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The effects of borrowing rates on intra-firm disequilibria between equity prices and CDS premiums – evidence from dynamic panel analysis.

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The effects of borrowing rates on intra-firm disequilibria between equity prices and CDS premiums – evidence from dynamic panel analysis.

Abstract

Cointegration techniques are used to estimate the long run equilibrium relationship between a firm's CDS premium and its equity price, for a panel of large-cap US firms. From these results, the estimated disequilibrium in daily CDS premiums, with respect to equity prices, is constructed. Dynamic panel methods are employed to show the importance of lagged changes in libor rates as determinants of the estimated disequilibrium. Evidence is found that the extent to which the markets deviate from equilibrium will increase as one-month libor rates rise, but, counter-intuitively, will decrease (return towards equilibrium) as longer term libor rates rise.

Keywords

arbitrage, libor, panel data, cointegration, arrellano-bond, efficient markets, capital structure, cds, derivatives, equity

Cover Page Footnote

1 I am exceedingly grateful to Prof. Jeremy Smith for his invaluable guidance, feedback and support throughout my research.

Introduction

Investors in corporate credit markets face numerous risks when securities are purchased and held. These risks arise from myriad sources including changes in the liquidity of securities, adverse exchange rate movements and, perhaps most crucially, credit or default risk. In the context of corporate bonds, credit risk can be concisely summarised as the risk borne by the investor that the obligor will default on some or all of the coupon or principle payments due as per the terms of the bond.

The credit default swap (CDS) is a derivative contract allowing the investor to transfer some or all of the credit risk arising from exposures within their portfolio to the CDS issuer. These derivatives bear some similarity to insurance contracts[1]: the buyer pays the issuer a periodic premium (denominated in basis points[2] on the amount to be insured against default (the notional)), and, in return, receives compensation equal to the notional in the event of default. The credit risk is therefore transferred from the bondholder to the CDS issuer.

CDS contracts have a range of uses, ranging from risk management to speculation, and are traded within a large and liquid segment of the derivatives market. The origination of the CDS contract is widely attributed to JP Morgan employees working in the late 1990s, and by the turn of the millennium the global market was estimated at c.$300bn[3]. The early 2000's saw near exponential expansion in the use of CDS, and by 2007 the global market contracts had swelled to over $62tn, according to statistics gathered by ISDA. The financial crisis initiated the thus-far continuous decline in the scale of the global CDS market, which today stands at just over $16tn, according to the Bank for International Settlements.

This paper will examine the link between the CDS premiums payable to protect an exposure to a specific obligor's bonds and the price of that obligor's equity. It will

1 The functioning of a CDS contract does not precisely equate to that of insurance agreements. For instance, unlike insurance, the seller of default protection is not required to post capital reserves against the CDS contracts issued, nor is the buyer of a contract required to hold the reference security. These aspects have led to widespread use of CDSs as speculative instruments, especially before the 2008 global crisis.
2 Where 1 basis point equals 1/100th of a per cent.
3 Tett, Gillian. "The Dream Machine: Invention of Credit Derivatives". Financial Times. March 24, 2006. Retrieved March 17, 2009.

demonstrate an equilibrium relationship between these two prices, and will examine the role played by changes in libor rates in determining the extent to which their ratio deviates from its equilibrium level.

The expectation that the CDS and equity markets integrate derives from a strong theoretical basis. The crucial determinant of a CDSs' premium is the expected probability of the obligor's default on some stipulation of the reference bond. Holding other premium determinants (such as expected recovery rates) constant, an increase in the perceived probability of default will produce an increase in the CDS premium – probability of default and CDS premiums will positively co-move, such that the latter reflects the expectation of the former.

CDS pricing models such as those proposed by Duffie (1999) and Hull and White (2000) offer a direct link between the premium of a CDS contract and the yield of the reference bond. Given the assumption of a term structure that is homogenous for the credit of all issuers, the yield of a bond above the risk-free rate[4] - the asset swap spread – reflects the credit risk pertaining to that bond. From this conclusion they argue that CDS premiums should equal to the asset swap spread in equilibrium, due to the actions of arbitrageurs. If a CDS premium is beneath the relevant bond's asset swap spread, an arbitrageur may borrow at libor and use this borrowing to purchase both the bond and a CDS contract to cover the bond's notional value, allowing for risk-free profit. Hence, arbitrage activity serves to adjust asset swap spreads and CDS premiums such that no risk-free profit may be made through speculation in the long run, i.e. when the two equate.

The link between equity prices and the issuing entity's credit risk is also well established in theoretical literature. Most notably, Merton (1974) proposes a model where a firm's liabilities are considered as call options on its assets. He derives a valuation of a corporate liability, which prices it as a function of probability of default, price volatility and the firm's leverage ratio. This approach can be generalized to both debt and equity-based liabilities, allowing the prices of both to be written as negative functions of their obligor's probability of default.

4 Taken to be libor in Duffie (1999) and US Treasury yields in Hull and White (2000)

Considering a simple definition of a bond's periodic yield as c/P_t, where P and C are the price and coupon respectively, Merton establishes that the yield of a bond and the probability of default relate positively. Given that equity prices can also be expressed as a negative function of the probability of default, a negative relation exists between equity prices and bond yields for a given obligor. Given the theoretical equality of CDS premiums and asset swap spreads outlined above, and under the assumption of universal term structure homogeneity, a negative relation will therefore exist between CDS premiums and equity prices[5]. The essential nature of the link between CDSs and equities can be restated through simply considering that both equity prices and CDS premiums reflect sentiment about the future prospects of the issuer. Hence we should expect CDS premiums and equity prices to relate both directly and via the intermediary of the yield on the issuer's bonds.

Of course, in practice, short-term deviations of either security from its equilibrium price, relative to the other, are observed, implying arbitrage opportunities between the CDS and bond market, and the bond and equities market. This empirical observation does not undermine the hypothesis that, over longer durations, CDS and equity prices should exist in equilibrium, both with each other and with the yield of the reference bond.

Potential explanations for why deviations from the equilibrium relationship may exist in the short run are numerous. Basak and Croitoru (2000) argue that deviations from equilibrium prices are an implied consequence of the heterogeneity of investor preferences and opinions. Longstaff and Liu (2004) argue that arbitrageurs constrain the capital allocated to investment within each market, limiting their ability to restore credit and derivative markets, or credit and equity markets, to equilibrium even in the long run.

The importance of the costs associated with arbitrage trades acting as a barrier to equilibrating activity has been highlighted by several authors. Despite the fact that

5 This should hold true even under imperfect information – the precise probability of default is ultimately unknowable, and hence securities' prices derive from the markets' estimation of this unknowable probability. CDS premiums and equity prices would still be expected to relate even if the distance between investors' expectations of the probability of default differs widely from the true probability.

equilibrium should prevail even given imperfect information, Merton (1987) argues that the costs of acquiring the information necessary for arbitrage trades impedes the convergence of credit and equity markets to the equilibrium. Given the variability of mispricing opportunities and their short-term duration, costs of obtaining the data necessary to detect a potential equilibrating trade may render the trade unprofitable. Abreu and Brunnermeier (2002) point out that individual investors will rarely have sufficient capital to single-handedly restore equilibrium, and hence a restoration of securities' prices to their equilibrium level will require the coordination of numerous investors, exacerbating the informational difficulties discussed by Merton. These and further potential reasons for the persistence of disequilibria are discussed extensively in Kapadia and Pu (2012).

A key barrier to equilibrating activity, and the central focus of this paper, is the availability and ease of the funding requisite to execute the necessary trades. Attari et al. (2005) and others discuss the central importance of trade costs as a determinant of arbitrage activity – intuitively, if the margin costs faced by the arbitrageur are sufficient to render the exploitation of a disequilibrium unprofitable, the disequilibrium may persist for longer than it would if arbitrageurs could use margin for a lesser cost. Linked to this is the condition that exploitation of the disequilibrium detected by the arbitrageur must yield higher returns than other opportunities open to them if arbitrage activity is to occur – in other words, arbitrage should not constitute an opportunity-cost versus other potential trades the trader may execute, including lending at libor. For this reason, rises in libor not only have the potential to impede adjustment to equilibrium, but to actively move premiums and prices away from their equilibrium levels.

This study considers the significance of changes in libor rates of different durations in determining the extent of the disequilibrium between equity prices and CDS premiums within a panel of large-cap US firms.

Literature Review

The existing body of literature concerning the relationships between the equity and CDS, equity and credit and credit and CDS markets is extensive, and a wide variety of approaches have been employed to study the equilibrium relationships, deviations from them and adjustment back towards them.

In a recent paper, Kim and Zhang (2014) discuss the residual basis (the portion of the difference between CDS premiums and bond yields not explicable by a variety of risk factors) as a measure of mispricing between the markets for the two securities, and present evidence that the magnitude of the residual basis is a significant predictor of future short term convergence between bond yields and CDS premiums – the higher the residual basis, the faster the expected return towards equilibrium. The non-residual basis, the portion of the difference between CDS premiums and bond yields explicable through consideration of known risk factors, is also found to significantly predict future bond yields.

Foley-Fisher (2010) examines the relationship between the CDS premiums for European government bonds and said bonds' spread over German Bunds. He finds inexplicable and sizeable (30-40 bps) positive movements in CDS premiums during the financial crisis, occurring in differing countries at different times. A strong association is detected between violations of the no-arbitrage condition and comparatively small divergences of investor sentiment, which leads the author to argue that heterogeneous beliefs may have a greater role in explaining this, and other arbitrage phenomena, than previously thought.

The interrelation of equity and credit markets is also discussed extensively within the existing body of literature. In a study of intraday stock and bond returns for the bonds and equities of 439 corporations, Downing et al (2007) present evidence of lead-lag relationships between equity and bond markets. They find that the returns of non-investment-grade bonds are predicted by equity returns, whereas a more significant predictor of the returns of investment-grade bonds is the interest rate. This is due to the fact that investment grade obligors are typically more consistent in their profitability, and so bond yields are not so heavily affected by cash flow news. They

present the lead-lag structure uncovered as evidence of the informational inefficiency of the bond market relative to the equity market – a further reason why disequilibria may exist between the two.

Fanga and Lim (2004) present further evidence of integration between credit and equity markets. Using a multivariate GARCH model, they use the conditional variance within each market as a proxy for volatility and find evidence of inter-market spillovers between equity and bond markets in the US and Australia. They also find evidence of volatility transmission from the US stock market to the Australian bond market. This evidence of inter-market and international volatility transmission adds further to the empirical case for supposing that bond and equity markets integrate. Further evidence of spillover effects is documented by Jacoby et al. (2009), who examine the spillover effects of liquidity shocks between CDS, corporate bond and equity markets using principle component analysis and vector autoregression methods. They find evidence spillover effects for liquidity shocks between equity and CDS markets but, counter intuitively, not between CDS and bond markets.

