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Sectoral and Regional Volatility Connectedness: The Case of CDS Spreads and Equities

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Abstract

This study analyses volatility connectedness at sectoral and regional level within and across the US, UK, EU and Japanese regions between the CDS and equity markets. Analysis is made on 32 sectors and 70 sub-sectors within the regions under study with each having 2,479 observations, covering the period between 2008 until June 2017. The sample is divided between crisis and after-crisis period and the novel connectedness index by Diebold-Yilmaz (2014) is proposed. The domestic and regional analysis show that connectedness between the two asset classes is in general higher during the crisis period. Although the static Gaussian results for the regional analysis show low levels of connectedness across the board, the dynamic analysis show significant connectedness levels, with levels being predominantly higher during the crisis period, signifying contagion effects also at regional level between the two asset classes. When considering the dynamic volatility connectedness between the two asset classes, equity is the asset class which transmits volatility the most. In the US and EU connectedness between the two asset classes in most sectors is predominantly large during disturbed periods, particularly the 2009 crisis and the EU sovereign crisis.

Keywords: CDS spreads, equity pricing, connectedness, volatility, crisis

1. Introduction

Credit related investments, like Credit Default Swaps (CDS), have grown tremendously both from a size and liquidity perspective. The magnitude of CDS spreads gauges the level of default risk exposure in different industry sectors. The link between CDS spreads and equity prices did not go unnoticed, with the first study dating back to the work of Merton (1974) who argues that there exists a strong tie between the two asset classes. The relationship stems from the fact that credit spreads theoretically represent credit risk, which is synonymous to the default probability introduced by Merton (1974). In addition, given that debt and equities are contingent claims to the same firm value, they share common systemic risk sources. Common systemic risk sources increase during turbulent times when markets are enduring a crisis. Therefore, this relationship becomes relatively more critical during crises periods.

This study contributes to the strand of literature on contagion or spillover effects, with a focus on the link between CDS spreads and equity volatility. Earlier studies have examined the interrelation of credit spreads and equity volatility, however, studies at a sectoral and geographical level have been given little attention. Volatility patterns of these asset classes played a fundamental role in the crisis of 2009, with an evident increase in volatility spillovers, contributing to volatility contagion.

This study proposes the cohesive framework of Diebold and Yilmaz (2014) to measure and assess the interdependency of CDS and equity volatility spillovers across sectors and geographical areas. Interconnectedness is crucial during perturbed periods as some sectors become central to the economy that volatility in a sector leads to propagation of shocks to all the other sectors, resulting in a systematic risk. The same is true for geographic associations.

The domestic and regional analysis showed that connectedness between the two asset classes is in general higher during the crisis period. This shows that when the two asset classes are in distress there is more tendency to exhibit parallel behaviour, exacerbating shocks between the two, thereby suggesting contagion effects between the two asset classes within regions. Although the static results for the regional analysis show low levels of connectedness across the board, the dynamic analysis show significant connectedness levels, with levels being predominantly higher during the crisis period, signifying contagion effects also at regional level between the two asset classes. This is in line with Merton (1974) in that equity and credit spreads should move in parallel in troubled times.

When considering the dynamic volatility connectedness between the two asset classes, equity is the asset class which transmits volatility the most. In the US and EU connectedness between the two asset classes is predominantly large during disturbed periods, particularly the 2009 crisis and the EU sovereign crisis.

2. Literature Review

Equity and fixed-income instruments are different asset classes with different risk-return characteristics. However, the valuation is reliant on the same underlying asset of the company in subject, and hence the risk-return trade-off should be systematically related. In other words, the joint behaviour of equity premiums and credit spreads on securities of the same company provides a direct statistical indication of the level of efficiency of the two markets, where market participants are expected to provide a long-term common risk assessment (Consigli, 2004). This theoretical link between equity and fixed-income instruments is fully defined by Merton (1974) through a structural approach applied on the option pricing theory of Black and Scholes (1973). The link between these two asset classes becomes relatively more important during periods of financial stress and volatility.

2.1 Empirical Evidence on the Relation between CDS and Equity Markets

Using a sample of 67 North American firms, Longstaff *et al*. (2003) applied a VAR model to investigate the relationship between equity returns, changes in bond spreads and changes in CDS spreads. It was concluded that information flows first into the CDS and equity market and then into the corporate bond market. However, no evidence was found that the stock market leads the CDS market. Lake and Apergis (2009) investigated the association between the equity market and CDS market in terms of mean as well as volatility. The authors found that the CDS market appears to lead the stock market, implying that information contents coming from the firm's environment seems to first affect the CDS market and then the equity market. In addition, equity market volatility has a positive impact on CDS spreads. Zhang (2005) suggests that the CDS market lead the equity market.

