The relationship between sovereign bonds and credit default swaps: Does arbitrage increase market volatility?

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ABSTRACT

This investigation is one of the first studies to examine the impact of arbitrage trading on the market volatility of sovereign bonds and credit default swaps (CDS) using the Markov-switching approach. Our empirical results show that the absolute value of the CDS-bond basis is positively related to the probability of a high volatility regime and negatively related to the probability of a low volatility regime. This result implies that arbitrage trading triggered by mispricing between CDS premium and bond spread increases CDS-bond market volatility. Our findings are consistent across mature-market and emerging-market countries. Moreover, the evidence we uncover suggests that the practice of managing default risk of bonds via the use of CDS may increase the interest rate risk of the bond, which implies both wins and woes from the introduction of CDS, particularly for mature-market countries.

JEL classification: G15, G12, C53

Keywords: Sovereign bonds; CDS; volatility; VECM; Markov-switching model

Data Availability: All data are obtained from publicly available sources

1. Introduction

This research focuses on credit default swaps (CDS) and sovereign bonds. The study explores the relationship between CDS and bond market and how the relationship affects market volatility – a matter of contemporary concern to policymakers. A number of questions remain. When considering CDS and sovereign bonds, it is appropriate to remember there are different types of risk in finance. Many people talk about risk in the financial market, given the risk associated with stock prices varying every day. However, a larger concern for many parties is the risk of completely losing an asset - that being a permanent loss. That risk is default risk or bankruptcy risk. It is the most important risk to consider.

One role of financial markets is to secure a more palatable risk exposure than the risk of bankruptcy. The use of CDS is one such example. It allows investors to trade default risk with others in much the same way they trade market risks. The CDS markets have experienced dramatic growth,[1] and they have become the most widely traded credit derivative instrument for transferring credit risk.[2] The common underlying assets for CDS contracts are sovereign bonds and corporate bonds. In this study, we focus on sovereign bonds rather than corporate bonds. We argue that because no international bankruptcy law exists, sovereign defaults would follow zero debt repayment, which supports the importance of sovereign CDS contracts (e.g., Yue 2006).

Moreover, the sovereign debt literature, e.g., Aguiar and Gopinath (2006) and Arellano (2008), typically focus on emerging countries because these countries are associated with high default risk. We argue that the default risk of mature counties is an issue given their increasing fiscal deficit and sovereign debts during recent years. As a result, CDS contracts

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[1] According to statistical data provided by the Bank for International Settlements (BIS), the total notional amount of outstanding CDS contracts had become $24.5 trillion by the end of June, 2013.

[2] In a CDS contract, one party (protection seller) agrees to pay compensation (namely, the CDS spread) to a counterparty (protection buyer) when the particular debtor has suffered from some credit events which indicate the particular debtor may fail to honor a promise to make a payment.

for sovereign bonds issued by mature counties are available in markets (e.g., Kim, et al. 2015). Accordingly, in this study, we adopt not only the data of emerging countries but also developed countries (i.e., U.S., U.K., Germany, and France) as the sample to examine the research issue.

Our research addresses the following anomaly. Theoretically, the CDS premium and the underlying bond spread should converge; therefore, there is no chance for arbitrage in the market. In practice, when a discrepancy occurs between the CDS premium and the bond spread, arbitrageurs will trigger an adjustment process to balance this disequilibrium.[3] Unlike previous studies, this work is one of the first studies to examine the impact of arbitrage trading due to mispricing between the CDS premium and bond spread based on the volatility of the CDS-bond market. In particular, we employ Hamilton and Susmel's (1994) Markov-switching ARCH (hereafter SWARCH) model to identify high and low volatility regimes in the CDS-bond markets. Then we extend the SWACH model by introducing the time-varying transition probability (TVTP) in which the lagged CDS-bond basis (i.e., the deviation between CDS premium and bond spread) is used to control the volatility regime turning process.

This study contributes to the existing literature in a number of ways. First, risk management has always been an important research topic in finance. Default risk and interest rate risk are the two main types of risk associated with bonds. As discussed, investors could use CDS to control the default risk of a bond. However, we argue that CDS-bond arbitrage would increase market volatility and the volatility of the bond's yield positively links to the interest rate risk of the bond. Accordingly, the introduction of CDS to manage default risk leads to an increase in interest rate risk. Our study gives a new insight into the relation

[3] In brief, when bond spread is higher than the CDS premium, the bond spread should decrease and the CDS premium should increase to return the long term equilibrium, the opposite being the case when the bond spread is lower than the CDS premium.

between the two types of risk. Moreover, as the default risk in bonds issued by developed countries is relatively small, the issue is critical for these countries. Second, the TVTP design, in which the transition probabilities of the Markov-switching process are conditional on the CDS-bond basis, provides evidence as to how the lagged CDS-bond basis impacts the variance-turning process. Moreover, the framework enables us to examine the relation between arbitrage correction and market volatility. Third, this study includes four mature-country markets (U.S., U.K., Germany, and France) in the research sample but also three important emerging-country markets (China, Mexico and South Africa). This provides clarity as to the relation between arbitrage correction and market volatility in both types of market. To the best of our knowledge, few if any, prior studies have ever explored these two critical issues in the literature of CDS.

The rest of the paper proceeds as follows. In Section 2, we review related studies and develop the research questions. In Section 3, we outline the underlying models used in this study, including (1) the conventional vector correction model (VECM) and (2) the TVTP-VECM-SWARCH for the system in which the regime-switching process is controlled by the CDS-bond basis. Subsequently, Section 4 introduces the empirical results and provides economic and financial explanations for them. Finally, Section 5 presents conclusions.

2. Related Studies and research question

As shown in the study of Duffie (1999) and Hull and White (2000), there is an arbitrage pricing relation among a combination of three instruments: the risky floating rate bond trading at par, the risk-free par floater of the same maturity and the CDS contract of the same maturity for the underlying reference risky bond. In particular, when a default event occurs, the CDS protection seller compensates the protection buyer for the difference between the face value and market value of the underlying reference bond upon the default event. Therefore, the investor with a long position in the risky bond and with a short position in the risk-free bond who buys the CDS protection receives the net payment of zero either upon the default event or upon the maturity of the three contracts (namely, if there was no default event). Accordingly, the bond spread between the yields on the risky and risk-free bonds must be equal to the CDS premium in order to exclude arbitrage opportunity. That is, the CDS basis (i.e., the deviation between CDS premium and bond spread) must be equal to zero in the ideal case.