A number of studies have sought to analyse the integration of CDS and equity markets directly. In a study of the relationship between the European iTraxx CDS index and major European equity indices, Bystrom (2005) finds significant correlation between iTraxx CDS premium changes and changes in stock returns. CDS premiums increase as stock prices fall, and stock prices fall as premiums rise. Evidence is presented of CDS premiums being led by equity prices, lending further support to the hypothesis that the CDS market is informationally inefficient relative to equity markets. Bystrom also provides evidence that the volatility of equity returns is significantly positively linked with the level of CDS premiums.

Da Silva et al. (2013) employ copula methods [6] to test for associations in the performance of European banking stocks and CDS markets between 2007 and 2012 in order to test dependence structures between the two markets in periods of financial distress. They find evidence of autoregressive interdependence between the two

6 The term *copula* refers to a multivariate probability distribution in which the marginal probability of each of the random variables modelled is equal. Copula methods are used to model dependence structures between stochastic variables.

markets but, contrary to the conclusions implied by Merton (1974), they find no support for the hypothesis that the co-dependence of equity prices and CDS premiums intensifies during periods of financial turbulence.

In a study of similar spirit to this one, Esen et al. (2015) test for cointegrating relationships between aggregated CDS premiums and national equity markets using a panel of 13 G20 countries, finding evidence of cointegrating, negative relationships in 7 of them. Their findings are consistent with those of Chan et al. (2009), who present evidence of inter-market cointegration in five out of seven Asian economies. Esen et al. additionally conclude that the direction of the dependence relationship flows from equity markets to CDS markets, providing further evidence that equity markets, of the three considered by this study (equity, credit and CDS) are most informationally efficient.

Their evidence is in accord with the findings of Fung et al. (2008), who examine market-wide relationships between US equities and CDS prices over a six-year period. They find that the stock market appears to lead both investment grade and sub-investment grade CDS markets, and detect strong feedback effects from sub-investment grade CDS markets back towards equity markets. Of the two, the investment grade CDS market is more distantly related to equity market movements.

This study contributes to the existing literature in two principle ways. Firstly, a large panel of diverse firms is employed to test the hypothesis that funding costs, proxied by libor, have no effect on the scale of the disequilibrium between a specific firm's equity prices and CDS premiums. With several exceptions, studies on linkages between equity and CDS markets have largely considered the two at the national or index level – this study will consider integration of CDS premiums and equity prices at the level of the individual firm, using conventional panel methods to account for unobserved firm-specific factors. Secondly, this study's approach of deriving estimates for pricing discrepancies, and proceeding to consider causal relations using said estimates, is unique, to the author's knowledge.

Data

Data was gathered from a variety of sources. Data pertaining to specific firms' equity prices and CDS premiums was drawn from the Reuters Eikon database, with some other firm specific factors (such as probability of default) and certain macroeconomic indicators (such as credit and equity market stress indices) being drawn from Bloomberg for use as controls. Data on libor rates, US govt. and AAA bond yields was sourced from the Federal Reserve of St. Louis' database. Summary statistics for dependent, independent and control variables can be viewed in table 1 of the appendix.

This study employs a panel covering 250 firms, all listed on the S&P 500, for approximately 250 days. The observation period runs from September 2014 to September 2015, excluding weekends and public holidays. Data was sampled daily, yielding approximately 62,000 firm-day observations, for to highly liquid securities relating to well known, large-cap firms. Of this original sample, evidence was found of a cointegrating relationship between the natural logarithm of CDS premiums and the natural logarithm of equity prices for 112 firms. The research question of this study, the effects of changes in libor rates on CDS-equity market disequilibrium, presupposes that an equilibrium relationship exists between the two – hence subsequent models were estimated on the subsample of firms within the panel for which a cointegrating relationship could be found. Firms with no cointegrating relationship were not analysed further.

The study proceeded in two stages, the first of which estimated cointegrating relationships between equity prices and CDS premiums, and the second of which sought to explain the extent of the disequilibrium between the two assets' prices. The dependent variable for the first stage in which cointegrating relationships were estimated was the natural logarithm of the CDS premium price, measured in basis points. Unit root tests of the form proposed by Im, Pesaran and Shin (2002)[7] on both of the lncdscloseprice and lnequitycloseprice series for cointegrating firms generated p-values of 0.000 and 0.214 respectively, and further tests, of the form proposed by

[7] The null hypothesis of the Im-Pesaran-Shin test is that all panels contain unit roots, vs. the alternative that some are stationary. The null of Hadri's test is that all panels are stationary, vs. the alternative that some are unit root.

Hadri (2000) generated p-values of 0.000 for both series. From these tests, we can conclude that all *lnequitycloseprice* series within the panel appear to contain a unit root, whereas a non-zero fraction of *lncdscloseprice* series appears to contain a unit root. Hence, cointegration is expected in some, but not all, panels. The results of these tests can be seen in table 2 of the appendix.

The dependent variable for the second stage of the study are the exponents of residuals from the first stage of the study, equivalent to the discrepancy in CDS prices implied by the difference between the observed CDS premium and the premium predicted by the cointegrating relationship with equity prices. The value of this disequilibrium is measured in basis points, a disequilibrium of -157 indicating that the CDS contract was under-priced relative to the premium implied by equity close prices by 1.57% of the notional per payment period. As these values are deviations from the estimated cointegrating relationship, they are mean-zero and stationary by construction.

Libor rates are sampled daily for borrowings of three durations – one, three and twelve months. The results of an Im, Pesaran and Shin unit root test provided strong evidence of the non-stationarity of these series, and so the first differences of libor rates were included as independent variables in the final model, to estimate their effect on the disequilibrium.

The results for stationarity tests on all independent variables employed in the final model are provided in table 3 of the appendix. Where variables were non-stationary, their difference was included in the final equation, and the level excluded.

Methodology

The existence of a cointegrating relationship between the natural logarithms of CDS premiums and lagged equity prices was tested across the panel using the methodology proposed by Westerlund (2007). Unlike alternative tests such as those of Pedroni (2004), which evaluate residual stationarity, Westerlund's test focuses on the significance of the hypothesized error correction term – a distinction that grants it favourable size and power properties relative to residual-based tests.

The existence of a significant error correction term is necessary and sufficient evidence for cointegration within the panel, and this implies that the cointegrating series are both I(1), at least within panels where a significant error correction term is detected. Nevertheless, before proceeding with formal cointegration tests, CDS premium and equity price time series were first tested for stationarity using the tests proposed by Im, Pesaran and Shin and Hadri. From these tests, it is concluded that both equity prices and CDS prices are unit root for a non-zero fraction of firms. Results of this test can be seen in table 2 of the appendix.

For the purposes of Westerlund's cointegration tests, the data is assumed to arise from a generation process of the form;

$$\Delta y_{it} = \delta_i' d_t + \phi_i(y_{it-1} - \beta_i' x_{it-1}) + \sum_{j=1}^{\rho_i} \theta_{ij} \Delta y_{it-j} + \sum_{j=-q_i}^{\rho_i} \vartheta_{ij} \Delta x_{it-j} + e_{it}$$

$$t \in \{1, \dots, T\} \quad , \quad i \in \{1, \dots, N\}$$

Where T and N represent the number of time periods and panels respectively, and ρ and q represent lag and lead orders, which are permitted to vary across individuals. d_t is a vector of deterministic terms, which can be empty or include one or both of a constant and trend, and x is a vector of controls. For simplicity, we model the vector x as a pure random walk, such that $\Delta x_{i□}$ and e_{it} are independent. We further assume

that values of e_{it} are independently and identically distributed across all periods in all panels[8]. The model can be re-written as;

$$1) \qquad \Delta y_{it} = \delta_i' d_t + \phi_i y_{it-1} + (-\phi_i \beta_i') x_{it-1} + \sum_{j=1}^{\rho_i} \theta_{ij} \Delta y_{it-j} + \sum_{j=-q_i}^{\rho_i} \vartheta_{ij} \Delta x_{it-j} + e_{it}$$

Thus the parameter ϕ_i determines the speed of the systematic error correction after a shock. Hence the (non)existence of an error-correcting process, and therefore of a cointegrating relationship between the dependent and independent variables, can be assessed by testing:

$$H_0 \colon \phi_i = 0 \; ; \; i = 1, \ldots, N.$$

Westerlund calculates four distinct tests of two categories: group tests and panel tests. The specification of the alternative hypothesis depends on the category of test selected: the panel tests assume $\phi_i = \bar{\phi}$ is equal for all firms, whereas the group tests do not impose this restriction, allowing ϕ_i to vary by firm. Their respective alternative hypotheses are therefore:

$$H_A^P \colon \phi_i < 0 \;\; for \, \forall \, i$$
$$H_A^G \colon \phi_i < 0 \;\; for \geq 1 \, i$$

To construct the group tests, model 1 is estimated for each firm, yielding;

$$\Delta y_{it} = \widehat{\delta_i}' d_t + \hat{\phi}_i y_{it-1} + \hat{\lambda}_i' x_{it-1} + \sum_{j=1}^{\rho_i} \hat{\theta}_{ij} \Delta y_{it-j} + \sum_{j=-q_i}^{\rho_i} \hat{\vartheta}_{ij} \Delta x_{it-j} + \widehat{e_{it}}$$

Fitted values for $\hat{\vartheta}_{ij}$ and $\widehat{e_{it}}$ are then used to obtain a matrix, $\hat{u}$, comprised of lags of independent variables and the stochastic error component;

[8] The procedure can be strengthened against a violation of the I.I.D. assumption through use of bootstrapping methods, which can be employed to mitigate the effects of contemporaneous error co-dependence between panels.

$$\widehat{u_{it}} = \sum_{j=-q_i}^{\rho_i} \hat{\vartheta}_{ij} \Delta x_{it-j} + \widehat{e_{it}}$$

This matrix is then used to compute $\hat{\phi}_i(1) = \hat{w}(\hat{u_i})/\hat{w}(\Delta y_{it})$, where $\hat{w}(.)$ is the long run estimator of the standard error of the sample mean under serial dependence proposed by Newey and West (1994). Group test statistics can therefore be computed;

$$G_\tau = N^{-1} \sum_{i=1}^{N} \frac{\hat{\phi}_i}{SE(\hat{\phi}_i)}$$

$$G_a = N^{-1} \sum_{i=1}^{N} \frac{T\hat{\phi}_i}{\hat{\phi}_i(1)}$$

Panel test statistics are computed by regressing the first difference and lag of the dependent variable on the deterministic vector, lagged first differences of the dependent variable and contemporaneous and lagged values of x to generate projection errors, $\widetilde{\Delta y_{it}}$ and $\tilde{y}_{it-1}$;

$$\widetilde{y_{it}} = y_{it-1} - \tilde{\delta}_i' d_t - \tilde{\lambda}_i' x_{it-1} - \sum_{j=1}^{\rho_i} \widetilde{\theta_{ij}} \Delta y_{it-j} - \sum_{j=-q_i}^{\rho_i} \widetilde{\vartheta_{ij}} \Delta x_{it-j} + e_{it}$$

$$\widetilde{\Delta y_{it}} = \Delta y_{it-1} - \hat{\delta}_i' d_t - \hat{\lambda}_i' x_{it-1} - \sum_{j=1}^{\rho_i} \widehat{\theta_{ij}} \Delta y_{it-j} - \sum_{j=-q_i}^{\rho_i} \hat{\vartheta}_{ij} \Delta x_{it-j} + e_{it}$$