Berndt and Ostrovnaya (2008) found that both CDS and option markets lead the stock market. On the contrary, Forte and Pena (2009) found that equity markets lead those of CDS, which in turn lead the corporate bond market. In addition, Fung *et al*. (2008) discovered strong links between the two markets and that the lead/lag relationships between the markets under study depend on credit quality. Specifically, significant apparent mutual feedback of information between the equity market and the high-yield segment of the CDS market in terms of pricing and volatility was found, while the stock market leads the investment-grade segment of the CDS index in the pricing process. Indeed, Forte and Lovreta (2008) confirmed that stronger relationship existed at lower credit quality levels. Trutwein and Schiereck (2011) show that equity and credit markets become more connected during times of heightened stress and that fast equity price changes lead furious CDS spread changes.

Acharya and Johnson (2007) provide empirical evidence that an information flow exists from the CDS markets to equity markets. The flow occurs only for negative credit events and for entities that subsequently experience adverse shocks, and more significant for entities with a greater number of bank relationships. Narayan *et al*. (2014) found empirical evidence that equity market contributes to price discovery in most sectors while the CDS market% contributes to price discovery in only a few sectors. When both markets contribute to price discovery, it is the equity market that dominates the price discovery. Also, Narayan et al. (2014) argued that when equities which have an investment grade credit rating are considered, the importance of the CDS market in price discovery improves but the equity market still dominates the price discovery process.

Ratner and Chiu (2013) report that CDS are a strong hedge against equity risk in all sectors under consideration and during extreme volatility periods, CDS demonstrate both strong and weak safe-haven characteristics against equity risk. More specifically, in times of extreme equity market volatility, CDS provide some evidence of a strong safe-haven in the broadest measure of volatility (ten percent quantile) in Basic Materials, Industrials, Healthcare, Telecommunications, Financials, and Technology. In these sectors, the CDS market is most responsive to extreme downturns in equities and may prove useful to contain portfolio volatility. On the other hand, from the sectors which function as weak safe havens, investors should not expect much protection from CDS during perturbed periods.

Mateev and Marinova (2019) investigated the relation between credit risk, as implied in the CDS market and equity prices of the Markit iTraxx Europe index companies. They found a long-run relation between CDS and equity prices of European companies, showing possible evidence for possible transmission of shocks between the two asset classes. Ballester and Urteaga (2020) concludes that equity returns anticipate CDS returns, while CDS returns anticipate the conditional volatility of equity returns.

2.2 Equity Volatility and Credit Spreads

Equity volatility should be positively correlated with corporate credit spreads. This stems from the fact that an increase in asset volatility or leverage will result into a higher probability that the value of assets relative to the value of debt will fall, resulting in default.

Zhang et al. (2009) found that the equity volatility alone predicts 48% of the change in CDS spread levels. On the other hand, jump risks seem to explain 19% of the changes and appear to affect CDS premia. In addition, negative jumps in equities affect three times larger CDS spreads than positive jumps. This means that the relationship between equity volatility and credit spreads is asymmetric: an increase in volatility has a bigger impact on credit spreads than a decrease in volatility of a similar magnitude.

Meng et al. (2009) found that shocks from the CDS market to the other two markets on average take longer to be absorbed than shocks received by the CDS market from the equity and bond market. Belke and Gokus (2011) suggest that volatility increases in times of crisis, especially for equity returns and CDS spread changes. In addition, correlations and covariances increased in absolute values after the crisis, indicating stronger dependency among the examined variables. Kajurova (2015) documented that equity volatility explains CDS spreads, with results being more significant during crisis period.

Narayan (2015) found that CDS return shocks are key in explaining the forecast error variance of sectoral equity returns for the US, especially of sectoral equity returns. In addition, CDS return shocks are most dominant during the global financial crisis, with their role maximised in the post-Lehman crisis period. Moreover, CDS return shocks have a heterogeneous effect, with some sectors being more affected than others. Finally, constructing a spillover index, Narayan (2015) suggest that spillovers are key to the connectedness between CDS returns and equity returns.

Mateev (2019) found supportive evidence that for many companies both correlations and covariances between CDS and equity prices exhibit time-varying pattern. \Volatility spillover between the two asset classes was found to be bi-directional. In addition, for 32 companies, the volatility spillover is transmitted from the CDS market to the equity market, while for eleven companies the direction of the spillover is the opposite.