Following their studies, many empirical studies (e.g., Hull and White, 2000, Longstaff et al., 2005, Blanco et al., 2005 and Zhu, 2006 and many others) show arbitrage trading forces CDS premiums to be approximately equal to the underlying bond spreads in the absence of market frictions. Several studies further discuss complications associated with arbitrage between CDS and bond markets in practice and thus consider a non-zero measured CDS basis. In brief, Blanco et al. (2005), Hull et al. (2004) and Duffie and Liu (2001) address the issue of floating-fixed credit spreads. Collin-Dufresne et al. (2001), Tang and Yan (2006) and Badaoui et al. (2016) discuss the issue of illiquidity premiums. Fontana and Scheicher (2016) and Rubia et al. (2016) address the issue of short-selling frictions. Gyntelberg, et al. (2018) examine arbitrage and price discovery dynamics in CDS-bond markets. Together these papers show the existing markets have complexities not visible in the simple stylized models of CDS trading.

While researchers have investigated the issue of arbitrage involving bond position and CDS protection in CDS-bond markets, to our knowledge, none has yet explicitly discussed the impact of arbitrage correction on CDS-bond market volatility. To address this gap in the literature, this study introduces the TVTP-VECM-SWARCH model and uses it to link the

CDS-bond basis with market volatility. Measuring arbitrate by CDS-bond basis, we build our arguments because prior studies have documented a significant association between them. Moreover, we argue that, in finance theory, an investor can make infinite profits from a slight imbalance in the price by taking unlimited positions in an arbitrage situation. Hence, we predict a positive association between CDS-bond mispricing and market volatility.

Our argument has an important implication for risk management. First, the purpose of introducing CDS is to manage the default risk of the bond. However, we postulate that the CDS-bond arbitrage increases market volatility. The increase in the volatility of the bond's yield appears to enlarge interest rate risk of the bond because a change in a bond's yield triggers a shift in that bond's price. Restated, CDS are increasingly popular in financial markets, since being introduced in the early 1990s. CDS serving as a tool to control default risk is undoubtedly the greatest benefit for investors. We question, however, whether the arbitrage opportunity due to the mispricing between CDS and bond might have unintended consequences for the existing bond markets because the introduction of CDS would likely attract arbitrageurs. Arbitrage trading affects the prices of the bonds because CDS and bond yield are tied by arbitrage. The introduction of CDS exposes the underlying bonds to new shocks, which can make the prices of the underlying bonds more volatile. Our empirical results provide a unique insight into this conjecture and its implications for risk management.

3. Model specifications

3.1 The VECM

If two data series are nonstationary and share a common stochastic trend, then they can be concluded to be cointegrated. To examine whether CDS premium and bond spread are cointegrated, this study follows Engle and Granger (1987) and establishes the following regression:

$$CDS_t = \lambda_0 + \lambda_1 \cdot BS_t + Z_t \,, \tag{1}$$

where CDS_t and BS_t are the log prices of CDS premium and bond spread, respectively, which are multiplied by 100 at time t, respectively. The Z_t variable can serve as a measure of the deviation from the equilibrium between CDS premium and bond spread, namely the error correction term (EC hereafter). If the EC term Z_t (i.e., CDS-bond basis) is a stationary I (0) variable, then CDS premium and bond spread are cointegrated.

According to earlier investigations, CDS premium and bond spread are generally found to be non-stationary and are integrated with an order of one. Accordingly, the EC term should be included in the model since the CDS premium and bond spread display cointegration. The conventional VECM model is given by:

$$\Delta CDS_t = \alpha^c + \beta^c \cdot Z_{t-1} + \sum_{i=1}^{p} \gamma_i^{cc} \cdot \Delta CDS_{t-i} + \sum_{j=1}^{q} \gamma_j^{cb} \cdot \Delta BS_{t-j} + e_t^c \tag{2}$$

$$\Delta BS_t = \alpha^b + \beta^b \cdot Z_{t-1} + \sum_{i=1}^{p} \gamma_i^{bc} \cdot \Delta CDS_{t-i} + \sum_{j=1}^{q} \gamma_j^{bb} \cdot \Delta BS_{t-j} + e_t^b \tag{3}$$

where Δ denotes the difference operator (such as $\Delta CDS_t = CDS_t - CDS_{t-1}$). Notably, this study sets the lagged EC term Z_{t-1}, as $CDS_{t-1} - \lambda_0 - \lambda_1 \times BS_{t-1}$, which represents the last period disequilibrium between CDS premium and bond spread. One key feature of the VECM is its consideration of the long-term adjustments to disequilibrium. Briefly, when $Z_{t-1} > 0$, then CDS_t should decrease, and BS_t should increase to return the price relationship to the long-run equilibrium, the opposite being the case when $Z_{t-1} < 0$. Therefore, the signs of β^c and β^b should be negative and positive, respectively. In addition to using the lagged EC term (i.e., Z_{t-1}) to capture the long-term cointegrated adjustment, the lagged returns on CDS premium and bond spread (i.e., ΔCDS_{t-i} and ΔBS_{t-j}) are employed to capture the short-term interactions between CDS and bond markets.

Next, we discuss the variance-covariance matrix of the 2x1 vector of the residuals e_t (a 2x1 vector):

$$e_t = \begin{bmatrix} e_t^c \\ e_t^b \end{bmatrix} \sim BN(0, \quad H) \tag{4}$$

where $e^c{}_t$ and $e^b{}_t$ are the residuals at time t for the equation of CDS premium and bond yield spread, respectively. The BN denotes the bivariate normal distribution, and H is a constant 2x2 positive definite conditional variance-covariance matrix, which is specified in the following equation:

$$H = \begin{bmatrix} \sigma^c \cdot \sigma^c & \rho^{cb} \cdot \sigma^c \cdot \sigma^b \\ \rho^{cb} \cdot \sigma^c \cdot \sigma^b & \sigma^b \cdot \sigma^b \end{bmatrix} \tag{5}$$

where σ^c and σ^b are the unconditional standard errors of the return of CDS premium and bond yield spread, respectively. The ρ^{cb} is the correlation coefficient between them.

Importantly, the conventional VECM model suffers from two limitations. First, the variance is constant. Numerous previous studies have pointed out that market volatilities are heterogeneous.[4] Second, the conventional VECM is unable to capture the relation between CDS-bond basis and market volatilities.