These results are then used to estimate a common error-correction parameter, $\hat{\phi}$, and its standard error, which can be used to construct the panel test statistics. The panel statistics are;

$$P_\tau = \frac{\hat{\phi}}{SE(\hat{\phi})}$$

$$P_a = T\hat{\phi}$$

These statistics can be normalized and compared to the left tale of the standard normal distribution in order to test hypotheses. The procedure is conveniently executed in Stata by the *xtwest* module by Persyn and Westerlund (2008). Two of the four test statistics strongly rejected the null at 5%, and three at 10%, providing evidence of the presence of cointegrating relationships within the panel as a whole. The results of this test can be seen in table 4 in the appendix. Individual error correction models were estimated firm-by-firm, and firms where the error correction term was not <0 and significant at the 5% level (i.e. when no equilibrium relationship between the natural log of CDS premiums and that of equity prices could be shown to exist at the 5% level) were not included in later models of the effects of changes in libor rates on disequilibrium.

Results of tests for significant error correction terms, by firm, are provided in table 5 of the appendix.

A cointegrating relationship of the form;

$$lnCDS_{it} = \alpha + \beta_i \ln equityprice_{it} + e_{it}$$

Was estimated, where the cointegrating vector $\beta_i, i = 1, \ldots, 112,$ contained heterogeneous elements for all firms, allowing the cointegrating relationship to vary between firms. Statistical output corresponding to this equation estimation can be seen in table 6 of the appendix. Thus the estimate of the disequilibrium between the two markets was taken to be the exponential of the residuals of this cointegrating equation;

$$\hat{\varepsilon}_{it} = \exp\{lnCDS_{it}\} - \exp\{\alpha + \beta_i \ln equityprice_{it}\}$$

The cointegration residuals for each firm in the dataset were demeaned and converted into absolute values, denoted $disequilibrium_{it}$ and denominated in basis points. High positive values of $disequilibrium$ denote a high degree of disintegration in the equilibrium relationship between CDS premiums and equity prices. This disintegration can be in the positive or negative (CDS premiums are higher or lower

than suggested by the estimated equilibrium relationship, respectively). When the value of $disequilibrium$ is zero, the CDS premium is at the level suggested by the postulated long-run equilibrium relationship with the equity price.

The significance of interest rates and arbitrage costs, proxied by libor rates of various frequencies, was tested by regressing $disequilibrium_{it}$ on independent and control variables. A dynamic panel model was estimated by including two autoregressive terms, which was found to be free from problematic serial correlation of errors. To overcome the well-documented likelihood of parametric inconsistency arising from model dynamism [9], models for the disequilibrium were estimated using the generalized method of moments based procedure of Arellano and Bond (1991).

Anderson and Hsiao (1981) proposed resolving the parametric inconsistency of dynamic panel estimators by estimating a model of the form;

$$y_{it} - y_{it-1} = \varphi(y_{it-1} - y_{it-2}) + (x_{it} - \square_{it-1})'\beta + (e_{it} - e_{it-1})$$

using y_{it-2} to instrument $(y_{it-1} - y_{it-2})$. Assuming errors are serially uncorrelated, this procedure will provide consistent parameter estimates. Arellano and Bond (1991) improved on their procedure, demonstrating that increasing the number of lags of the dependent variable used as instruments will improve the efficiency of the resulting model. As this results in over identification, two-stage-least-squares or GMM is used for estimation. The estimator is;

$$\hat{\varrho} = \left[\left(\sum_{i=1}^{\square} \widetilde{X}_i' Z_i\right) W_N \left(\sum_{i=1}^{N} Z_i' \widetilde{X}_i\right)\right]^{-1} \left(\sum_{i=1}^{N} \widetilde{X}_i' Z_i\right) W_N \left(\sum_{i=1}^{N} Z_i' \widetilde{y}_i\right)$$

Where $\hat{\varrho}$ represents the coefficient on instrumented variables, $\widetilde{X}_i$ denotes a (T-2)(K+1) matrix with t'th row $(\Delta y_{it-1}, \Delta x_{it}')$ for t = 3,…T. $\widetilde{y}_i$ is a (T-2)(1) vector with tth row Δy_{it}, W_N is a weighting matrix and Z_i is a diagonal matrix of instruments;

9 See Nickell (1981).

$$Z_i = \begin{bmatrix} z'_{i3} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & z'_{iT} \end{bmatrix}$$

The method is easily adapted to accommodate higher order autoregressive processes, and, provided certain assumptions used to construct moment conditions are met, is asymptotically consistent.

One and two-step varieties of the procedure are available, the former of which is outlined above. The two-step version of the estimator is computed using the residual vectors of the one-step estimate, and is consistent and asymptotically efficient under panel-specific heteroskedasticity. The model for the disequilibrium is estimated using both one-step and two-step versions of the Arellano-Bond procedure. GMM standard errors computed via the two-stage procedure frequently suffer from substantive negative bias, leading to significant risk of under-rejection. For this reason, the standard errors in the two-step version of the model are adjusted in accordance with the correction proposed by Windmeijer (2005), and those of the one-step version employ Arellano and Bond's heteroskedasticity and autocorrelation robust standard errors.

Thus, using the GMM-based procedure described above, a model of the following form is estimated;

$$(1 - \varphi_{1i}L - \varphi_{2i}L^2)disequilibrium_{it} = \alpha + \sum_{i=0}^{3} L^i(\mathcal{L}'\gamma) + x'_{it}\theta + e_{it}$$

Where $\mathcal{L}$ is a (24)(1) vector of the contemporaneously exogenous first, second and third differences of one month, three month and twelve month libor rates, as well as the squares of all said differences. x'_{it} Is a vector of controls, transformed as necessary for stationarity. Two autoregressive disequilibrium terms are included, and are instrumented, via the one and two step procedure, employing the first ten available lagged values (i.e. disequilibrium 3-12 days prior to the present).

Aside from the libor rates, which constitute the key independent variables of interest, controls are selected for inclusion based upon economic theory. The first to third lags of equity closing bid-ask spreads are included to control for potential effects of the diversity of investors' opinions and equity liquidity. Lagged differences of Bloomberg's estimated, firm specific default probability control for firm-idiosyncratic risk. The percentage change in the firm's equity price within the day is included as a control for volatility, and differences in Bloomberg's credit stress index, Moody's AAA bond yield index, and the spread of the US 10 year bond over 12-month libor are included to control for general credit market conditions.

That the errors of the estimated model be serially uncorrelated beyond the first order is a crucial assumption of the Arellano-Bond method. This is tested using the test proposed by Arellano and Bond, by which we cannot reject the null of no autocorrelation beyond the first lag in any of the varieties of model specified. Sargan's test of the validity of over identifying restrictions rejects the null of validity for the one-step model wherein ten lags of the dependent variable are used to instrument the autoregressive term. However, the test fails to reject the null of validity for the two-step model employing the same instruments. Models are estimated using the standard, non-robust variance-covariance matrix for the purposes of this test[10]. The results of the Sargan tests can be seen in table 7 of the appendix.

Two models are therefore specified;

1) Uses a one-step version of the Arellano-Bond estimator, with ten lags of the dependent variable as instruments.
2) Uses a two-step version of the Arellano-Bond estimator, with ten lags of the dependent variable as instruments.

10 Sargan's test cannot be carried out with Arellano-Bond robust errors, as the distribution of the test statistic is unknown.

Results

Consistently with Esen et al. (2015) and Chan et al. (2009), evidence is found of a statistically significant and negative cointegrating relationship between the natural logarithms of CDS premiums and equity prices. The cointegrating relationship is found to vary significantly between firms, and the estimated equilibrium relationship between equity prices and CDS premiums differs significantly from the group-wide relationship for 96.4% of cointegrating firms (at the 5% confidence level). The scale and direction of this relationship is unsurprising given the extensive theoretical and intuitive reasoning which links the equity and CDS markets together. A cointegrating relationship between the equity prices and CDS premiums of at least some firms is a presupposition of this paper's research question and, as such, the precise details of this relationship are a secondary concern, which will not be explored in detail. However, a table of estimated cointegrating coefficients, and firm-by-firm results of Westerlund's test for a significant error correction term, can be found in tables 5 and 6 in the appendix.

Although coefficient estimates between model 1 (calculated using the one-step Arellano Bond procedure with Arellano and Bond's robust standard errors) and model 2 (calculated using the two step procedure with Windmeijer's robust standard errors) do not differ to a statistically significant extent, and both methods provide asymptotically consistent parameter estimates, the statistical significance of uncovered marginal effects of libor changes does differ substantively by estimation method.

One-month libor

In line with expectation and theory, model 1 evidences a statistically significant, positive relationship between first-differenced one-month libor rates and the absolute value of the estimated disequilibrium. The relationship is significant at 5% for changes in one-month libor occurring two to three days before the present, but the coefficient on changes in one-month libor occurring the previous day is insignificant at 5%. A positive change in one-month libor rates on date t (equal to the mean daily change observed over the sampling period - +0.020% points) is found to reduce the

absolute value of the disequilibrium by 0.0087 bps on date t+1, but increase it by 0.2265 bps and 0.4742 bps on dates t+2 and t+3 respectively. The long run effect of such a change is to increase the extent to which equity prices and CDS premiums deviate from equilibrium by 2.0308 bps.

The magnitude of expected effects in model 2 (using two-step Arellano-Bond estimation) is very similar to those in model 1 – an increase in one-month libor of 0.02% points produces an expected long run increase in the extent of the disequilibrium between CDS premiums and equity prices of 1.9338 bps. However, when the two-step methodology is employed, coefficients on all lagged changes in libor are insignificant at 5%.

Three-month libor

The mean change in three-month libor rates observed during the sample period was an increase of 0.0395% points. Estimates derived in model 1 suggest such a change on date t will produce an expected change in the absolute value of disequilibrium of -0.0801 bps, -0.1090 bps and -0.0262 bps on dates t+1, t+2 and t+3 respectively, with a long run effect of -0.2510 bps. Estimates derived in model 2 suggest a mean change in three month libor rates on date t will produce an expected increase in disequilibrium of -0.0767 bps, -0.1079 bps and -0.0466 bps on dates t+1, t+2 and t+3 respectively, with a long run expected effect of -0.3261 bps.