3. Data and Methodology

Diebold and Yilmaz (2014) developed a unified framework to measure connectedness at different levels, from pairwise through system-wide. This approach uses a variance decomposition (VD) technique. VDs allow for a split of the *H*-step-ahead forecast error variances of each variable into parts attributable to the system shocks.

The framework derives from the VD matrix of a VAR approximating model. Considering a covariance-stationary *N*-variable VAR(p), $x_t = \sum_{i=1}^{p} \Phi_i x_{t-i} + \varepsilon_t$, where $\varepsilon \sim (0, \Sigma)$ is a vector of independently and identically distributed disturbances.

In the Generalised Forecast Error Variance Decomposition (GFEVD) framework, "*own variance shares*" are considered as fractions of the *H*-step-ahead error variances in forecasting x_i that are due to shocks to x_i, for $i = 1,2, \dots, N$, and "cross variance shares", or as known in literature "spillovers", as the fractions of the *H*-step-ahead error variances in forecasting x_i that are due to shocks to x_j, for $i, j = 1,2, \dots, N$, such that $i \neq j$. Therefore, denoting *H*-step-ahead FEVD by $\theta_{ij}^{g}(H)$, for $H = 1,2, \dots$, the GFEVD is represented by:

$$\boldsymbol{\theta}_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} \left(e_i' A_h \Sigma e_j\right)^2}{\sum_{h=0}^{H-1} \left(e_i' A_h \Sigma A_h' e_i\right)^2} \tag{1}$$

where Σ is the variance matrix for the error vector ε, σ_{jj} is the standard deviation of the error term for the j^{th} equation, ε_j, and ε_i is the selection vector with i^{th} element unity and zeros elsewhere. A_h, $h = 0,1,2, \dots$ are the coefficient matrices in the infinite moving average representation. As noted, the sum of the VD matrix (1) may not equal unity $\left[\sum_{j=1}^{N} \theta_{ij}^{g}(H) \neq 1\right]$ and therefore each entry of the VD matrix in the calculation of the spillover index is normalised by:

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N} \theta_{ij}^{g}(H)} \tag{2}$$

It is important to note that by construction, $\sum_{j=1}^{N} \tilde{\theta}_{ij}^{g}(H) = 1$ and $\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H) = N$.

Apart from enabling us to understand how much of shocks spill over different variables, the generalised framework also provides relevant information on the direction of spillovers. $\tilde{\theta}_{ij}^{g}(H)$ provides a measure of *pairwise directional connectedness* from j to i at horizon H: $C_{i \leftarrow j}(H)$.

The *directional connectedness* is calculated using the normalised elements of the generalised VDs. The directional spillovers are aggregated into two versions: the "from" and "to". The directional volatility spillovers absorbed by market i from all other markets j are measured as:

$$C_{i \leftarrow \cdot}(H) = \frac{\sum_{j=1, j \neq 1}^{N} \tilde{\theta}_{ij}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H)} \times 100 = \frac{\sum_{j=1, j \neq 1}^{N} \tilde{\theta}_{ij}^{g}(H)}{N} \times 100 \tag{3}$$

In a similar fashion, the directional spillovers transmitted by the market i to all other markets j are measured as:

$$C_{\cdot \leftarrow i}(H) = \frac{\sum_{j=1, j \neq 1}^{N} \tilde{\theta}_{ji}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ji}^{g}(H)} \times 100 = \frac{\sum_{j=1, j \neq 1}^{N} \tilde{\theta}_{ji}^{g}(H)}{N} \times 100 \tag{4}$$

Directional connectedness should prove useful in providing a decomposition of the total spillovers to those coming from (or to) a particular shock. Therefore, the net total directional connectedness is obtained by:

$$C_i(H) = C_{\cdot \leftarrow i}(H) - C_{i \leftarrow \cdot}(H) \tag{5}$$

The *net total connectedness* is the difference between the gross shocks transmitted to and those received from all the other variables. In addition, the *net pairwise total connectedness* $C_{ij}(H) = C_{i \leftarrow j}(H) - C_{j \leftarrow i}(H)$ can be measured as:

$$C_{ij}(H) = \left(\frac{\tilde{\theta}_{ji}^{g}(H)}{\sum_{i,k=1}^{N} \tilde{\theta}_{ik}^{g}(H)} - \frac{\tilde{\theta}_{ij}^{g}(H)}{\sum_{j,k=1}^{N} \tilde{\theta}_{jk}^{g}(H)} \right) \times 100 = \left(\frac{\tilde{\theta}_{ji}^{g}(H) - \tilde{\theta}_{ij}^{g}(H)}{N} \right) \times 100 \tag{6}$$

The net pairwise connectedness between market i and j is simply the difference between the gross volatility shocks transmitted from market i to market j and those transmitted from market j to market i.