3.2 The TVTP-VECM-SWARCH

This study establishes the TVTP-VECM-SWARCH approach to capture the dynamic process in CDS-bond market volatilities and its relation to the CDS-bond basis. In particular, to capture dynamic volatilities involved in the residuals in Equations (2) and (3), the variance-covariance H matrix now is controlled by a state-dependent process:

$$e_t \mid \psi_{t-1} = \begin{bmatrix} e_t^c \\ e_t^b \end{bmatrix} \mid \psi_{t-1} \sim BN(0, \quad H_t) \tag{6}$$

[4] Volatility is one of the key factors for pricing derivative securities. Engle's (1982) ARCH or Bollerslev's (1986) GARCH are the most commonly used methods to characterize market volatility.

$$H_t = \begin{bmatrix} h_t^c & h_t^{c,b} \\ h_t^{c,b} & h_t^b \end{bmatrix} \tag{7}$$

$$\frac{h_t^c}{g_{s_t}^c} = \eta_0^c + \sum_{l=1}^{m} \eta_{t-l}^c \frac{(e_{t-l}^c)^2}{g_{s_{t-l}}^c} \tag{8}$$

$$\frac{h_t^b}{g_{s_t}^b} = \eta_0^b + \sum_{l=1}^{m} \eta_{t-l}^b \frac{(e_{t-l}^b)^2}{g_{s_{t-l}}^b} \tag{9}$$

where Ψ_{t-1} refers to the information available at time *t-1* and s_t is the unobservable state variable with two possible outcomes of 1 and 2, which indicates the volatility regime at time *t* for the CDS-bond market. Without incurring a loss of generality, we follow the study of Hamilton and Susmel (1994) to normalize g_1^c and g_2^b, the scale coefficient for regime I, to be unity, whereas $g_2^c > 1$ and $g_2^b > 1$ for the case of regime II. In brief, a conventional ARCH (*m*) process is employed to capture the conditional variance dynamics of regime I and the conditional variances for regime II are g_2^c and g_2^b times those of regime I in the equation of futures and spot returns, respectively. In the special case with $g_1^c = g_2^c = 1$ and $g_1^b = g_2^b = 1$, the two residual terms in the model follow the fundamental ARCH (*m*) process. Because this study assumes that two variance regimes characterize the CDS-bond market, two states are available for modeling the covariance between CDS and bond markets:

$$h_t^{cb} = \rho^{cb} \times (h_t^c \cdot h_t^b)^{1/2} \tag{10}$$

To control the dynamic process of the state variable s_t, Hamilton and Susmel (1994) assume it associating a first-order Markov chain process whose transition probabilities are specified as follows:

$$\begin{aligned} &p(s_t = 1 \mid s_{t-1} = 1) = p_{11}, \quad p(s_t = 2 \mid s_{t-1} = 1) = p_{12} = 1 - p_{11} \\ &p(s_t = 2 \mid s_{t-1} = 2) = p_{22}, \quad p(s_t = 1 \mid s_{t-1} = 2) = p_{21} = 1 - p_{22} \end{aligned} \tag{11}$$

where the transition probability p_{12} yields the probability that regime I is followed by regime II, the opposite being the case for the transition probability p_{21}, and the transition probabilities

p_{11} and p_{22} provide the probability that the market state will remain unchanged in the following period.

This study extends the study of Hamilton and Susmel (1994) via adopting the TVTP framework. The TVTP is presented as follows:

$$\begin{aligned} p_{11,t} &= p(s_t = 1 \mid s_{t-1} = 1,\ \ Z^*_{t-1}) = \frac{\exp(\theta_{q0} + \theta_{q1} \cdot Z^*_{t-1})}{1 + \exp(\theta_{q0} + \theta_{q1} \cdot Z^*_{t-1})} \\ p_{22,t} &= p(s_t = 2 \mid s_{t-1} = 2,\ \ Z^*_{t-1}) = \frac{\exp(\theta_{p0} + \theta_{p1} \cdot Z^*_{t-1})}{1 + \exp(\theta_{p0} + \theta_{p1} \cdot Z^*_{t-1})} \end{aligned} \tag{12}$$

where Z^*_{t-1} represents the average value of the absolute CDS-bond basis over the last three days and the weighting of the most recent, second most recent and third most recent days follows the pattern 3:2:1:[5]

$$Z^*_{t-1} = \frac{3}{6} \cdot |Z_{t-1}| + \frac{2}{6} \cdot |Z_{t-2}| + \frac{1}{6} \cdot |Z_{t-3}| \tag{13}$$

Importantly, the system of Hamilton and Susmel (1994) is a special case of our TVTP with the restriction of $\theta_{q1} = \theta_{p1} = 0$. Moreover, we postulate that mispricing in CDS-bond market (proxied by the absolute value of CDS-bond basis) triggers arbitrage and thus increases market volatility. Accordingly, we hypothesize that θ_{q1} and θ_{p1} are negative and positive, respectively.[6]

4. Sample and empirical results

4.1 Sample

Our sample comprises the daily CDS premium and bond yield spread in the four

[5] If CDS premium and bond spread differ, arbitrage trading between the CDS and bond markets will be triggered regardless of whether the price deviation is positive or negative. Consequently, this study adopts the absolute value of CDS-bond deviation as an indicator of market variances.

[6] Markov-switching approach has been widely used in many areas of applied economics and econometrics, such as Hamilton (1988), Driffill (1992), Garcia and Perron (1996) and Gray (1996) on short-term interest rates; Hamilton (1989), Lam (1990), Ghysels (1994), Durland and McCurdy (1994), Filardo (1994), Diebold and Rudebusch (1996), Hamilton and Lin (1996) on aggregative output and business cycles; Engel and Hamilton (1990), Engle (1994) and Li (2008) on exchange rates; and Hamilton and Susmel (1994), Cai (1994) and Ramchand and Susmel (1998a and b) on stock market volatility. Our study serves as a first attempt to apply the Markov-switching approach to the interrelation dynamics between the CDS premium and bond spread.

mature-country markets: U.S., U.K., Germany and France, and the three emerging-country markets: China, Mexico, and South Africa. The daily CDS premiums (mid-quotes) are based on a ten-year contract and obtained with the DataStream database for the period from 2008 to 2014. Panel A of Table 1 shows the number of available CDS quotes, the credit rating and the denominating currency for each of CDS contracts in our sample. The basic statistics of the CDS premiums are presented in Panel B of Table 1. Clearly, the developed counties enjoy a higher credit rating thank emerging countries, and associate with a lower value of CDS premiums. As the CDS quotes and bond market data should be reasonably comparable, we collect ten-year government bond yield for each country. Next, we select the ten-year swap rates dominated in the same currency to conduct the bond yield spread.[7]

[Insert Table 1 about here]

4.2 The unit root and cointegration tests

Tables 2 and 3 list the unit root and cointegration tests for the CDS premium and bond yield spread for mature and emerging countries, respectively. Using the 1% significance level as a criterion, the empirical results in Tables 2 and 3 reveal that the level of CDS premium and bond spread is non-stationary in all markets, except CDS premium in Mexico. However, the first difference of CDS premium and bond spread (i.e., % Return) is stationary. Additionally, the cointegration test indicates that the error correction term (i.e., CDS-bond basis) is stationary for all the cases. That is, the cointegration relationship of the price series for the CDS and bond markets holds.

