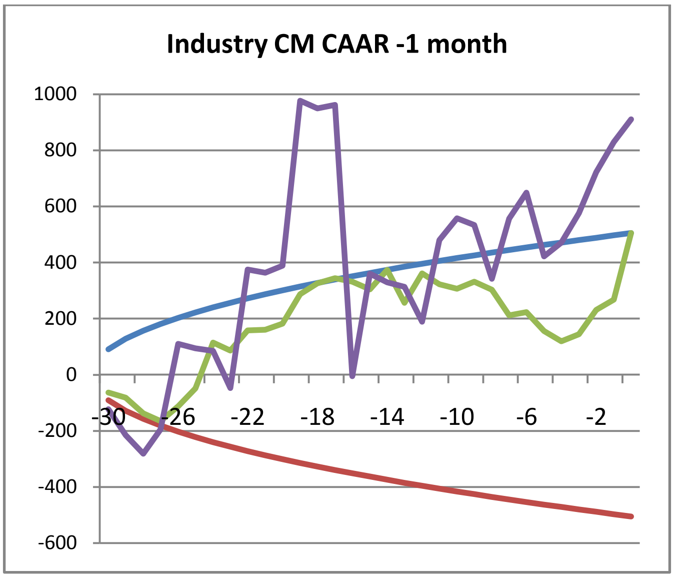
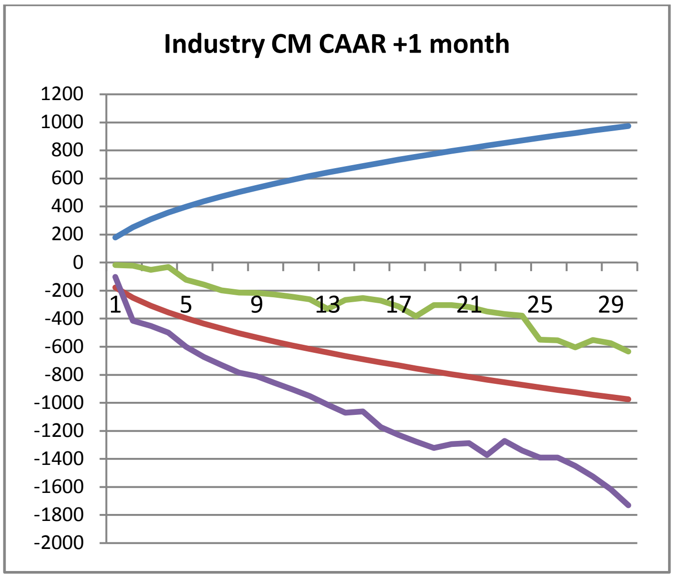


Figure 21: Constant-Mean CAAR, default -3 months to day 0



‘Financial’ sub-sample ‘Non-Financial’ sub-sample

Note: These charts show constant-mean (CM) cumulated average abnormal adjusted returns (CAAR) for all four event windows for both sub-samples. Vertical axis: CM CAAR in basis points, Horizontal axis: time in days around default.