Finally, *total connectedness* or *system-wide connectedness* can be measured as:

$$C(H) = \frac{\sum_{i,j=1, i \neq j}^{N} \tilde{\theta}_{ij}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H)} \times 100 = \frac{\sum_{i,j=1, i \neq j}^{N} \tilde{\theta}_{ij}^{g}(H)}{N} \times 100 \tag{7}$$

This is the connectedness index developed by Diebold and Yilmaz (2014) measuring the contribution of spillovers of shocks across all the variables into the system.

3.1 The Approximating Model

This study uses a VAR (2) approximating model to obtain the VDs and subsequent connectedness measures. The approximated VAR models can be represented by:

$$x_{t,j,s} = \alpha_0 + \sum_{i=1}^{k} \beta_i x_{t-i,j,s} + \varepsilon_t; \tag{8}$$

$$x_{t,j,\bullet} = \alpha_0 + \sum_{i=1}^{k} \beta_i x_{t-i,j} + \varepsilon_t; \tag{9}$$

where $x_{t,j,s}$ is an N × 1 column vector representing CDS spreads and equity volatility for sector s and country j. The first model aims to represent equity volatility spillovers between sectors or sub-sectors within country j. The second model on the other hand represent spillovers for a particular sector or sub-sector across all countries j.

Volatility of both asset classes is proxied by the rolling five-day period standard deviation and is taken in natural logarithm to approximate normality, given that volatilities have a right-skewed distribution. The parameter, α_0, is an N × 1 column vector of constant terms while β_i are N × N matrices of coefficients. ε_t is a column vector of disturbances or shocks.

Network measures are defined in relation to a reference universe, namely the set of x's.The choice of x has important implications for the appropriate approximating model and accordingly x is sub-divided into three functions: i) x object which refers to the type of variable being studied; ii) x choice which refers to which and how many variables are selected for the study; iii) x frequency which refers to the observational frequency of x variables. Succinctly, the x object is the natural log of volatility, x choice are the 72 main sectors and 139 sub-sectors in US, EU, UK, and Japan, while the x frequency is daily. Moving to the connectedness horizon, this study uses a horizon of H = 10 days.

Given that connectedness is non-linear, it is of essence to also allow for time-varying parameters to allow for non-linearity in the approximating model. This study opts for the rolling estimation window to allow for time-varying parameters. The choice of window width w is of essence in this method. In this study we opt for a window of w = 200.

Daily data from 01/01/2008 to 30/06/2017 (2479 observations) from the CDS Spreads and equity indices are used. Analysis is carried within and across regions. All indices data for the period were obtained from Thomson Reuters Datastream. The regions covered include: United States (US), United Kingdom (UK), Europe (EU) and Japan.

To assess volatility spillovers during and after the crisis, the sample has been divided into two sub-samples, covering crisis and after-crisis periods. The industry analysis is carried out at various levels of detail, data permitting.

5. Empirical Results

The static analysis shall capture an overall average, or unconditional behaviour, while the dynamic analysis (Note 1) shall capture the secular and cyclical movements in the spillovers. The focus of the analysis will be on the crisis period.

5.1 CDS Spreads and Equity Volatility Sectors Connectedness: Within Regions Static Analysis

Common sectors and sub-sectors in the CDS and equity market are examined to understand whether spillovers exist between sectors across the two asset classes. A general finding is that CDS spreads volatility is affected by equity volatility in almost all sectors. However, the reverse is not true and is almost completely explained by its own shocks and shocks in related sub-sectors in the equity segment. In addition, own-volatility connectedness in general decreases during the crisis period, supporting the notion that there is a large dependency between the two asset classes during distressed periods, possibly indicating contagion effects. Table 1 provides a summary of the sectoral connectedness between the two asset classes within regions.

In the US, connectedness between the two asset classes is higher during the crisis, bar for the telecommunications sector. Also, as expected in the US, equity sectors are net transmitters of volatility across most sectors. One of the main reasons could be that the equity market is much more developed and liquid than the CDS market and more prone to market events. In the financial sectors, equity is a predominant transmitter of volatility, in line with a-priori expectations given that the US financial sector was the sector which triggered the unprecedented crisis, spreading shocks across other sectors in the economy. The CDS banking and financial services sectors have been affected by other sectors. From a CDS perspective, consumer services and consumer goods sectors are the main transmitters of volatility. Investors caused this volatility in these sectors by demanding insurance coverage given the cyclical nature of these sectors. Also, the telecommunication sector is dominates by the CDS market. This can be possibly explained by the fact the telecommunications sector is insensitive to the economic cycle, but investors might have requested insurance coverage to protect their returns, pushing up spreads.