[Insert Tables 2 and 3 about here]

4.3 The empirical results of the VECM

Tables 3 and 4 list the empirical results of the conventional VECM for mature and

[7] See McCauley (2002) for the related discussions for the adoption of the 10-year swap rates.

emerging countries, respectively. Using the significance level of 10% as a criterion, the two estimated coefficients on the lagged EC term (β^c and β^b) are significant and have the opposite sign as hypothesized (i.e., β^c and β^b are negative and positive, respectively) in most of the cases. Moreover, the estimated coefficients on the lagged returns on CDS premium and bond spread (i.e., $\gamma^{cb}{}_1$ and $\gamma^{bc}{}_1$) are also significant for most of the cases.[8] These results imply that the long-run cointegrated equilibrium and the short-run interaction between CDS and bond markets are held, which is consistent with prior studies (e.g., Blanco et al., 2005; Zhu, 2006; Fontana, 2010; Ammer and Cai, 2011). Last, the estimated correlation coefficient (ρ^{cb}) is significant for all the countries, and ranges from 0.6695 (Germany) to 0.9719 (UK). The high correlation coefficients further support the relation between CDS premium and bond spread.

[Insert Tables 3 and 4 about here]

4.4 The empirical results of the TVTP-VECM-SWARCH

To capture the dynamic market volatility in the CDS-bond market and the impact of CDS-bond basis on the market volatility, the study develops the TVTP-VECM-SWARCH. Tables 6 and 7 present the estimation results for mature and emerging countries, respectively. First, the estimates of $g^c{}_2$ and $g^b{}_2$ markedly exceed unity (i.e., the value for the $g^c{}_1$ and $g^b{}_1$) for all the countries. Using the U.K. market as an illustrated example, the $g^c{}_2$ and $g^b{}_2$ estimates are 13.9346 and 13.9340 with the standard deviation of 1.1927 and 1.1483, respectively. This finding is consistent with the notion that the volatility of regime II is 13.9346 times that of regime I for the CDS market, and 13.9340 for the bond market. Moreover, the confidence levels of estimates of $g^c{}_2$ and $g^b{}_2$ do not overlap with unity at a level of confidence of 95%, and thus this investigation confidentially identifies regime II as a high volatility state and

[8] For reasons of convenience, we set the order of auto-regression for the return of CDS premium and bond yield as unity (i.e., $p = q = 1$ in Equations (2) and (3)), and focus on discussing the relation between CDS-bond basis and market volatilities (see Section 4.4).

regime I as a low one. Next, the estimated coefficients on the ARCH term (i.e., $\eta^c{}_1$ and $\eta^b{}_1$) are significant for all the countries, except the bond market in China.[9] These results imply that time-varying and state-varying volatility dynamics appear in the CDS-bond markets.

Another key feature of our model is the adoption of TVTP design. As shown in Tables 6 and 7, the two transition probability parameters, θ_{q1} and θ_{p1}, have an opposite sign (θ_{q1} and θ_{p1} are negative and positive, respectively) as hypothesized by this study. Further, both the θ_{q1} and θ_{p1} estimates are significant at the 10% at least for all the cases. This result indicates that the lagged deviation between CDS premium and bond spread could serve as an indicator variable for the volatility-switching process. Moreover, the negative value of θ_{q1} and the positive value of θ_{p1} imply that the CDS-bond deviation is negatively and positively related to the transition probabilities p_{11} (the probability that market remains in low volatility) and p_{22} (the probability that market remains in high volatility), relatively. These findings support our argument that arbitrage triggered by the mispricing between CDS and bond market would increase market volatility. Moreover, our argument is consistent across mature- and emerging-country markets.

[Insert Tables 6 and 7 about here]

4.5 Explanations and discussion

Non-constant variances in financial markets have been well documented in the literature. This study employs the SWARCH model in which both the time-varying technique (i.e., ARCH term) and the state-varying facility (i.e., low versus high volatility regimes) are encompassed. Using the U.K. CDS-bond market as an example, Panels A and B of Figure 1 graph the level of CDS premium and bond spread (i.e., CDS_t and $BS_{t,}$) and the return on them

[9] Even with this simple structure involving one lagged ARCH component, there are 19 parameters that require estimation. A more general structure with a higher order ARCH term could increase the number of parameters to be estimated. Furthermore, similarly to Hamilton and Susmel (1994), this study also found that the higher-order ARCH parameter estimates do not differ significantly from zero after filtering out the variance-switching process. To save space, this study does not report the results of the higher lag order setting.

(i.e., ΔCDS_t and ΔBS_t), respectively. First, Panel A provides the evidence of a long-term equilibrium relation between CDS premium and bond spread, which is consistent with our results shown in Tables 2 to 5. Next, Panel B shows the volatility of return on CDS premium and bond spread is substantially bigger (or smaller) than the average during some periods. Thus, one cannot take the overall sample period variance as a constant. Being consistent with our empirical results, the estimated coefficients on the parameters of the SWARCH model are significant (see Tables 6 and 7). Moreover, comparing Tables 4 and 5 with Tables 6 and 7 indicate that the SWARCH setting largely increases the value of the log-likelihood function (e.g., -5674.3 vs. -4798.3 for the case of the U.K.). The comparison shows that the setting of dynamic volatilities enhances the model's performance on fitting returns on CDS premium and bond spread.