Table 1: Summary Statistics for CDS prices & returns by event number

		CDS Spreads (Prices)				CDS Spread Changes (Returns)			
Variable	Obs	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
event1	301	1889.32	1503.03	622.1	8211.4	9.92	289.30	-2585.8	2605.7
event2	301	1295.48	329.95	598.0	1825.7	0.36	123.86	-910.4	1226.8
event3	301	425.31	279.93	157.5	1100.6	1.59	27.70	-128.3	221.3
event4	301	1551.57	398.08	1074.0	2643.9	0.34	124.97	-890.6	941.7
event5	301	2126.22	552.64	872.8	2815.7	2.22	175.61	-1223.3	1434.3
event6	301	602.12	109.11	46.0	710.0	1.45	37.71	-162.5	616.5
event7	301	47.90	4.86	40.4	60.8	-0.03	0.84	-3.1	7.0
event8	301	489.26	65.49	246.8	617.0	-0.93	34.05	-244.8	233.2
event9	153	51.96	7.26	39.0	75.0	-0.08	1.66	-14.2	9.0
event10	301	914.75	769.67	251.7	3472.0	7.73	167.35	-1450.0	1372.0
event11	301	1268.48	941.71	251.7	3472.0	7.97	167.31	-1450.0	1372.0
event12	301	1052.05	820.22	206.2	3144.3	9.79	73.87	-297.1	770.3
event13	301	44.68	7.74	34.5	64.2	0.11	1.64	-9.1	13.0
event14	301	2472.76	3486.13	201.7	12728.9	31.26	515.10	-3679.8	5543.8
event15	301	956.44	708.82	337.7	3222.1	6.91	131.53	-798.9	1140.0
event16	301	4570.46	4032.96	903.9	17700.1	30.25	717.50	-5616.0	7753.1
event17	301	1776.55	1026.76	823.3	4987.5	0.31	321.84	-2865.0	2552.5
event18	301	2215.82	1512.36	782.7	9526.8	0.03	328.56	-2833.0	2952.5
event19	301	2181.12	1133.51	951.0	4469.7	7.25	63.62	-322.2	441.1
event20	301	2352.46	1098.85	1094.4	4915.8	7.24	105.64	-507.6	582.4
event21	301	810.46	719.94	253.4	3072.3	7.77	133.66	-1241.6	1713.5
event22	301	825.84	732.58	255.0	3072.3	7.75	133.66	-1241.6	1713.5
event23	301	1013.67	790.48	116.2	4151.5	8.11	130.48	-1127.9	1405.0
event24	301	61.86	10.12	45.5	75.2	0.05	2.57	-23.2	24.0
event25	301	936.84	631.19	218.9	3006.7	4.73	131.03	-660.1	1609.8
event26	301	283.95	150.34	119.4	641.9	1.80	20.45	-108.2	219.7
event27	301	290.82	154.68	119.4	641.9	1.81	20.45	-108.2	219.7
event28	301	1762.42	872.11	902.1	5301.9	2.10	194.55	-1801.7	2304.8
event29	301	3386.51	1169.71	1631.1	5221.2	11.73	179.50	-1231.6	2128.9
event30	301	3473.47	2090.89	810.0	12660.7	12.35	711.00	-5678.2	6527.2
event31	301	70.23	23.87	36.5	106.7	-0.04	2.27	-7.0	31.0
event32	301	2576.10	1382.70	878.3	8680.7	11.68	397.98	-4362.0	3987.0
event33	251	81.68	13.33	59.6	102.0	0.07	3.01	-23.0	33.0
event34	301	1085.07	555.08	529.6	3137.9	3.83	161.18	-846.3	1933.7
event35	301	1269.45	551.50	355.0	2118.0	-4.04	73.91	-779.3	409.3
event36	301	5683.22	4247.55	2605.0	16413.7	40.92	450.20	-2267.0	6146.6
event37	301	1267.79	1746.84	251.7	6235.2	18.87	221.60	-1247.9	2874.4
event38	301	1286.54	1767.78	251.7	6235.2	18.87	221.60	-1247.9	2874.4
event39	301	610.01	288.66	26.5	1009.4	-2.98	49.54	-509.4	316.2

Note: This table presents the summary statistics for both unadjusted CDS prices and returns (daily changes) for each default event. The default events are numbered from 1 to 39 in order of date occurrence.

Table 2: Summary statistics of average adjusted CDS prices and cumulated prices (left), returns and cumulated returns (right)

Variable	Obs	Mean	Std. Dev.	Min	Max
avap96	91	546.7666	84.12286	428.2114	708.8322
avap60	181	1078.702	401.785	645.9509	2262.313
avap63	91	760.9453	77.46112	645.9509	990.78
avap30	91	1395.493	336.7276	947.751	2262.313
avap41	91	1075.79	229.3036	693.8568	1573.196
avap10	31	1771.642	261.7541	1252.754	2262.313
avap01	30	2153.386	48.0899	2077.137	2247.3
caap96	91	24609.41	15150.06	492.3412	52832.39
caap60	181	83704.02	57416.18	749.5221	206206.2
caap63	91	34438.92	20577.23	730.4689	71371.79
caap30	91	58212.3	36842.8	1019.371	130553.4
caap41	91	44261.75	28692.57	770.6729	97896.91
caap10	31	26427.32	16563.22	1338.313	54920.89
caap01	30	33300.51	18917.44	2245.068	64601.59