In the EU, the connectedness indices between CDS and equity volatility are higher in almost all sectors during the crisis period. As in the case of the US, the equity sector has been the main transmitter of volatility compared to the CDS sector. Volatility from the banking and other financial services equity sectors dominates volatility transmission in the financial sector. This is in line with the above findings, in that the financial equity sectors are the catalyst of the crisis, creating havoc in other related sectors. This was not the case from a CDS perspective, as financials spreads are contaminated by spillovers from other sectors, mostly consumer services and consumer goods sectors. The results in the latter sectors, are also in line with the above results. As in the US, consumer services and consumer goods sectors are the only two main sectors which are net transmitters of volatility from a CDS perspective. This may be explained by rising premiums following request for insurance versus these cyclical sectors. The utility sector shows no connection whatsoever between the two asset classes, further exhibiting the independence nature of this sector.

Volatility connectedness indices in the UK are higher across all sectors during the crisis period. In the UK, the results are quite mixed. In the financial sector, equity volatility is the main net transmitter in the banking segment, while, the CDS sector transmits shocks mostly to the other financials and life insurance sub-sectors. In the consumer services and retail sectors, both the CDS and equity volatility play a role spreading shocks into the system. The consumer goods and telecommunications sectors are the main transmitters of volatility, from an equity perspective.

In Japan, all sectors experience an increase in connectedness between equity and CDS spreads volatility, bar the consumer services sector during the crisis period. In the financial sector, the banking equity sector is the major transmitter of volatility during the crisis. In line with US and EU, the consumer services sector has CDS spreads as the main source of volatility, while in a sub-sector environment [other consumer services and retail stores sectors] equity volatility is the main transmitter of volatility. Utility sector is the least connected out of all which is in line with a-priori hypothesis that this sector is insensitive to the economic cycle.

Table 1. Total Connectedness level between assets classes within Regions

	United States		United Kingdom		Europe		Japan	
	Crisis	After-Crisis	Crisis	After-Crisis	Crisis	After-Crisis	Crisis	After-Crisis
Consumer Goods	56.8%	43.2%	34.8%	20.9%	48.5%	43.9%	-	-
Financials	54.3%	35.4%	46.9%	34.0%	55.0%	48.3%	34.9%	20.1%
Consumer Services	58.8%	48.0%	45.7%	42.2%	37.4%	42.3%	50.9%	54.7%
Industrials	51.4%	46.2%	-	-	40.4%	35.8%	33.5%	30.8%
Healthcare	37.8%	29.9%	-	-	-	-	-	-
Oil&Gas	31.6%	27.7%	-	-	7.6%	0.9%	-	-
Basic Materials	31.2%	14.9%	-	-	33.7%	19.7%	30.8%	23.8%
Telecommunications	40.7%	44.8%	47.1%	45.6%	27.8%	28.4%	47.6%	45.1%
Utility	27.4%	25.0%	-	-	0.2%	0.1%	1.7%	0.3%
Information/Data Technology	0.6%	1.7%	-	-	-	-	-	-

5.2 CDS Spreads and Equity Volatility Sectors Connectedness: Across Regions Static Analysis

Looking at regional spillovers, volatility connectedness is very low between the two asset classes across regions. However, a point to note is that connectedness between the two asset classes is higher across all the regions under study in all sectors and sub-sectors, bar for conglomerate diversified and retail sectors during the crisis period as can be evidenced in Table 2. In general, own-volatility shocks are contained compared to the after-crisis period.

In the financial sector, sectoral equity is the main transmitter of volatility, especially the US and UK banking sectors. This is expected for two main reasons; since US banks were at the forefront in the recent financial crises as they spread havoc in the world economy, while the UK is the world financial centre. EU sectoral equity is a net receiver of volatility, especially from the US and the UK. Japan seems to be disconnected as the Japanese region had only been significantly associated with the domestic CDS and equity market, without any association with external sectoral CDS and equity markets. The CDS market for banks is mostly explained by its own shocks in the market. Only the UK and EU markets are moderate net transmitter of volatility and this makes intuitive sense since European banks came under scrutiny during the 2012 EU debt crisis.

In the other financials sector, the UK CDS market is the net transmitter of volatility, affecting the other CDS sectoral markets across all regions. When it comes to equity, there is a mild association between UK and EU, probably due to the economic and political ties these two regions share.