Panels A and B of Figure 2 graph the price deviation between CDS premium (proxied by the absolute value of EC term in Equation (1)) and bond spread and the probability of high volatility state in the U.K. CDS-bond market, respectively. Our empirical results of the TVTP setting (see Tables 6 and 7) indicate the relation between them. This finding requires further discussion. First, the error correction process between CDS premium and bond yield is restated as follows: simultaneous short selling of the position on CDS premium and purchasing of the position on bond yield when the mispricing term (or CDS-bond basis) is positive, the opposite being the case when it is negative. Clearly, this price adjustment process implied by such arbitrage behaviors causes the change in CDS premium and bond yield, and thus increase market volatility.

5. Conclusions

On the basis of a Markov-switching technique, this study analyzes the relation between CDS premium and bond spread. The volatility regime switching characterizing the CDS-bond markets is examined with the aim of investigating how arbitrage triggered by CDS-bond mispricing corresponds to changes in volatility regime. The following conclusions are drawn on the basis of the analyses carried out in this study. First, the long-term cointegration and the short-term interaction between CDS and bond markets are held. Second, the lagged CDS-bond basis functions as an indicator for the variance-turning process, which implies that arbitrage trading increases market volatility. Third, the aforementioned findings are consistent across mature and emerging countries.

Our findings should have crucial implications for traders and policymakers. In particular, CDS allows investors to control the default risk of a bond. However, the evidence we uncover suggests that the CDS-bond arbitrage increases the volatility of bond yield, a measure of interest rate risk. This implies that adding CDS, a new credit derivative security to the market, could provide investors with a useful tool to manage default risk, but it could also lead to unintended consequences, i.e., an increase in interest rate risk. Considering the sum of credit and interest risk as the total risk of a bond, our empirical results indicate that the control for default risk via CDS associates with a cost in terms of transformation from default risk to interest rate risk.

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Table 1
Information on CDS premiums

Panel A: Credit rating and availability of quotes

	Credit rating	Data period	# of Obs.	Currency
Mature markets				
U.S.	AA+	10/22/2008~03/11/2014	1,405	U.S. dollar
U.K.	AAA	11/11/2008~03/11/2014	1,391	Euro
Germany	AAA	01/07/2008~03/11/2014	1,612	Euro
France	AA+	05/27/2008~03/11/2014	1,511	Euro
Emerging markets				
China	AA-	10/22/2008~03/11/2014	1,405	U.S. dollar
Mexico	BBB+	10/22/2008~03/11/2014	1,405	U.S. dollar
South Africa	BBB+	10/08/2008~03/11/2014	1,415	U.S. dollar

Panel B: Descriptive statistics (Unit = basis point)

	Mean	S.D.	Median	Q1	Q3
Mature markets					
U.S.	52.36	12.40	53.38	60.28	43.65
U.K.	74.96	19.83	71.29	83.09	61.61
Germany	37.94	17.22	35.37	47.16	27.46
France	72.40	34.94	67.95	86.70	54.69
Emerging markets					
China	127.33	1.09	116.83	155.84	97.00
Mexico	180.24	1.98	153.27	179.37	140.79
South Africa	207.81	2.03	185.19	230.34	163.00

Notes: The credit rating of sovereign bonds is provided by Standard & Poor's (S&P). All of the CDS premiums are based on 10-year U.S dollar or Euro contracts with the CR restricting clause and the sovereign bonds are also required to be denominated in the same currency as the CDS contract.

Table 2
Unit root tests and co-integration tests of CDS premium and bond spread: Mature countries

	CDS premium	Bond spread
U.S.		
Log levels	-2.1246	-2.5934
% Returns	-34.8590*	-22.7793*
Error correction term	-11.1722*	
U.K.		
Log levels	-2.6177	-2.7636
% Returns	-41.5807*	-40.9490*
Error correction term	-3.7266*	
Germany		
Log levels	-2.5785	-2.3466
% Returns	-40.3497*	-34.4381*
Error correction term	-5.3248*	
France		
Log levels	-2.9285	-2.7632
% Returns	-34.6001*	-23.8999*
Error correction term	-6.5317*	

Notes: To conduct the unit root test for the log levels and return rates (first difference) of CDS premium and bond spread, we use the Dickey and Fuller (1979)'s augmented Dickey-Fuller test (ADF test). The cointegration tests are based on Engle-Granger (1987) procedure. This study uses the maximum lag length for 15-order by Schwarz Info Criterion when conducting the Unit root test. The * denotes the significance in 1%. The data source is consistent with Table 1.

Table 3
Unit root tests and co-integration tests of CDS premium and bond spread: Emerging countries

	CDS premium	Bond spread
China		
Log levels	-2.5989	-2.0614
% Returns	-36.6275*	-43.2246*
Error correction term	-11.1711*	
Mexico		
Log levels	-4.4542*	-2.0716
% Returns	-30.8434*	-38.2503*
Error correction term	-9.8526*	
South Africa		
Log levels	-2.9255	-3.0028
% Returns	-36.0529*	-38.3362*
Error correction term	-6.8983*	

Notes: All the notations are consistent with Table 2.

Table 4
Estimated results of the conventional VECM: Mature countries

	U.S.	U.K.	France	Germany
CDS premium equation				
α^c	-0.0082 (0.0187)	-0.0156 (0.0128)	0.0923 (0.0924)	0.0620 (0.1321)
β^c	-0.0120 (0.0095)*	0.0047 (0.0171)	-0.0390 (0.0125)***	-0.0181 (0.0096)**
$\gamma^{cc}{}_1$	0.2021 (0.0343)***	-0.1147 (0.0282)***	0.1479 (0.0348)***	0.0353 (0.0037)***
$\gamma^{cb}{}_1$	-0.1193 (0.0281)***	0.0064 (0.0140)	-0.0360 (0.0265)*	-0.0463 (0.0230)**
Bond spread equation				
α^b	0.0287 (0.0443)	0.0015 (0.0109)	0.0890 (0.0870)	0.0636 (0.0515)
β^b	0.0258 (0.0115)**	0.0230 (0.0173)*	0.0262 (0.0170)*	0.0440 (0.0130)***
$\gamma^{bc}{}_1$	-0.0537 (0.0396)*	-0.2390 (0.0380)***	0.3692 (0.0457)***	0.3154 (0.0277)***
$\gamma^{bb}{}_1$	0.1300 (0.0316)***	0.1364 (0.0289)***	-0.2847 (0.0344)***	-0.3283 (0.0298)***
Variance-covariance matrix				
σ^c	2.9251 (0.0553)***	3.8208 (0.0725)***	4.3624 (0.0795)***	4.8481 (0.0855)***
σ^b	3.3731 (0.0637)***	3.8913 (0.0739)***	5.5958 (0.1019)***	6.1499 (0.1085)
ρ^{cb}	0.9387 (0.0032)***	0. 9719 (0.0015)***	0.7273 (0.0121)***	0.6695 (0.0138)***
Log-lik.	-5691.0035	-5674.3407	-8524.3424	-9544.3451

Notes: Please refer to this study's Equations (2) and (3) for the model specification of the CDS premium and bond spread equations. This study sets the lag number order in the VECM to unity, namely p=1 and q=1. The specification of variance-covariance matrix is detailed in Equation (5). The value in the parenthesis denotes the standard error of parameter estimate. The *, ** and *** denote the significance in 10%, 5% and 1%, respectively.