Coefficients on changes in three-month libor rates are not statistically significant at 5% in either model 1 or model 2.

Twelve-month libor

Contrary to expectations, model 1 provides evidence of a negative association between twelve-month libor rates and the extent of the absolute estimated disequilibrium between CDS premiums and equity prices. Model 1 suggests that an increase in twelve month libor rates of 0.11% (the mean observed increase) on date t produces an expected decline in disequilibrium of 0.2368 bps, 0.5139 bps and 0.7701 bps on dates t+1, t+2 and t+3 respectively, and has the long run effect of reducing the

absolute value of disequilibrium by 3.6372 bps. Coefficients on the first, second and third lags of changes in twelve-month libor rates are all significant at 5%. Model 2 yields similar results, the long run effect of a 0.11% increase in twelve-month libor rates being a reduction in the absolute value of the disequilibrium of 3.4026 bps. However, coefficients on the first, second and third lags of changes in twelve-month libor rates are not significant at 5% in model 2.

A full table of coefficients for all models, and a table illustrating implied marginal effects, are provided in tables 8 and 9 of the appendix.

Discussion

The above findings as to the direction and order of magnitude of the marginal effects of changes in one-month libor rates are in accordance with existing literature and in line with expectations. Positive increases in one-month libor rates are associated with a increase in the absolute size of the disequilibrium between CDS premiums and equity prices – this makes intuitive sense, as increases in libor rates raise the cost of funding trades to close the disequilibrium. Arbitrage activity, which may otherwise return equity prices and CDS premiums to their equilibrium level over a number of days, becomes increasingly unprofitable and declines, causing the absolute level of the disequilibrium to be higher on subsequent days (after the libor rise) than it would have been had the usual volume of equilibrating trades occurred.

More surprising and counterintuitive is the finding that changes in three and twelve month libor rates produce negative expected changes in the disequilibrium between equity prices and CDS premiums, i.e. that increasing longer-term interest rates cause the prices of the two securities to return towards their equilibrium levels. This equilibrating effect is not statistically significant at 5% for three-month libor rates in either model, but is significant for twelve-month rates in model 1.

The difference between the directions of the marginal effects for changes in one month libor and changes in three and twelve month libor, and the fact that the magnitude of the marginal effect of the former is greater than for either of the latter, can be explained by the proposition that arbitrage traders favour shorter-term

borrowing. If we accept this proposition, it stands to reason that the volume of arbitrage trading activity, and hence the extent of prevailing capital structure disequilibrium, should be more heavily determined by changes in short term borrowing rates than longer term rates. This hypothesis may explain why absolute disequilibrium and one month libor rates are positively linked (whereas disequilibrium and three and twelve month rates are negatively linked) and why the marginal effects of changes in one month libor rates are much larger in magnitude.

The negative association between changes in three and twelve-month libor rates and the absolute value of disequilibrium are contrary to what may be expected, given the theory discussed in the introduction to this paper. Ostensibly, even given arbitrage trader’s potential preference for short-term vs. longer-term borrowings, this result is surprising. A potential explanation may be the potential for higher longer-term interest rates to attract capital away from equity markets, making fixed-income and money market securities comparatively more attractive, which, in turn, causes equity prices to fall towards their equilibrium level, with respect to CDS prices. This hypothesis would seem to imply that the majority of the disequilibrium between CDS premiums and equity prices is due to equity prices exceeding their equilibrium level (with respect to bond yields and CDS premiums), rather than being too low, relative to their equilibrium level.

A further result of interest is the significance of extended lags of changes in one and twelve month libor rates. Changes in one and twelve month libor rates are found to have a statistically significant effect on disequilibrium levels up to three days after the change occurs, suggesting that equity and CDS markets adjust to new information somewhat slowly. This finding accords with the results of Downing et al (2007) and Bystrom (2005), who present further evidence of informational inefficiencies in the three markets relevant to the relationship between CDS premiums and equity prices (CDS, corporate bond and equity markets).

The lack of statistical significance in model 2, and the lack of any significant marginal effect for changes in three-month libor rates according to either model, is puzzling and troublesome. A well-known problem with the two-step Arellano-Bond method is its proclivity to produce downward-biased standard errors in small samples, leading to

an over-rejection of null hypotheses. Out of caution with respect to this issue, model 2 has been estimated using Windmeijer's robust standard errors, whereas model 1 is estimated using one-step standard errors, corrected for heteroskedasticity and autocorrelation. Given the comparatively large size of this study's sample, and the fact that the two-step downward bias is largely a small-sample problem, it is feasible that the Windmeijer-corrected standard errors of model 2 are over-conservative, leading to under-rejection of false nulls. The standard errors of one-step GMM estimators are known to be approximately asymptotically un-biased, if less efficient than those of two-step estimators, and for this reason researchers have traditionally reported results of one-step and two-step Arellano-Bond procedures together, using the standard errors of the former for inference. When the significance of coefficients estimated by model 2 is tested using the standard error estimates of model 1, similar patterns of significance exist between both models.

Methodological evaluation and extensions

This study contributes to the extensive subject literature by providing additional evidence as to the significance and causal nature of the relationship between changes in borrowing costs and CDS-equity market disequilibria. However, the ultimate picture remains incomplete.

Contemporaneous regressors were not included within the final model of conditional disequilibria in order to ensure the condition of contemporaneous exogeneity of regressors was met. Pre-determined, weakly exogenous lags of variables were included in order to resolve this issue. Difficulties were encountered in the collection of granular, firm-level data regarding security prices and the idiosyncrasies of firms and securities pertaining to them, with coverage in some areas being extremely limited. Sourcing reliable information on specific CDS contracts beyond their premiums, such as their ownership, turnover and bid-ask spreads, proved infeasible, and hence the models estimated were constrained to assessing very high-level data. An area for future research is to test the sensitivity of the relationships discussed herein to inclusion of further variables describing specific equities and CDS contracts in greater detail, for instance CDS bid-ask spreads and traded volume.

Where previous literature on the subject of CDS and Equity market integration by the likes of Bystrom (2005) and Da Silva et al. (2014) has focussed on integration at the index-wide or market-wide level, this study contributes by examining integration between CDS premiums and equity prices at a firm-specific level for large-cap firms, with data collected at a daily frequency. Further research opportunities are available by allowing the frequency and granularity of observations to vary – results may differ substantively if the sampling frequency is adjusted to be higher (hourly or minutely) or lower (weekly or monthly).

A further potential area for future research is the exploration of the marginal effects of libor upon disequilibria between the CDS premiums and equity prices of firms of differing size. This study has focussed exclusively on large-cap firms, a focus that was partly motivated by the diminished likelihood that one shareholder would individually control a significant stake. Smaller firms are more likely to be dominated by one individual or institutional shareholding, and therefore may be inherently more likely to experience disequilibria between the prices of their securities and those securities' derivatives. It is conceivable, for instance, that the equity of a smaller firm may be significantly controlled by one investor, whereas the investor base for its credit (and, therefore, the base of individuals who may be active in the market for CDS contracts with that firm as an obligor) may be more broad and diverse. For such a firm, the price of its equity may be relatively fixed while the price of CDS contracts against its credit fluctuates much more. This may be particularly true if the major shareholder is a long-term investor (for instance, a founder or venture capitalist).

Perhaps the most obvious and interesting extension to this paper involves the consideration of shorter-duration borrowing rates (e.g. one week and overnight libor rates), and the impact of changes in these upon CDS-equity market disequilibrium. The unexpected finding that increases in longer term libor rates have significant equilibrating effects also provides ample scope for future research.

Conclusion

This study examined the effect of changes in libor rates upon the extent of estimated disequilibrium between the equity prices and CDS premiums of individual firms.

Evidence was presented of a cointegrating relationship between the natural logarithms of the two time series, allowing an equilibrium relationship to be estimated and estimated disequilibria calculated. Using one and two step Arellano-Bond GMM estimation procedures, changes in one month libor rates were found to have statistically significant, positive associations with the extent of the prevailing price disequilibrium. Counter-intuitively, a negative association was found for three and twelve month libor rates. The significance of lagged versions of libor variables suggested the association was causal, and provided further evidence regarding the informational inefficiency of markets.

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Appendix

Table 1: Summary statistics for variables

Variable	Obs	Mean	Std. Dev.	Min	Max	Units	Source	Description
lncdscloseprice	2,250	4.134857	0.746153	2.410542	7.061866	ln bps	Reuters Eikon	Premium payable for the purchase of a CDS contract for that issuer. Purchaser pays bps on the notional per payment period.
lnequitycloseprice	2,250	4.069600	0.666372	1.512927	6.620246	ln US Dollars	Reuters Eikon	Equity close prices for that issuer.
disequilibrium	2,984	10.124230	60.660000	-157.804000	332.201500	bps	Derived	The difference between the observed CDS premium price and that predicted by the estimated equilibrium relationship.
onemonthlibor	3,117	0.174961	0.014646	0.151500	0.204600	% annualized	FRED	Interbank one month rate.
threemonthlibor	3,117	0.268221	0.028489	0.228100	0.334000	% annualized	FRED	Interbank three month rate.
twelvemonthlibor	3,117	0.173945	0.014384	0.151500	0.204600	% annualized	FRED	Interbank 12 month rate.
excessonemonth	2,984	6.351214	9.295653	-0.195816	123.568400	bps	Derived	*One month libor* subtracted from *Disequilibrium*
moodysaaabondindex	3,117	3.864197	0.254336	3.290000	4.330000	% annualized	FRED	Annualized yields on an index of AAA rated US corporate bonds.
twi	3,117	113.067100	4.384156	104.300000	120.300000	Index	FRED	Trade-weighted index of US Dollar exchange rates.
us10yrspread	3,117	2.011436	0.202545	1.508750	2.476500	% annualized	Bloomberg	The difference between 12 month libor and the yield of US govt. 10 year bonds (highly liquid, low risk securities).
pdequitywithin	3,117	-0.000184	0.013023	-0.107115	0.110493	%	Reuters Eikon	The percentage change between an equity's opening and closing price over the same day.
lnequityvolumes	3,117	19.093460	0.903856	16.017660	23.679400	ln no. of shares	Reuters Eikon	Volumes of equities traded that day.
pdefault	2,868	6.995125	5.226871	0.971000	32.398000	% probability	Bloomberg	Bloomberg predicted probability of an issuer defaulting on any obligation within one year.
creditstress	2,868	8.724538	0.624869	7.670000	10.010000	Index	Bloomberg	A bloomberg index of respondent's perceptions about the future stability of credit markets.
d.disequilibrium	2,851	0.021583	2.818652	-60.459590	63.293580	bps	Derived	The difference between the observed CDS premium price and that predicted by the estimated equilibrium relationship.
d.onemonthlibor	2,984	0.000206	0.001603	-0.005050	0.005000	% annualized	FRED	Interbank one month rate.
d.threemonthlibor	2,984	0.000399	0.002161	-0.005750	0.011200	% annualized	FRED	Interbank three month rate.
d.twelvemonthlibor	2,984	0.000205	0.001585	-0.004500	0.005000	% annualized	FRED	Interbank 12 month rate.
d.excessonemonth	2,851	0.014182	2.578919	-43.242600	63.294630	bps	Derived	*One month libor* subtracted from *Disequilibrium*
d.moodysaaabondindex	2,984	0.000000	0.050926	-0.140000	0.140000	% annualized	FRED	Annualized yields on an index of AAA rated US corporate bonds.
d.twi	2,984	0.064516	0.365137	-0.975998	0.953995	Index	FRED	Trade-weighted index of US Dollar exchange rates.
d.us10yearspread	2,984	-0.001657	0.052015	-0.160000	0.130000	% annualized	Bloomberg	The difference between 12 month libor and the yield of US govt. 10 year bonds (highly liquid, low risk securities).
d.pdequitywithin	2,984	-0.000001	0.018696	-0.152019	0.140394	%	Reuters Eikon	The percentage change between an equity's opening and closing price over the same day.
d.lnequityvolumes	2,984	0.000960	0.378640	-2.441162	2.751247	ln no. of shares	Reuters Eikon	Volumes of equities traded that day.
d.pdefault	2,736	-0.004241	0.224373	-4.841999	4.420000	% probability	Bloomberg	Bloomberg predicted probability of an issuer defaulting on any obligation within one year.
d.creditstress	2,736	0.008548	0.063077	-0.320001	0.320000	Index	Bloomberg	A bloomberg index of respondent's perceptions about the future stability of credit markets.