In the consumer goods sector, there is a strong pairwise association between the EU and UK CDS market, while the US CDS market is mainly explained by its own shocks. However, on the equity front all the regions seem to be fairly connected to each other, showing strong contagion effects. A point to note is also the fact that connectedness in this sector is also significant in tranquil periods. This shows that this sector is connected globally through trade ties.

For the consumer services sector, the results are in line with that of the banking sector. From a CDS perspective, markets are quite independent of what happens in other regions, while there is a close association between sectoral equity in the US, EU and the UK. Japan seems to be rather disconnected from the other regions, while US and UK sectoral equity are the main net transmitters of volatility. This is in line with expectations since both economies are dependent on services and the respective equity markets are larger and more liquid than that of their counterparts.

In the metals and mining sector, the US sectoral equity takes a leading role in transmitting volatility. Indeed, shocks in the US equity market affected equity across regions and the Japanese CDS market. Neither shocks in EU nor in the Japanese CDS market contribute to shocks in the US CDS market.

In the telecommunications sector, sectoral equity in the US has been the one which diffused most shocks into the system. US sectoral equity mostly affected the EU and Japanese sectoral equity. In the UK, the telecommunication sector was somewhat insulated from external shocks, as volatility in the CDS and equity sectoral markets are explained by domestic shocks.

Table 2. Total Connectedness level between assets classes across regions

	Crisis	After-Crisis
Leisure	11.0%	5.0%
Industrails	6.5%	6.2%
Oil&Gas	15.8%	4.5%
Cable Media	14.0%	5.0%
Conglomerate/Diversified Mfg	12.1%	11.3%
Other Financials	12.2%	8.5%
Transportation	9.4%	4.7%
Utility	15.1%	3.1%
Other Retail	13.4%	17.9%
Metals&Mining	25.6%	12.1%
Electronics	14.3%	9.5%
Chemicals	20.7%	11.6%
Consumer Goods	38.7%	21.0%
Beverages/Bottling	31.5%	14.9%
Banking	41.2%	20.8%
Consumer Services	32.7%	28.5%
Other Consumer Services	28.4%	20.2%
Financials	30.7%	20.9%
Telecommunications	36.1%	22.8%
Other Telecommunications	34.0%	26.3%

5.3 CDS Spreads and Equity Volatility Sectors Connectedness: Within Regions Dynamic Analysis

As with the case of the static analysis, sectors and sub-sectors are grouped under one sector classification. On average, the equity volatility is the asset class which transmitted volatility the most. The analysis can be made available upon request.

In the US, the sectors included in the analysis are basic materials, consumer goods, consumer services, financials, healthcare, industrials, information technology, oil and gas, telecommunications, and utility. As expected, the connectedness between the two asset classes is predominantly larger during disturbed periods, particularly in the 2009 crisis and the EU sovereign crisis. Regarding oil and gas sector, the connectedness index is higher during the oil price crisis in 2015. Finally, the connectedness in the utility sector is somewhat stable in connectedness after the crisis, in line with expectations, given that this sector volatility is independent of events. In general, the equity sectoral volatility has been the main transmitter of shocks across sectors, which is in line with a-priori expectations, as the US equity market is larger and more liquid than the CDS market.

For the EU region, the sector classifications include basic materials, consumer goods, consumer services, financials, industrials, oil and gas, telecommunications, and utility. The connectedness between the two asset classes in the EU shares some commonalities with the US, in that the association increases during the 2009 financial events. However, as opposed to the US region, connectedness is higher during the EU debt crisis, the Cypriot banking crisis and the Brexit referendum. In general, equity volatility is the asset class which spread shocks the most.

In the UK, the sector classifications include consumer goods, consumer services, financials and telecommunications. In line with the US and EU regions, the connectedness is higher during the main crisis described above together with Brexit. Likewise, in the UK, the equity market transmits volatility the most, bar for the consumer goods sector where the net pairwise volatility spillovers are equal between the two asset classes.

In Japan, the sector classifications include basic materials, consumer services, financials, industrials, telecommunications and utility. The highest connectedness index levels are registered in the financial crisis 2009 and in the aftermath of the natural disasters. Contrary to the other regions, in Japan both equity and CDS spreads volatility are transmitters of volatility. For basic materials and industrials sectors, which are both associated to the manufacturing sector, equity volatility is the main source of shocks. The same argument holds for the consumer services sector. For telecommunications and financials sectors, CDS spreads are key in spreading shocks. Finally, in the utility sector, the transmission of shocks is somewhat balanced between the two asset classes.