Table 5
Estimated results of the conventional VECM: Emerging countries

	China	Mexico	South Africa
CDS premium equation			
α^c	-0.0340 (0.0418)	-0.0870 (0.0556)	-0.0468 (0.0202)**
β^c	-0.0298 (0.0102)***	-0.0456 (0.0130)***	-0.0030 (0.0088)
$\gamma^{cc}{}_1$	0.3632 (0.0404)***	0.3059 (0.0420)***	0.1588 (0.0393)***
$\gamma^{cb}{}_1$	-0.3326 (0.0380)***	-0.1448 (0.0472)***	-0.1791 (0.0432)***
Bond spread equation			
α^b	0.0302 (0.0787)	-0.0282 (0.0351)	-0.0212 (0.0136)
β^b	0.0372 (0.0108)***	0.0264 (0.0115)**	0.0531 (0.0098)***
$\gamma^{bc}{}_1$	0.5108 (0.0403)***	0.4146 (0.0372)***	0.1319 (0.0355)***
$\gamma^{bb}{}_1$	-0.4992 (0.0381)***	-0.3868 (0.0418)***	-0.1296 (0.0392)***
Variance-covariance matrix			
σ^c	3.0910 (0.0584)***	2.9975 (0.0567)***	3.7364 (0.0704)***
σ^b	3.1680 (0.0598)***	2.6332 (0.0498)***	3.4713 (0.0654)***
ρ^{cb}	0.8114 (0.0091)***	0.8088 (0.0093)***	0.8162 (0.0089)***
Log-lik.	-6419.8753	-6126.5296	-6846.2661

Notes: All the notations are consistent with Table 4.

Table 6
Estimated results of the TVTP-VECM-SWARCH: Mature countries

	U.S.	U.K.	France	Germany
Transition probability				
θ_{q0}	2.0353 (0.1657)***	2.1073 (0.3621)***	1.4169 (0.2368)***	2.0507 (0.1675)***
θ_{p0}	-0.4066 (0.2589)*	1.5292 (0.2918)***	-0.2312 (0.1800)*	-1.3234 (0.306)***
θ_{q1}	-0.1654 (0.0275)***	-0.1346 (0.0489)***	-0.1017 (0.0502)**	-0.0614 (0.0208)***
θ_{p1}	0.0644 (0.0282)**	0.0458 (0.0350)*	0.0575 (0.0072)***	0.1364 (0.0304)***
CDS premium equation				
α^c	-0.0928 (0.0348)***	-0.0908 (0.0593)*	-0.0135 (0.0125)	-0.0561 (0.1354)
β^c	0.0013 (0.0072)	-0.0126 (0.0124)	-0.0186 (0.0056)***	-0.0125 (0.0136)
$\gamma^{cc}{}_1$	0.0666 (0.0419)*	-0.0435 (0.0319)*	0.2269 (0.0115)***	0.1127 (0.0236)***
$\gamma^{cb}{}_1$	-0.0513 (0.0365)*	0.0314 (0.0251)	-0.0124 (0.0119)	-0.0504 (0.0085)***
Bond spread equation				
α^b	-0.0940 (0.0389)***	-0.0969 (0.0609)*	0.0960 (0.0324)***	-0.0010 (0.0702)
β^b	0.0059 (0.0081)	-0.0144 (0.0126)	0.0347 (0.0143)***	0.0282 (0.0122)**
$\gamma^{bc}{}_1$	-0.0424 (0.0445)	-0.1090 (0.0285)***	0.6213 (0.0326)***	0.4811 (0.0351)***
$\gamma^{bb}{}_1$	0.0609 (0.0405)*	0.0818 (0.0253)***	-0.4521 (0.0243)***	-0.4359 (0.0286)***
Variance-covariance matrix				
$\eta^c{}_0$	0.765 (0.0593)***	1.5015 (0.1704)***	1.0821 (0.1196)***	3.8928 (0.3003)***
$\eta^c{}_1$	0.1567 (0.0313)***	0.2278 (0.0288)***	0.6487 (0.0610)***	0.2487 (0.0424)***
$g^c{}_2$	26.7998 (1.8786)#	13.9346 (1.1927)#	18.8970 (1.5940)#	16.2197 (1.3626)#
$\eta^b{}_0$	0.9732 (0.0718)***	1.5788 (0.1746)***	3.4434 (0.2617)***	7.8159 (0.4842)***
$\eta^b{}_1$	0.1455 (0.0322)***	-0.2260 (0.0290)***	0.4965 (0.0504)***	0.1371 (0.0278)***
$g^b{}_2$	27.5371 (1.8816)#	13.9340 (1.1483)#	9.6099 (0.7403)***	13.9636 (1.1317)#
ρ^{cb}	0.9291 (0.0048)***	0.9724 (0.0019)***	0.7088 (0.0147)***	0.6815 (0.0095)***
Log-lik.	-4485.1094	-4798.3159	-7619.3865	-8618.1283