Table 2: Stationarity tests for *lnequitycloseprice* and *lncdscloseprice*

Im-Pesaran-Shin test

	lncdscloseprice	lnequitycloseprice
t bar	-1.9829	-1.5634
t tilde bar	-1.8801	-1.5536
Z t tilde bar	-6.9987	-0.7877
P Value	0.0000	0.2154
Outcome	Reject	Do not reject

H0: All panels contain unit roots.
Ha: Some panels are stationary

Hadri test

	lncdscloseprice	lnequitycloseprice
Statistic	1200	1600
P Value	0.0000	0.0000
Outcome	Reject	Reject

H0: All panels are stationary.
Ha: Some panels contain unit roots

Table 3: Stationarity tests for independent variables in the final model

Variable	Test type	P Value	Outcome
One month libor	Im-Pesaran-Shin	1.000	Cannot reject
Three month libor	Im-Pesaran-Shin	1.000	Cannot reject
Twelve month libor	Im-Pesaran-Shin	1.000	Cannot reject
Credit stress	Im-Pesaran-Shin	1.000	Cannot reject
Probability of default	Im-Pesaran-Shin	1.000	Cannot reject
ln equity volumes	Im-Pesaran-Shin	0.000	Reject
% change equity within day	Im-Pesaran-Shin	0.000	Reject
US 10 yr yield - 12 month libor	Im-Pesaran-Shin	0.000	Reject
Equity close spread	Levin-Lin-Chu	0.000	Reject
TWI	Im-Pesaran-Shin	1.000	Cannot reject
Moodys AAA bond yield index	Im-Pesaran-Shin	0.104	Cannot reject
d. onemonthlibor	Im-Pesaran-Shin	0.000	Reject
d. threemonthlibor	Im-Pesaran-Shin	0.000	Reject
d. twelvemonthlibor	Im-Pesaran-Shin	0.000	Reject
d. credit stress	Levin-Lin-Chu	0.000	Reject
d. probability of default	Levin-Lin-Chu	0.000	Reject
d. twi	Im-Pesaran-Shin	0.000	Reject
d.Moodys AAA bond yield index	Im-Pesaran-Shin	0.000	Reject

For the Im-Pesaran-Shin test;

H0; All panels contain unit roots
H1; Some panels are stationary

For the Levin-Lin-Chu test;

H0; Panels contain unit roots
H1; Panels are stationary

Table 4: Westerlund's panel cointegration test statistics (for whole panel)

Statistic	Value	Z-value	P-value
Gt	-1.861	-1.473	0.070
Ga	-10.551	-9.9	0.000
Pt	-23.442	-0.556	0.289
Pa	-5.273	-3.715	0.000

H0: Error correction term = 0, no cointegration.

n = 62,250

Table 5: Firm-by-firm results of Westerlund's test for cointegration

Firm	Error correction coefficient	P-value	Cointegration Evidenced?
3M Co	-0.0597	0.0220	Y
ACE Ltd	0.0085	0.3210	N
AES Corp	-0.0358	0.0700	N
AT&T Inc	-0.0063	0.3370	N
Abbott Laboratories	-0.0333	0.0030	Y
Aetna Inc	-0.0089	0.1810	N
Agilent Technologies Inc	-0.1188	0.0060	Y
Air Products and Chemicals Inc	-0.0364	0.0310	Y
Alcoa Inc	-0.0560	0.0090	Y
Allstate Corp	-0.0004	0.9660	N
Altria Group Inc	-0.0134	0.1380	N
Ameren Corp	-0.0108	0.3230	N
American Electric Power Company Inc	-0.0105	0.2450	N
American Express Co	-0.0297	0.0410	Y
American International Group Inc	-0.0392	0.0060	Y
American Tower Corp	-0.0449	0.0140	Y
AmerisourceBergen Corp	-0.0471	0.0240	Y
Amgen Inc	0.0108	0.1450	N
Anadarko Petroleum Corp	-0.0341	0.0460	Y
Analog Devices Inc	-0.0356	0.0280	Y
Apache Corp	-0.0190	0.0940	N
Apple Inc	-0.0876	0.0040	Y
Applied Materials Inc	-0.0300	0.0850	N
Archer Daniels Midland Co	-0.0837	0.0250	Y
Assurant Inc	-0.0325	0.1110	N
AutoNation Inc	-0.0284	0.0320	Y
Autozone Inc	-0.0253	0.0700	N
AvalonBay Communities Inc	-0.0073	0.4920	N
BB&T Corp	-0.0316	0.0050	Y
Baker Hughes Inc	-0.0140	0.3330	N
Ball Corp	-0.1877	0.0010	Y
Bank of America Corp	-0.0867	0.0000	Y
Baxter International Inc	-0.0049	0.4620	N
Berkshire Hathaway Inc	-0.0494	0.0090	Y
Best Buy Co Inc	-0.0452	0.0080	Y
Boeing Co	-0.0350	0.0980	N
BorgWarner Inc	-0.0267	0.1000	N
Boston Properties Inc	-0.0268	0.1060	N
Boston Scientific Corp	-0.0196	0.3180	N
Bristol-Myers Squibb Co	-0.0171	0.1520	N
CA Inc	0.0044	0.6460	N
CBS Corp	-0.0081	0.7000	N
CMS Energy Corp	-0.0374	0.0570	N
CSX Corp	0.0028	0.7060	N
CVS Health Corp	-0.0037	0.6360	N
Cablevision Systems Corp	-0.0552	0.0020	Y
Campbell Soup Co	-0.0255	0.0310	Y
Capital One Financial Corp	-0.0158	0.1170	N
Cardinal Health Inc	-0.0221	0.1760	N
Carnival Corp	-0.0251	0.1430	N
Caterpillar Inc	-0.0279	0.0610	N
CenterPoint Energy Inc	-0.0510	0.0100	Y
CenturyLink Inc	-0.1021	0.0000	Y
Chesapeake Energy Corp	-0.0461	0.0800	N
Chevron Corp	-0.0228	0.0720	N
Chubb Corp	-0.0299	0.0160	Y
Cigna Corp	-0.0159	0.0820	N
Cisco Systems Inc	-0.0153	0.3450	N
Citigroup Inc	-0.0347	0.0290	Y
Clorox Co	-0.0441	0.0320	Y
Coca-Cola Co	-0.0293	0.0430	Y
Colgate-Palmolive Co	-0.0435	0.0830	N
Comcast Corp	-0.0048	0.7190	N
ConAgra Foods Inc	-0.0216	0.0900	N
ConocoPhillips	-0.0281	0.0930	N

Firm	Error correction coefficient	P-value	Cointegration Evidenced?
Constellation Brands Inc	-0.0281	0.0930	N
Corning Inc	-0.0947	0.0030	Y
Costco Wholesale Corp	-0.0649	0.0010	Y
Cummins Inc	0.0040	0.7380	N
D.R. Horton Inc	0.0047	0.7500	N
DTE Energy Co	-0.0346	0.0660	N
DaVita HealthCare Partners Inc	-0.0389	0.0340	Y
Danaher Corp	-0.0001	0.8520	N
Darden Restaurants Inc	-0.0026	0.8140	N
Deere & Co	-0.0528	0.0040	Y
Delta Air Lines Inc	-0.0066	0.6760	N
Devon Energy Corp	-0.0653	0.0030	Y
Diamond Offshore Drilling Inc	-0.0197	0.0340	Y
Dominion Resources Inc	-0.0181	0.0780	N
Dover Corp	-0.0008	0.9680	N
Dow Chemical Co	-0.0170	0.4340	N
E I du Pont de Nemours and Co	-0.0060	0.6010	N
EMC Corp	-0.0569	0.0140	Y
EOG Resources Inc	-0.1063	0.0010	Y
Eastman Chemical Co	-0.0244	0.1630	N
Ecolab Inc	0.0000	0.7220	N
Eli Lilly and Co	-0.0706	0.0280	Y
Emerson Electric Co	-0.0565	0.0450	Y
Entergy Corp	-0.0352	0.0870	N
Estee Lauder Companies Inc	-0.0254	0.1200	N
Eversource Energy	-0.3497	0.0000	Y
Exelon Corp	-0.0464	0.0010	Y
Expedia Inc	-0.0259	0.0630	N
Exxon Mobil Corp	-0.0148	0.1710	N
FMC Corp	-0.0874	0.0480	Y
FedEx Corp	-0.0299	0.0280	Y
FirstEnergy Corp	-0.0381	0.0040	Y
Ford Motor Co	-0.0066	0.7330	N
Freeport-McMoRan Inc	-0.0675	0.0110	Y
Frontier Communications Corp	0.0035	0.7600	N
Gap Inc	-0.0281	0.0060	Y
General Dynamics Corp	-0.1163	0.0010	Y
General Mills Inc	-0.0182	0.0880	N
General Motors Co	-0.0593	0.0090	Y
Goldman Sachs Group Inc	-0.0825	0.0010	Y
Goodyear Tire & Rubber Co	-0.0085	0.5900	N
HCP Inc	-0.0258	0.0370	Y
Halliburton Co	-0.0051	0.6240	N
Harris Corp	-0.2508	0.0000	Y
Hartford Financial Services Group Inc	-0.0613	0.0020	Y
Hasbro Inc	-0.0262	0.0480	Y
Hershey Co	-0.0529	0.0040	Y
Hess Corp	-0.0337	0.0160	Y
Home Depot Inc	-0.0130	0.2270	N
Honeywell International Inc	-0.0177	0.0950	N
Host Hotels & Resorts Inc	-0.0390	0.0890	N
Humana Inc	-0.0185	0.2030	N
Illinois Tool Works Inc	-0.1693	0.0000	Y
Intel Corp	-0.0072	0.6270	N
International Business Machines Corp	-0.0480	0.0160	Y
International Paper Co	-0.0542	0.0010	Y
Interpublic Group of Companies Inc	-0.0343	0.0000	Y
Intuit Inc	-0.0543	0.0340	Y
JPMorgan Chase & Co	-0.0422	0.0190	Y
Johnson & Johnson	-0.0083	0.4370	N
Johnson Controls Inc	0.0050	0.6590	N
Juniper Networks Inc	-0.0223	0.1430	N
Kellogg Co	-0.0271	0.0800	N
KeyCorp	-0.0099	0.3370	N
Kimberly-Clark Corp	-0.0205	0.0780	N