5.4 CDS Spreads and Equity Volatility Sectors Connectedness: Across Regions Dynamic Analysis

The dynamic analysis shows strong ties between the two asset classes, as opposed the static one. Connectedness levels are higher during the crisis period, further supporting notion of contagion between the two asset classes.

Looking at the banking sector, connectedness seems high during the crisis period between 2009 and 2011 to ease in the following years, with mild increases in 2016 due to the uncertainty surrounding Brexit and the US presidential election. During the 2009 crisis, the US and UK equity volatility is the main transmitter of shocks into the system in line with the above results. The volatility of EU bank equity is clearly affected by that of US and UK. During the EU debt crisis both EU bank equity and CDS spreads volatility are the main transmitters of volatility as during that period, CDS spreads of banks in the EU have widened and equity volatility increased. During Brexit, as expected equity bank returns are the most volatile and as such UK equity volatility has been the main transmitter of volatility. CDS spreads for the UK banking sector have not instigated any volatility shocks into the system. A plausible explanation could be that the shocks originated from regions most of the banks are domiciled in, like in the US and/or EU.

The sector other financials have the same pattern for total volatility spillovers for the time period under consideration. The connectedness index is highest during crises and in the uncertain period for the UK and US. The volatility in the UK CDS market is the main source of shocks into the system. The UK equity volatility has been also at times a net transmitter of volatility. This could have been because the UK is considered a world financial hub and as such each shock is triggered from this market. A point to note is that CDS volatility contributes to more volatility connectedness in this sector when compared to its equity counterparts.

In the consumer services sector, volatility connectedness is at its highest in the aftermath of the EU debt crisis due to a mild recession. In addition, the index never really decreases both from a sectoral and sub-sectoral perspective. This may be due to the fact that consumer services sector is a cyclical one and moves in accordance to the health of the economy. In both the sector and sub-sector of consumer services, US and UK equity volatility are the main transmitters of volatility, followed by the EU. The Japanese assets classes are somewhat disconnected and absorb shocks the most.

The consumer goods sector shares some commonalities with the banking and other financials sector. Indeed, connectedness levels are highest during the US and EU crisis and during the political uncertainty in the UK and US. As expected, and in line with the above results, the equity asset class has been the main transmitter of volatility particularly during the high levels of connectedness. During tranquil periods, CDS spreads volatility seems to spread shocks across the system, due to perhaps widening and/or narrowing of spreads in re-assessing risk. The beverages sub-sector has somewhat the same total volatility spillovers pattern, showing that the sub-sector closely follows the main sector, that is, consumer goods. Looking at the net pairwise volatility spillovers, the US and UK CDS spreads and equity volatility generate shocks which are predominantly absorbed by the EU asset classes. In addition, in the equity segment, the spreading of shocks is more evident than in the CDS market, being more liquid and larger.

The industrials sector registers high levels of connectedness during the financial crisis of 2009. This makes intuitive sense as industrials sector is one of the hardest-hit sectors during the recession. The US equity is the principal source of volatility into the sector followed by US CDS spreads. Japanese equity transmits most of the volatility during the US crisis which is in line with expectations given that the domestic economy heavily depends on this sector. Volatility in the main sector produced a domino effect which negatively affects sub-sectors like electronics. The sub-sectors share the pattern for total volatility spillovers. Again, the equity asset class is dominant over the CDS market, with the US and Japanese equity volatility being the focal transmitters of volatility shocks.

In line with the above results, connectedness levels in the chemical sector are higher during 2011 and 2012. A plausible explanation can be that the nuclear disaster in Japan has affected CDS spreads and equity volatility across other regions. Indeed, Japanese equity and CDS spreads are net transmitters of volatility in this period to their US and EU counterparts. For the period under consideration, equity volatility in the US chemical sector has been on average the key transmitter of volatility.

Looking at the commodity sector, the metals and mining sub-sector registers the highest level between the two asset classes during the 2009 crisis. US and Japanese equity volatility are the main transmitters of shocks. The oil and gas sub-sector connectedness is high during the financial events described above. In addition, during the year 2016, the connectedness between the two asset classes have risen to more than 25%, following the oil price crisis. In this sub-sector, CDS is the asset class which spreads volatility shocks the most, particularly in the EU market. During the oil price crisis, CDS spreads are the main transmitter of volatility. A plausible reason may be that market participants wanted to hedge against a fall in oil price through CDS contracts with the consequence of affect spreads. Another sector where CDS market is the main transmitter of volatility is the telecommunications sector and its sub-sector other telecommunications.