Variable	Obs	Mean	Std. Dev.	Min	Max
avar96	90	2.857566	16.27532	-85.91473	47.5074
avar60	181	9.07912	58.8703	-316.1178	274.6495
avar63	91	3.241545	22.09756	-69.19803	75.13535
avar30	91	14.63655	77.56603	-307.2515	267.4219
avar41	91	6.183524	48.03492	-125.0079	137.9296
avar10	31	27.39056	103.6385	-299.2899	260.5649
avar01	30	-4.984556	39.42108	-106.3621	68.9212
caar96	90	89.21493	87.79661	-35.767	258.0638
caar60	181	395.968	422.9444	-59.06062	1643.321
caar63	91	59.91522	79.17445	-57.49324	294.9806
caar30	91	441.9941	345.5447	-17.32318	1331.926
caar41	91	300.1777	229.3036	-81.75584	797.5833
caar10	31	358.4363	261.7541	-160.4515	849.1074
caar01	30	-108.9266	48.08989	-185.1756	-15.01282

Note: The left-hand table presents summary statistics for the average adjusted (by matching firm) CDS prices and cumulated prices over each event window. The right-hand table presents summary statistics for the average adjusted (by matching firm) CDS returns and cumulated returns over each event window. 'Avap/r' is 'average adjusted price/return', 'caap/r' is 'cumulated adjusted price/return' and the numerical component of the name equal to the start of the given period in months, followed by the end of the given period in months from default.

Table 3: One-sample t-tests of mean = 0 for adjusted CDS spread price changes from beginning to end of event window

One-sample t test	Obs	Mean	Std. Err.	Std. Dev.	Ho: mean = 0	DF	Ha: mean < 0	Ha: mean != 0	Ha: mean > 0
change0180 == 0	37	1637.09	550.68	3349.67	t = 2.97	36	1.00	0.01**	0.00**
change090 == 0	38	1305.21	516.30	3182.71	t = 2.53	37	0.99	0.02*	0.01**
change030 == 0	39	924.00	386.90	2416.20	t = 2.39	38	0.99	0.02*	0.01*
change300 == 0	39	-149.54	111.83	698.37	t = -1.34	38	0.09	0.19	0.91

Note: This table shows one-sample t-tests that the mean of each variable is equal to zero. Rejection of Ho implies the mean is significantly different to zero, the Ha results indicate whether it is greater or smaller. The variables tested here are the CDS price at the end of the event window minus the price at the beginning. For example, change0180 is the price change from default -180 days (6 months) to the day of default (day 0). For all tests: ** Significant at 1%, * Significant at 5%.

Table 4: One-sample t-test of mean = 0 for average adjusted CDS returns across estimation/event windows

One-sample t test	Obs	Mean	Std. Err.	Std. Dev.	Ho: mean = 0	DF	Ha: mean < 0	Ha: mean != 0	Ha: mean > 0
avar96 == 0	90	2.86	1.72	16.28	t = 1.67	89	0.95	0.10	0.05*
avar60 == 0	181	9.08	4.38	58.87	t = 2.07	180	0.98	0.04*	0.02*
avar63 == 0	91	3.24	2.32	22.10	t = 1.40	90	0.92	0.17	0.08
avar30 == 0	91	14.64	8.13	77.57	t = 1.80	90	0.96	0.08	0.04*
avar41 == 0	91	6.18	5.04	48.03	t = 1.23	90	0.89	0.22	0.11
avar10 == 0	30	27.39	18.61	103.64	t = 1.47	30	0.92	0.15	0.08
avar01 == 0	31	-4.98	7.20	39.42	t = -0.69	29	0.25	0.49	0.75

Note: This table shows the one-sample t-test results testing the Ho: mean = 0 for the time series of adjusted CDS returns during each estimation and event window. For example, avar96 is the average adjusted return series from -9 to -6 months before default. Rejection of Ho implies a mean return during the given period that is significantly different from zero, with the Ha indicating the direction of difference. Each event window is preceded by its estimation period in the table.

Table 5: One-sample t-test of mean = 0 for cumulated average adjusted CDS returns in each estimation/event window

One-sample t test	Obs	Mean	Std. Err.	Std. Dev.	Ho: mean = 0	DF	Ha: mean < 0	Ha: mean != 0	Ha: mean > 0
caar1800 == 0	37	1643.32	548.53	3336.56	t = 3.00	36	1.00	0.00**	0.00**
caar900 == 0	38	1331.93	513.57	3165.83	t = 2.59	37	0.99	0.01*	0.01**
caar300 == 0	39	849.11	400.59	2501.70	t = 2.12	38	0.98	0.04*	0.02*
caar030 == 0	39	-149.54	111.83	698.37	t = -1.34	38	0.09	0.19	0.91

Note: This table shows the results from a one-sample t-test of CAARs (cumulated adjusted abnormal returns) for each defaulted firm in each event window. The Ho and Ha, and variable descriptors can be interpreted as in Table 3.