Firm	Error correction coefficient	P-value	Cointegration Evidenced?
Kimco Realty Corp	-0.0173	0.1320	N
Kinder Morgan Inc	-0.0173	0.1730	N
Kohls Corp	-0.0715	0.0050	Y
Kroger Co	-0.0055	0.4730	N
L Brands Inc	-0.0201	0.2610	N
Laboratory Corporation of America Holdings	-0.0357	0.0100	Y
Lennar Corp	-0.0740	0.0020	Y
Level 3 Communications Inc	-0.0481	0.0120	Y
Lincoln National Corp	-0.0029	0.7180	N
Lockheed Martin Corp	-0.0101	0.1200	N
Loews Corp	-0.0214	0.1230	N
Lowe's Companies Inc	0.0037	0.6840	N
Macys Inc	0.0003	0.9770	N
Marathon Oil Corp	-0.0261	0.0230	Y
Marriott International Inc	0.0016	0.9170	N
Marsh & McLennan Companies Inc	0.0038	0.5110	N
Martin Marietta Materials Inc	-0.2621	0.0000	Y
Masco Corp	-0.0115	0.1920	N
Mattel Inc	-0.0137	0.2180	N
McDonald's Corp	-0.0341	0.0010	Y
McKesson Corp	-0.0234	0.1710	N
Merck & Co Inc	-0.0415	0.0240	Y
Metlife Inc	-0.0493	0.0330	Y
Micron Technology Inc	-0.4136	0.0000	Y
Microsoft Corp	-0.1807	0.0000	Y
Mohawk Industries Inc	-0.0763	0.0080	Y
Molson Coors Brewing Co	-0.2412	0.0000	Y
Mondelez International Inc	-0.0264	0.1040	N
Monsanto Co	0.0169	0.0780	N
Morgan Stanley	-0.0718	0.0030	Y
Motorola Solutions Inc	-0.0066	0.5140	N
Murphy Oil Corp	-0.0185	0.0550	N
NRG Energy Inc	-0.0424	0.0070	Y
Newell Rubbermaid Inc	-0.0186	0.0820	N
Newmont Mining Corp	-0.0255	0.2570	N
NextEra Energy Inc	-0.0179	0.1100	N
Nike Inc	-0.0534	0.1500	N
Noble Energy Inc	-0.0173	0.1700	N
Nordstrom Inc	-0.0214	0.1780	N
Norfolk Southern Corp	-0.0201	0.1300	N
Northrop Grumman Corp	-0.0119	0.1830	N
Nucor Corp	-0.0044	0.8310	N
ONEOK Inc	-0.0180	0.0630	N
Occidental Petroleum Corp	-0.0413	0.0040	Y
Omnicom Group Inc	0.0030	0.8270	N
Oracle Corp	-0.0177	0.1320	N
Owens-Illinois Inc	-0.0325	0.0380	Y
PNC Financial Services Group Inc	-0.2627	0.0000	Y
PPG Industries Inc	-0.0325	0.0600	N
Pepco Holdings Inc	-0.0459	0.0210	Y
PepsiCo Inc	-0.0130	0.2200	N
PerkinElmer Inc	-0.0251	0.1170	N
Philip Morris International Inc	-0.0550	0.0180	Y
Pioneer Natural Resources Co	-0.0287	0.0270	Y
Pitney Bowes Inc	-0.0264	0.0200	Y
Praxair Inc	-0.0316	0.0950	N
Principal Financial Group Inc	-0.1561	0.0020	Y
Procter & Gamble Co	-0.0204	0.0340	Y
Prudential Financial Inc	-0.0159	0.1670	N
PulteGroup Inc	-0.0922	0.0000	Y
Quest Diagnostics Inc	-0.0143	0.2250	N
Raytheon Co	-0.0253	0.0800	N
Regions Financial Corp	0.0000	0.9440	N
Republic Services Inc	-0.0098	0.2760	N
Reynolds American Inc	-0.0206	0.0330	Y

Firm	Error correction coefficient	P-value	Cointegration Evidenced?
Rockwell Automation Inc	-0.0148	0.131	N
Royal Caribbean Cruises Ltd	-0.0602	0.005	Y
Ryder System Inc	-0.0233	0.058	N
Schlumberger NV	-0.1367	0.004	Y
Sealed Air Corp	-0.0567	0.005	Y
Sempra Energy	-0.0272	0.104	N
Sherwin-Williams Co	0.0049	0.77	N
Southern Co	-0.2121	0	Y
Southwest Airlines Co	-0.0107	0.374	N
Stanley Black & Decker Inc	-0.0293	0.116	N
Staples Inc	-0.0462	0.004	Y
Starwood Hotels & Resorts Worldwide Inc	-0.0271	0.039	Y
Sysco Corp	-0.2947	0	Y
TE Connectivity Ltd	0.0015	0.891	N
TECO Energy Inc	-0.0114	0.391	N
TJX Companies Inc	-0.0399	0.03	Y
Target Corp	-0.0190	0.165	N
Tegna Inc	-0.0396	0.033	Y
Tenet Healthcare Corp	-0.1140	0	Y
Tesoro Corp	-0.0492	0.009	Y
Texas Instruments Inc	-0.2980	0	Y
Textron Inc	-0.0256	0.105	N
Thermo Fisher Scientific Inc	-0.6606	0	Y
Time Warner Cable Inc	-0.0224	0.048	Y
Time Warner Inc	0.0035	0.84	N
Travelers Companies Inc	0.0040	0.671	N
Tyson Foods Inc	-0.0405	0.001	Y
U.S. Bancorp	-0.0377	0.001	Y
Union Pacific Corp	-0.0328	0.02	Y
United Continental Holdings Inc	-0.0559	0.002	Y
United Parcel Service Inc	-0.0272	0.174	N
United Rentals Inc	-0.1067	0.007	Y
United Technologies Corp	-0.0160	0.334	N
Universal Health Services Inc	-0.0303	0.057	N
Unum Group	0.0094	0.569	N
VF Corp	-0.0289	0.138	N
Valero Energy Corp	-0.0274	0.061	N
Viacom Inc	-0.0197	0.346	N
Vulcan Materials Co	-0.1284	0	Y
Wal Mart Stores Inc	-0.0672	0.061	N
Walt Disney Co	0.0011	0.909	N
Waste Management Inc	-0.0022	0.818	N
Wells Fargo & Co	-0.0084	0.512	N
Western Union Co	-0.0450	0.002	Y
Weyerhaeuser Co	-0.0366	0	Y
Whirlpool Corp	0.0073	0.42	N
Williams Companies Inc	-0.0235	0.021	Y
Wyndham Worldwide Corp	-0.0344	0.224	N
Xcel Energy Inc	-0.1822	0	Y
Xerox Corp	-0.0490	0.032	Y
Yum! Brands Inc	-0.0235	0.041	Y
eBay Inc	0.0000	0.972	N
Becton Dickinson and Co	-0.0296	0.1	N
HP Inc	-0.0594	0	Y
Welltower Inc	-0.0038	0.713	N