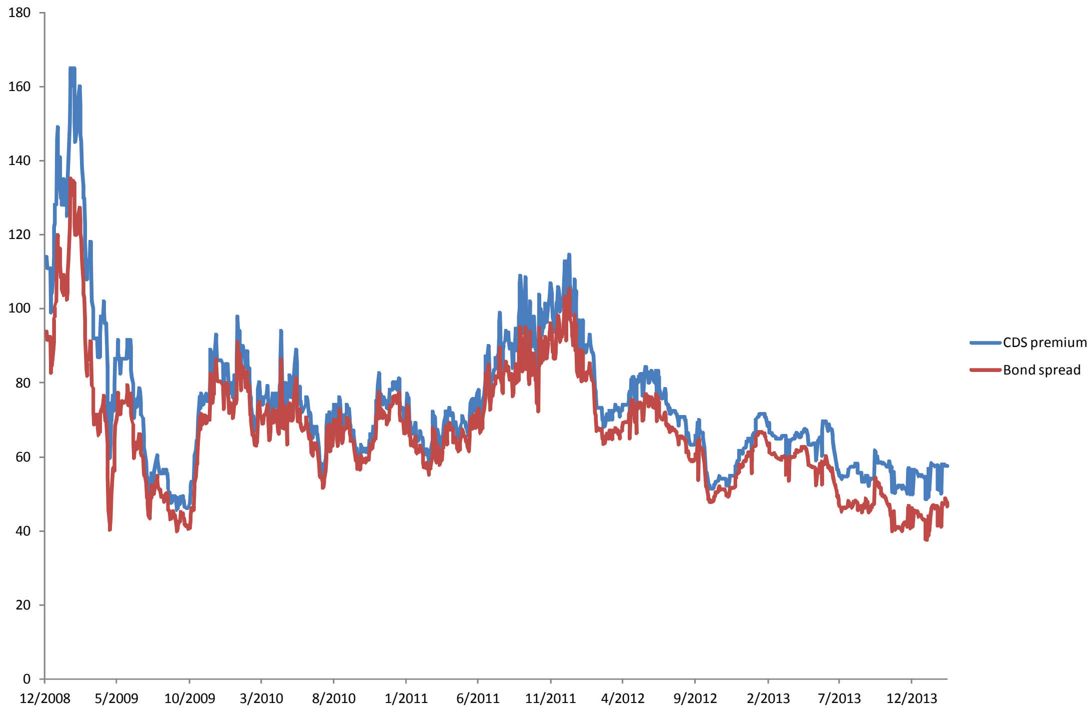
Notes: Please refer to this study's Equations (6) to (10) for the setting of variance-covariance matrix and SWARCH. The setting of TVTP is presented in Equation (12) of the study. The *, ** and *** denote the significance in 10%, 5% and 1%, respectively. The # denotes the estimate is significantly greater than unity at the 1% significance level. The data source is consistent with Table 1.

Table 7
Estimated results of the TVTP-MRS-VECM: Emerging countries

	China	Mexico	South Africa
Transition probability			
θ_{q0}	2.7187 (0.2602)***	4.4774 (0.4856)***	3.9766 (0.3576)***
θ_{p0}	0.1561 (0.2201)	3.3181 (0.4720)***	-3.4297 (1.0826)***
θ_{q1}	-0.0436 (0.0320)*	-0.1053 (0.0045)***	-0.1736 (0.0443)***
θ_{p1}	0.0598 (0.0359)**	0.0077 (0.0039)**	0.2831 (0.0796)***
CDS premium equation			
α^c	-0.0797 (0.0602)*	-0.0066 (0.0434)	0.0455 (0.0765)
β^c	-0.0064 (0.0075)	0.0284 (0.0103)***	0.0548 (0.0138)***
$\gamma^{cc}{}_1$	0.2095 (0.0513)***	0.1051 (0.0412)***	0.1666 (0.0312)***
$\gamma^{cb}{}_1$	-0.1657 (0.0472)***	0.0351 (0.0380)	-0.0500 (0.0273)**
Bond spread equation			
α^b	-0.0472 (0.0692)	0.0069 (0.0490)	0.0787 (0.0669)
β^b	-0.0044 (0.0081)	0.0570 (0.0096)***	0.0914 (0.0140)***
$\gamma^{bc}{}_1$	0.5275 (0.0546)***	0.3831 (0.0360)***	0.4542 (0.0352)***
$\gamma^{bb}{}_1$	-0.5186 (0.0504)***	-0.3725 (0.0363)***	-0.3882 (0.0344)***
Correlation			
$\eta^c{}_0$	3.3708 (0.2770)***	3.3168 (0.2277)***	4.4960 (0.3398)***
$\eta^c{}_1$	0.0717 (0.0280)***	0.1156 (0.0221)***	0.2232 (0.0354)***
$g^c{}_2$	9.9390 (0.9924)#	4.4659 (0.3690)#	22.1462 (3.8414)#
$\eta^b{}_0$	4.9082 (0.2730)***	4.0611 (0.2219)***	4.9302 (0.3054)***
$\eta^b{}_1$	0.0159 (0.0229)	0.0652 (0.0233)***	0.1515 (0.0262)***
$g^b{}_2$	6.3853 (0.6703)#	2.4922 (0.2160)***	16.4931 (2.9072)***
ρ^{cb}	0.7772 (0.0120)***	0.7987 (0.0107)***	0.8322 (0.0100)***
Log-lik.	-6041.7724	-5864.0301	-6023.9911

Notes: All the notations are consistent with Table 6.