Table 6: Two-sample t-test of mean equality between estimation/event window cumulated average adjusted CDS returns

Two-sample t test with unequal variances	Obs	Mean	Std. Err.	Std. Dev.	Ho: mean = 0	DF	Ha: mean < 0	Ha: mean != 0	Ha: mean > 0
caar1800	37	1643.32	548.53	3336.56					
caar270180	37	257.18	86.52	526.26					
mean(caar1800) - mean(caar270180)		1386.14	555.31		t = 2.50	37.79	0.99	0.02*	0.01**
caar900	38	1331.93	513.57	3165.83					
caar18090	38	294.98	167.53	1032.70					
mean(caar900) - mean(caar18090)		1036.95	540.20		t = 1.92	44.79	0.97	0.06	0.03*
caar300	39	849.11	400.59	2501.70					
caar12030	39	562.70	239.47	1495.46					
mean(caar300) - mean(caar12030)		286.41	466.71		t = 0.61	62.08	0.73	0.54	0.27
caar030	39	-149.54	111.83	698.37					
caar300	39	849.11	400.59	2501.70					
mean(caar030) - mean(caar300)		-998.64	415.91		t = -2.40	43.89	0.01*	0.02*	0.99

Note: This table presents the results of a two-sample t-test with Ho = means are equal. The variables tested are the cumulated average adjusted daily returns during the estimation and event windows. For example, caar1800 is cumulated average adjusted return from default -180 days to day 0. Ha results indicate whether the mean of the event is greater or smaller than the mean of the estimation period.

Table 7: Regressions of event and estimation period cumulated average adjusted returns

Dependant Var.	Independent Var.	Coefficient	Std. Error	t-stat	P>t	Adj R-squared
caar60	caar96	0.60	0.07	8.77	0.00**	0.46
	constant	5.11	8.60	0.59	0.55	0.46
caar30	caar63	2.84	0.35	8.07	0.00**	0.42
	constant	272.02	34.78	7.82	0.00**	0.42
caar10	caar41	1.29	0.50	2.60	0.02*	0.16
	constant	298.62	48.82	6.12	0.00**	0.16
caar01	caar10	-0.01	0.04	-0.24	0.81	-0.03
	constant	-105.97	15.31	-6.92	0.00**	-0.03

Note: These regressions use OLS estimation to test for the correlation structure or relationship between estimation period and event window prices. caar60 is cumulated average adjusted return from default -6 months to day 0.

Table 8: One-sample t-test that the mean = 0 for Constant-Mean abnormal adjusted returns for each event window

One-sample t test	Obs	Mean	Std. Err.	Std. Dev.	Ho: mean = 0	DF	Ha: mean < 0	Ha: mean != 0	Ha: mean > 0
cmar60 == 0	181	6.26	4.38	58.87	t = 1.43	180	0.92	0.15	0.08
cmar30 == 0	91	11.66	8.13	77.57	t = 1.43	90	0.92	0.16	0.08
cmar10 == 0	31	20.31	18.61	103.64	t = 1.09	30	0.86	0.28	0.14
cmar01 == 0	30	-32.38	7.20	39.42	t = -4.50	29	0.00**	0.00**	1.00

Note: Cmar60 is the constant-mean abnormal adjusted return time series from default -6 months to day 0.

Table 9: Regression of event window constant-mean abnormal prices and estimation period adjusted prices

Dependant Var.	Independent Var.	Coefficient	Std. Error	t-stat	P>t	Adj R-squared
cmap60	avap96	0.67	0.07	9.09	0.00**	0.48
	constant	-140.66	40.86	-3.44	0.00**	0.48
cmap30	avap63	2.92	0.36	8.15	0.00**	0.42
	constant	-1566.54	273.63	-5.72	0.00**	0.42
cmap10	avap41	1.29	0.50	2.60	0.02*	0.16
	constant	-362.27	410.32	-0.88	0.39	0.16
cmap01	avap10	-0.01	0.04	-0.24	0.81	-0.03
	constant	396.93	64.47	6.16	0.00**	-0.03

Note: These regressions use OLS estimation to test for the correlation structure or relationship between the variables. Variables: e.g. avap96 is average adjusted price from default -9 to -6 months; cmap60 is constant-mean abnormal price from default -6 months to day 0.