Table 6: Cointegrating regression output

Random Effects GLS Regression, dependent variable is ncdscloseprice

Variable	Coefficient	Std. errors	t statistic	P-value	Confidence bands	
Equity close price						
L1.	-0.2711027	0.0414282	-6.54	0.000	-0.3523006	-0.1899049
Equity close price - firm specific effect						
3M Co	-0.5896429	0.0412606	-14.29	0.000	-0.6705122	-0.5087737
Abbott Laboratories	-0.736816	0.04135	-17.82	0.000	-0.8178604	-0.6557715
Agilent Technologies Inc	-0.4129347	0.041377	-9.98	0.000	-0.4940321	-0.3318373
Air Products and Chemicals Inc	-0.3915903	0.0412614	-9.49	0.000	-0.4724611	-0.3107195
Alcoa Inc	-0.4771377	0.0417517	-11.43	0.000	-0.5589695	-0.395306
American Express Co	-0.4777123	0.0412984	-11.57	0.000	-0.5586557	-0.396769
American International Group Inc	-0.4866618	0.0413234	-11.78	0.000	-0.5676541	-0.4056695
American Tower Corp	-0.1630968	0.041285	-3.95	0.000	-0.244014	-0.0821797
AmerisourceBergen Corp	-0.4759201	0.0412723	-11.53	0.000	-0.5568123	-0.395028
Anadarko Petroleum Corp	-0.3050562	0.0413074	-7.39	0.000	-0.3860173	-0.2240951
Analog Devices Inc	-0.4694936	0.0413209	-11.36	0.000	-0.550481	-0.3885062
Apple Inc	-0.5622376	0.0412686	-13.62	0.000	-0.6431225	-0.4813526
Archer Daniels Midland Co	-0.6044574	0.0413497	-14.62	0.000	-0.6855012	-0.5234135
AutoNation Inc	0.0197612	0.0413168	0.48	0.632	-0.0612183	0.1007407
BB&T Corp	-0.450654	0.0413803	-10.89	0.000	-0.5317578	-0.3695501
Ball Corp	-0.2808059	0.0413071	-6.8	0.000	-0.3617664	-0.1998453
Bank of America Corp	-0.75215	0.0416186	-18.07	0.000	-0.8337209	-0.6705791
Berkshire Hathaway Inc	-0.3430536	0.0412646	-8.31	0.000	-0.4239307	-0.2621765
Best Buy Co Inc	-0.1822192	0.0413872	-4.4	0.000	-0.2633367	-0.1011017
Cablevision Systems Corp	-0.2219102	0.0415069	-5.35	0.000	-0.3032622	-0.1405582
Campbell Soup Co	-0.5335081	0.0413472	-12.9	0.000	-0.6145472	-0.452469
CenterPoint Energy Inc	-0.77104	0.0415343	-18.56	0.000	-0.8524457	-0.6896342
CenturyLink Inc	-0.2193406	0.0414101	-5.3	0.000	-0.3005028	-0.1381783
Chubb Corp	-0.6371131	0.0412683	-15.44	0.000	-0.7179976	-0.5562287
Citigroup Inc	-0.4285149	0.0413329	-10.37	0.000	-0.5095259	-0.347504
Clorox Co	-0.3807419	0.0412698	-9.23	0.000	-0.4616291	-0.2998547
Coca-Cola Co	-0.7588125	0.04137	-18.34	0.000	-0.8398961	-0.6777289
Corning Inc	-0.7849073	0.0415358	-18.9	0.000	-0.866316	-0.7034986
Costco Wholesale Corp	-0.5689143	0.0412597	-13.79	0.000	-0.6497818	-0.4880468
DaVita HealthCare Partners Inc	-0.0801012	0.0412965	-1.94	0.052	-0.1610409	0.0008385
Deere & Co	-0.5106669	0.0412881	-12.37	0.000	-0.5915902	-0.4297437
Devon Energy Corp	-0.3472146	0.0413417	-8.4	0.000	-0.4282428	-0.2661864
Diamond Offshore Drilling Inc	-0.1576436	0.0414479	-3.8	0.000	-0.23888	-0.0764072
EMC Corp	-0.6014542	0.0414572	-14.51	0.000	-0.6827089	-0.5201996
EOG Resources Inc	-0.4406993	0.0412967	-10.67	0.000	-0.5216394	-0.3597592
Eli Lilly and Co	-0.6184439	0.0412928	-14.98	0.000	-0.6993763	-0.5375115
Emerson Electric Co	-0.540706	0.0413367	-13.08	0.000	-0.6217243	-0.4596876
Eversource Energy	-0.6164256	0.0413409	-14.91	0.000	-0.6974524	-0.5353989
Exelon Corp	-0.6457122	0.0414037	-15.6	0.000	-0.726862	-0.5645624
FMC Corp	-0.3673338	0.041344	-8.88	0.000	-0.4483666	-0.2863011
FedEx Corp	-0.3571403	0.0412571	-8.66	0.000	-0.4380027	-0.2762778
FirstEnergy Corp	-0.4303238	0.0413958	-10.4	0.000	-0.5114581	-0.3491894
Freeport-McMoRan Inc	-0.2605359	0.0415868	-6.26	0.000	-0.3420446	-0.1790273
Gap Inc	-0.4499672	0.0413878	-10.87	0.000	-0.5310858	-0.3688486
General Dynamics Corp	-0.5618817	0.0412606	-13.62	0.000	-0.642751	-0.4810123
General Motors Co	-0.3337339	0.0414081	-8.06	0.000	-0.4148922	-0.2525756
Goldman Sachs Group Inc	-0.233608	0.0412525	-5.66	0.000	-0.3144614	-0.1527547
HCP Inc	-0.447365	0.0413729	-10.81	0.000	-0.5284544	-0.3662756
Harris Corp	-0.4107945	0.0412974	-9.95	0.000	-0.4917359	-0.329853
Hartford Financial Services Group Inc	-0.532048	0.0413571	-12.86	0.000	-0.6131064	-0.4509895
Hasbro Inc	-0.4028932	0.0412993	-9.76	0.000	-0.4838382	-0.3219481
Hershey Co	-0.5049696	0.041283	-12.23	0.000	-0.5858828	-0.4240565
Hess Corp	-0.2369478	0.0413243	-5.73	0.000	-0.3179419	-0.1559537
Illinois Tool Works Inc	-0.5280359	0.041287	-12.79	0.000	-0.6089569	-0.4471148
International Business Machines Corp	-0.3653016	0.0412669	-8.85	0.000	-0.4461832	-0.2844201

International Paper Co	-0.4590891	0.0413428	-11.1	0.000	-0.5401196	-0.3780586
Interpublic Group of Companies Inc	-0.7039744	0.0415396	-16.95	0.000	-0.7853905	-0.6225584
Intuit Inc	-0.3672106	0.0412827	-8.9	0.000	-0.4481232	-0.286298
JPMorgan Chase & Co	-0.4390643	0.041314	-10.63	0.000	-0.5200381	-0.3580904
Kohls Corp	-0.3462514	0.0413196	-8.38	0.000	-0.4272363	-0.2652665
Laboratory Corporation of America Holdings	-0.2247598	0.0412696	-5.45	0.000	-0.3056467	-0.1438728
Lennar Corp	-0.205884	0.041337	-4.98	0.000	-0.2869029	-0.124865
Level 3 Communications Inc	-0.1839653	0.0413395	-4.45	0.000	-0.2649892	-0.1029415
Marathon Oil Corp	-0.404639	0.0414857	-9.75	0.000	-0.4859495	-0.3233286
Martin Marietta Materials Inc	-0.2791143	0.0412566	-6.77	0.000	-0.3599759	-0.1982528
McDonald's Corp	-0.5024723	0.041282	-12.17	0.000	-0.5833836	-0.421561
Merck & Co Inc	-0.7173952	0.0413284	-17.36	0.000	-0.7983974	-0.636393
Metlife Inc	-0.4494493	0.0413388	-10.87	0.000	-0.5304718	-0.3684269
Micron Technology Inc	-0.1328927	0.0414772	-3.2	0.001	-0.2141864	-0.0515989
Microsoft Corp	-0.7128498	0.0413564	-17.24	0.000	-0.7939069	-0.6317926
Mohawk Industries Inc	-0.2733921	0.0412467	-6.63	0.000	-0.3542342	-0.19255
Molson Coors Brewing Co	-0.4220054	0.0413033	-10.22	0.000	-0.5029584	-0.3410525
Morgan Stanley	-0.4899053	0.0413879	-11.84	0.000	-0.5710241	-0.4087865
NRG Energy Inc	-0.1205883	0.041488	-2.91	0.004	-0.2019034	-0.0392733
Occidental Petroleum Corp	-0.3678596	0.0413072	-8.91	0.000	-0.4488202	-0.2868991
Owens-Illinois Inc	-0.3085232	0.0415011	-7.43	0.000	-0.3898639	-0.2271824
PNC Financial Services Group Inc	-0.3707054	0.0412845	-8.98	0.000	-0.4516215	-0.2897894
Pepco Holdings Inc	-0.6351558	0.0414615	-15.32	0.000	-0.7164188	-0.5538928
Philip Morris International Inc	-0.5553441	0.0412944	-13.45	0.000	-0.6362797	-0.4744084
Pioneer Natural Resources Co	-0.2002875	0.0412771	-4.85	0.000	-0.2811891	-0.1193859
Pitney Bowes Inc	-0.5432853	0.0415129	-13.09	0.000	-0.6246491	-0.4619216
Principal Financial Group Inc	-0.4482429	0.0413405	-10.84	0.000	-0.5292688	-0.3672169
Procter & Gamble Co	-0.6553203	0.0412989	-15.87	0.000	-0.7362646	-0.574376
PulteGroup Inc	-0.4123334	0.0415299	-9.93	0.000	-0.4937306	-0.3309363
Reynolds American Inc	-0.5896867	0.0413754	-14.25	0.000	-0.670781	-0.5085924
Royal Caribbean Cruises Ltd	-0.1950584	0.041287	-4.72	0.000	-0.2759793	-0.1141375
Schlumberger NV	-0.4823365	0.0412999	-11.68	0.000	-0.5632827	-0.4013902
Sealed Air Corp	-0.2805603	0.0413424	-6.79	0.000	-0.36159	-0.1995306
Southern Co	-0.5549167	0.0413543	-13.42	0.000	-0.6359697	-0.4738638
Staples Inc	-0.4515699	0.0416555	-10.84	0.000	-0.5332132	-0.3699266
Starwood Hotels & Resorts Worldwide Inc	-0.3739006	0.0413014	-9.05	0.000	-0.4548499	-0.2929514
Sysco Corp	-0.5851295	0.0413777	-14.14	0.000	-0.6662283	-0.5040308
TJX Companies Inc	-0.6067516	0.0413035	-14.69	0.000	-0.687705	-0.5257982
Tegna Inc	-0.2571514	0.0414577	-6.2	0.000	-0.3384071	-0.1758958
Tenet Healthcare Corp	-0.0568516	0.0413471	-1.37	0.169	-0.1378904	0.0241872
Tesoro Corp	-0.1486264	0.0412786	-3.6	0.000	-0.229531	-0.0677217
Texas Instruments Inc	-0.5938999	0.0413348	-14.37	0.000	-0.6749147	-0.5128851
Thermo Fisher Scientific Inc	-0.3966244	0.0412682	-9.61	0.000	-0.4775085	-0.3157402
Time Warner Cable Inc	-0.2586158	0.0412527	-6.27	0.000	-0.3394696	-0.177762
Tyson Foods Inc	-0.5182274	0.041365	-12.53	0.000	-0.5993013	-0.4371536
U.S. Bancorp	-0.5285831	0.0413599	-12.78	0.000	-0.6096469	-0.4475192
Union Pacific Corp	-0.6312507	0.0412838	-15.29	0.000	-0.7121654	-0.550336
United Continental Holdings Inc	-0.0441609	0.0413181	-1.07	0.285	-0.1251429	0.0368212
United Rentals Inc	-0.091491	0.0413034	-2.22	0.027	-0.1724441	-0.0105378
Vulcan Materials Co	-0.2567257	0.0412803	-6.22	0.000	-0.3376337	-0.1758177
Western Union Co	-0.4731705	0.0415599	-11.39	0.000	-0.5546263	-0.3917146
Weyerhaeuser Co	-0.656691	0.0414153	-15.86	0.000	-0.7378635	-0.5755186
Williams Companies Inc	-0.2519069	0.0413468	-6.09	0.000	-0.3329451	-0.1708688
Xcel Energy Inc	-0.7441158	0.0413983	-17.97	0.000	-0.8252549	-0.6629767
Xerox Corp	-0.7695887	0.0418008	-18.41	0.000	-0.8515168	-0.6876606
Yum! Brands Inc	-0.3765965	0.0412917	-9.12	0.000	-0.4575267	-0.2956662
HP Inc	-0.6838485	0.0416676	-16.41	0.000	-0.7655155	-0.6021814
Constant	7.122658	0.0260057	273.89	0.000	7.071688	7.173628

N	112	**Within R2**	0.1851
T	248	**Between R2**	1.0000
Obs.	27776	**Overall R2**	0.9778

Table 7: Results of Arellano and Bond and Sargan tests

Arellano Bond test for zero autocorrelation in first-differenced residuals

H0: No autocorrelation.