Panel A: Level of CDS premium and bond spread



Panel B: Return on CDS premium and bond spread

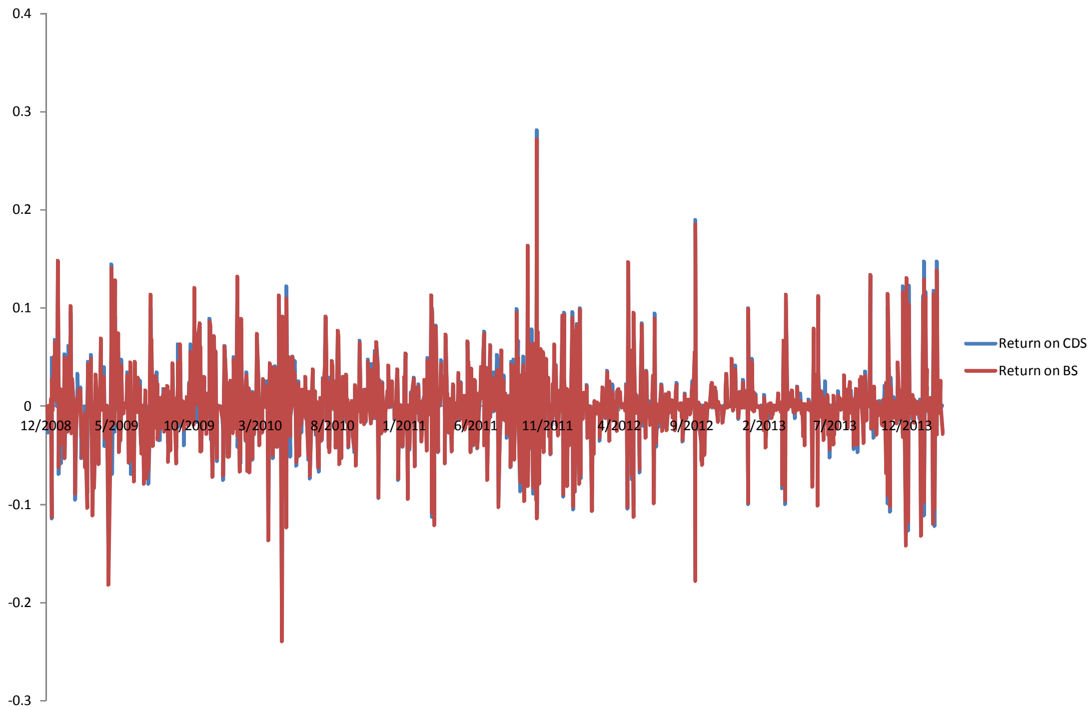
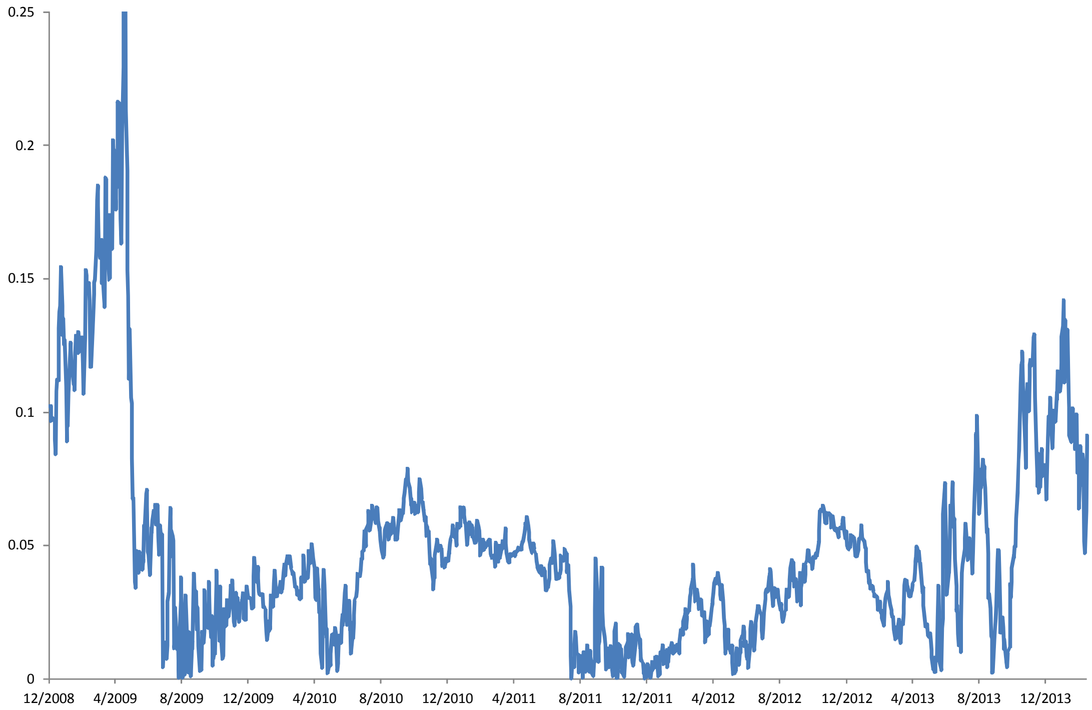


Figure 1 CDS premium and bond spread: An example of U.K.

Panel A: Absolute value of CDS-bond basis



Panel B: Probability of high volatility regime

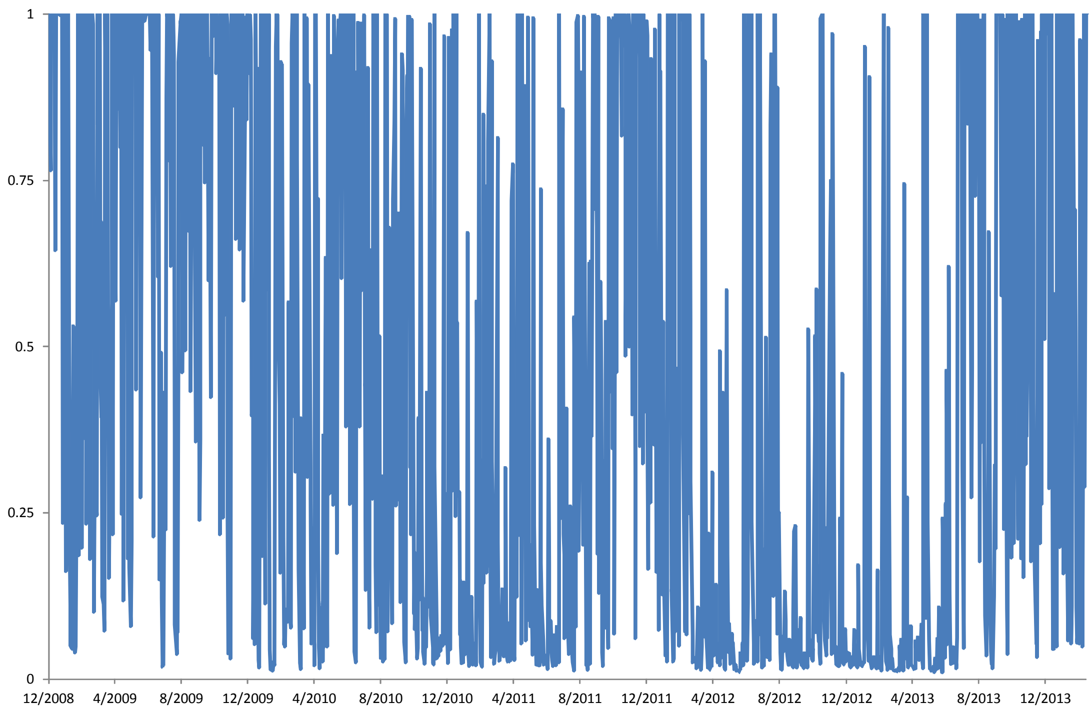


Figure 2 Price deviation and probability of high volatility regime in CDS-bond market: An example of U.K.