	Instrumented with 1st - 10th Lag					
	One-step method			Two-step method		
Order	**Z statistic**	**P-value**	**Outcome**	**Z statistic**	**P-value**	**Outcome**
1	-3.9702	0.0001	Reject	-3.9181	0.0001	Reject
2	0.92409	0.3554	Cannot reject	0.87835	0.3798	Cannot reject

Sargan test of overidentifying restrictions

H0: Overidentifying restrictions are valid

	Chi Sq.	**Degrees of freedom**	**P-value**	**Outcome**
One-step method	25463.49	2389	0.0000	Reject
Two-step method	88.54	2389	1.0000	Cannot reject

N.B. Sargan test cannot be calculated with robust variance-covariance matrices as distribution of test statistic is unknown. Results have been calculated using the standard GMM vce, rather than the robust version.

Table 8a: Statistical output for model 1

One-step estimation with Arellano-Bond robust standard errors

Variable	Lag	Coef.	Std. Err.	z	P-value	95% Confidence bounds	
absdisequilibrium							
	L1.	**0.8497375**	**0.0283916**	**29.93**	**0.000**	**0.7940911**	**0.9053839**
	L2.	**-0.0989395**	**0.0227184**	**-4.36**	**0.000**	**-0.1434668**	**-0.0544122**
onemonthlibor							
	LD.	-43.9438	429.5148	-0.1	0.919	-885.7773	797.8897
	L2D.	**1177.606**	**570.2741**	**2.06**	**0.039**	**59.88953**	**2295.323**
	L3D.	**1413.535**	**463.8785**	**3.05**	**0.002**	**504.3497**	**2322.72**
onemonthlibor2							
	LD.	1.663398	1250.333	0	0.999	-2448.944	2452.271
	L2D.	**-3427.032**	**1699.587**	**-2.02**	**0.044**	**-6758.162**	**-95.90252**
	L3D.	**-3992.767**	**1346.312**	**-2.97**	**0.003**	**-6631.489**	**-1354.045**
threemonthlibor							
	LD.	-202.987	352.9698	-0.58	0.565	-894.795	488.821
	L2D.	-103.604	328.3039	-0.32	0.752	-747.0678	539.8597
	L3D.	148.2076	275.2692	0.54	0.590	-391.3101	687.7252
threemonthlibor2							
	LD.	182.3188	640.6771	0.28	0.776	-1073.385	1438.023
	L2D.	20.4086	594.3596	0.03	0.973	-1144.515	1185.332
	L3D.	-404.1482	519.1845	-0.78	0.436	-1421.731	613.4347
twelvemonthlibor							
	LD.	**-214.8574**	**89.61737**	**-2.4**	**0.017**	**-390.5042**	**-39.21058**
	L2D.	**-283.6204**	**99.2475**	**-2.86**	**0.004**	**-478.142**	**-89.09891**
	L3D.	**-323.7356**	**120.0797**	**-2.7**	**0.007**	**-559.0875**	**-88.38365**
twelvemonthlibor2							
	LD.	**152.2602**	**64.41092**	**2.36**	**0.018**	**26.01708**	**278.5033**
	L2D.	**187.4168**	**72.21342**	**2.6**	**0.009**	**45.8811**	**328.9525**
	L3D.	**212.6304**	**85.0407**	**2.5**	**0.012**	**45.95372**	**379.3071**
moodysaaabondindex							
	L1.	-4.029623	3.521965	-1.14	0.253	-10.93255	2.873302
twi							
	LD.	**0.2252483**	**0.1203731**	**1.87**	**0.061**	**-0.0106787**	**0.4611753**
equityclosebidaskspread							
	L1.	-0.0051589	0.0804578	-0.06	0.949	-0.1628532	0.1525354
	L2.	**0.3925152**	**0.1739997**	**2.26**	**0.024**	**0.0514821**	**0.7335484**
us10yrspreadoverlibor							
	L1.	2.746642	2.764101	0.99	0.32	-2.670897	8.164181
	L2.	3.091149	3.29423	0.94	0.348	-3.365423	9.547721
pdequitywithin							
	L1.	18.33819	12.17511	1.51	0.132	-5.524587	42.20097
lnequityvolumes							
	L1.	**0.9342351**	**0.3284062**	**2.84**	**0.004**	**0.2905708**	**1.577899**
pdefault							
	LD.	0.5266619	0.3957261	1.33	0.183	-0.2489471	1.302271
creditmarketsclevelandstress							
	L1.	**-10.9779**	**2.020377**	**-5.43**	**0.000**	**-14.93777**	**-7.018036**
Constant							
		63.83543	15.63446	4.08	0.000	33.19245	94.47841

(N)T	27,440	**Instruments**	2400
N	112	**Wald Chi2(30)**	11,933.20
T	245	**Prob > Chi2**	0.000

Table 8b: Statistical output for model 2

Two-Step estimation with Windmeijer's robust standard errors

Variable		Coef.	Std. Err.	z	P-value	95% Confidence bounds	
absdisequilibrium							
	L1.**	**0.8499585**	**0.0280237**	**30.33**	**0.000**	**0.7950331**	**0.9048839**
	L1.**	**-0.1019276**	**0.0174777**	**-5.83**	**0.000**	**-0.1361832**	**-0.0676719**
onemonthlibor							
	LD.	-17.13052	1269.04	-0.01	0.989	-2504.404	2470.143
	L2D.*	1087.012	1963.249	0.55	0.580	-2760.884	4934.908
	L3D.**	1382.598	2266.411	0.61	0.542	-3059.486	5824.683
onemonthlibor2							
	LD.	-74.38232	3506.768	-0.02	0.983	-6947.522	6798.757
	L2D.*	-3165.606	5772.904	-0.55	0.583	-14480.29	8149.077
	L3D.**	-3915.033	6809.12	-0.57	0.565	-17260.66	9430.597
threemonthlibor							
	LD.	-194.2752	1086.897	-0.18	0.858	-2324.555	1936.005
	L2D.	-108.2466	1297.854	-0.08	0.934	-2651.995	2435.501
	L3D.	94.46399	2428.061	0.04	0.969	-4664.448	4853.376
threemonthlibor2							
	LD.	173.6205	2031.397	0.09	0.932	-3807.844	4155.085
	L2D.	30.28265	2577.401	0.01	0.991	-5021.33	5081.895
	L3D.	-303.8284	4587.573	-0.07	0.947	-9295.307	8687.65
twelvemonthlibor							
	LD.**	-207.733	612.5228	-0.34	0.735	-1408.256	992.7896
	L2D.**	-269.5141	436.322	-0.62	0.537	-1124.69	585.6613
	L3D.**	-300.4713	528.1043	-0.57	0.569	-1335.537	734.594
twelvemonthlibor2							
	LD.**	146.9123	467.41	0.31	0.753	-769.1944	1063.019
	L2D.**	178.2555	341.4063	0.52	0.602	-490.8885	847.3995
	L3D.**	196.7555	392.0311	0.5	0.616	-571.6113	965.1223
moodysaaabondindex							
	L1.	-3.913431	15.08791	-0.26	0.795	-33.48519	25.65833
twi							
	LD.	0.2166615	0.4002337	0.54	0.588	-0.5677821	1.001105
equityclosebidaskspread							
	L1.	0.0001077	0.5336178	0	1.000	-1.045764	1.045979
	L2.**	0.3572464	0.2912175	1.23	0.220	-0.2135295	0.9280223
us10yrspreadoverlibor							
	L1.	2.64932	7.394693	0.36	0.720	-11.84401	17.14265
	L2.	2.903483	6.864865	0.42	0.672	-10.5514	16.35837
pdequitywithin							
	L1.	17.98913	40.67084	0.44	0.658	-61.72425	97.70252
lnequityvolumes							
	L1.**	0.8644093	1.199718	0.72	0.471	-1.486995	3.215814
pdefault							
	LD.	0.4757152	1.000497	0.48	0.634	-1.485224	2.436654
creditmarketsclevelandstress							
	L1.**	**-10.46409**	**4.079804**	**-2.56**	**0.010**	**-18.46036**	**-2.467822**
Constant							
		61.10714	47.4397	1.29	0.198	-31.87296	154.0872

(N)T	27,440	**Instruments**	2400
N	112	**Wald Chi2(30)**	11,482.61
T	245	**Prob > Chi2**	0.000

N.B. Coefficients marked ** are significant at 5% using one-step standard errors, whereas those marked * are significant at 10% using one-step standard errors.

Table 9: Implied marginal effects

Model		Mean Change		Largest observed positive change		Largest observed negative change		+25bps change		-25bps change	
		1	2	1	2	1	2	1	2	1	2
One Month Libor	After one day	-0.0087	-0.0034	-0.2197	-0.0875	0.1978	0.0756	-10.8820	-8.9315	11.0899	-0.3663
	After two days	**0.2265**	0.2131	**5.6157**	5.2815	**-5.2006**	-4.8914	**70.9652**	66.3112	**-499.1675**	-469.9147
	After three days	**0.4742**	0.4562	**11.7614**	11.3131	**-10.8804**	-10.4662	**165.2142**	158.2321	**-1028.1902**	-989.7097
	Long run	2.03084096	1.9338	50.3629	47.9564	-46.5992	-44.3747	694.8814	658.5372	-4415.8264	-4208.0902
Three Month Libor	After one day	-0.0801	-0.0767	-2.2506	-2.1541	1.1732	1.1228	-39.3518	-37.7175	62.1417	59.4201
	After two days	-0.1090	-0.1079	-3.0702	-3.0395	1.5933	1.5778	-58.0642	-57.2273	79.9806	79.4589
	After three days	-0.0262	-0.0466	-0.7770	-1.3440	0.3723	0.6734	-33.6532	-40.1697	-0.4969	18.8750
	Long run	-0.2510	-0.3261	-7.2197	-9.2979	3.6278	4.7348	-209.4070	-231.2180	108.3741	181.6458
Twelve Month Libor	After one day	**-0.2368**	-0.2290	**-5.6178**	-5.4317	**6.2471**	6.0397	**-44.1981**	-42.7512	**63.2306**	61.1153
	After two days	**-0.5139**	-0.4917	**-12.1990**	-11.6727	**13.5438**	12.9595	**-96.7483**	-92.5743	**136.3481**	130.4649
	After three days	**-0.7701**	-0.7259	**-18.2867**	-17.2355	**20.2898**	19.1226	**-145.4822**	-137.1474	**203.8274**	192.0755
	Long run	-3.6372	-3.4026	**-86.3545**	-80.7858	**95.8327**	89.6495	**-686.3273**	-642.1795	**963.3653**	901.1018