The retail sector has a volatile connectedness index, which is in line with expectations as it is a cyclical sector. In addition, this also shows that for this sector both asset classes tend to move together, that is, negative equity returns are synonymous with spread widening. Regarding net pairwise volatility spillovers, equity is the main source of shocks, particularly from the US and the UK, wherein this sector is a major contributor to the economy.

Finally, total volatility spillovers for the utility sector seem to be erratic as it does not have any commonalities with the other sectors, which makes the sector independent of the economic cycle. Shocks are mostly transmitted by the equity sector, particularly that of the US.

6. Conclusion

The domestic and regional analyses show that connectedness between CDS Spreads and equity volatility is in general higher during the crisis period. This shows that when the two asset classes are in distress there is more tendency to exhibit parallel behaviour, exacerbating shocks between the two, thereby suggesting contagion effects between the two asset classes within regions. Although the static Gaussian results for the regional analysis shows low levels of connectedness across the board, the dynamic analysis, using a rolling-period sample, shows significant connectedness levels, with levels being predominantly higher during the crisis period, signifying contagion effects also at regional level between the two asset classes. This is in line with Merton (1974) in that equity and credit spreads should move in parallel in troubled times.

When considering the dynamic volatility connectedness between the two asset classes, equity is the asset class which transmits volatility the most. In the US and EU connectedness between the two asset classes is predominantly large during disturbed periods, particularly the 2009 crisis and the EU sovereign crisis. The connectedness between the two asset classes is also high during the global financial crisis and the EU debt crisis but also in the aftermath of Brexit. In Japan, the highest connectedness index levels between the two asset classes are registered in the financial crisis 2009 and in the aftermath of the natural disasters. Contrary to the other regions wherein equity volatility is the main transmitter of shocks, in Japan both equity and CDS spreads volatility are transmitters of shocks.

The findings provide insight to portfolio and risk managers in showing that the CDS spreads and equity volatility is connected in distressed periods, therefore, diversification benefits, of having the two asset classes in the portfolio, are somewhat limited. In addition, it is pertinent to note that the equity market is more of a net transmitter, than CDS spreads which means that shocks in the equity market propagate in the CDS market, limiting any hedges taken by entering in CDSs.

References

Acharya, V. V., & Johnson, T. C. (2007). Insider-trading in Credit Derivatives. *Journal of Financial Economics*, *84*(1), 110-141. https://doi.org/10.1016/j.jfineco.2006.05.003

Ballester, L., & Urteaga, A. G. (2020). Is There a Connection between Sovereign CDS Spreads and the Stock Market? Evidence for European and US Returns and Volatilities. *Mathematics*, *8*(10), 1667. https://doi.org/10.3390/math8101667

Belke, A., & Gokus, C. (2011). *Volatility Patterns of CDS, Bond and Stock Markets Before and During the Financial Crisis: Evidence from Major Financial Institutions*. Ruhr Economic Papers 243, RWI - Leibniz-Institut für Wirtschaftsforschung, Ruhr-University Bochum, TU Dortmund University, University of Duisburg-Essen. https://doi.org/10.5539/ijef.v6n7p53.

Berndt, A., & Ostrovnaya, A. (2008). *Do Equity Markets favor Credit Market News over Options Market News?* Carnegie Mellon University, Pittsburgh, USA Working Paper. https://doi.org/10.1142/S2010139214500062

Black, F., & Scholes, M. S. (1973). The Pricing of Options and Corporate Liabilities. *Journal of Political Economy*, *81*(3), 637-654. https://doi.org/10.1086/260062

Consigli, G. (2004). *Credit Default Swaps and Equity Volatility: Theoretical Modeling and Market Evidence*. Workshop on Portfolio optimisation and option pricing Department of Applied Mathematics, University Ca'Foscari, Venice.

Diebold, F. X., & Yilmaz, K. (2014). On the Network Topology of Variance Decompositions: Measuring the Connectedness of Financial Firms. *Journal of Econometrics*, *182*(1), 119-134.

https://doi.org/10.1016/j.jeconom.2014.04.012

Forte, S., & Lovreta, L. (2009). *Credit Risk Discovery in the Stock and CDS Markets: Who Leads, When, and Why*. https://doi.org/10.2139/ssrn.1183202

Forte, S., & Pena, J. I. (2009). Credit Spreads: An Empirical Analysis on the Informational Content of Stocks, Bonds, and CDS. *Journal of Banking and Finance, 33*(11), 2013-2025. https://doi.org/10.1016/j.jbankfin.2009.04.015.

Fung, H. G., Sierra, G. E., Yau, J., & Zhang, G. (2008). Are the U.S. Stock Market and Credit Default Swap Market Related? Evidence from the CDX Indices. *Journal of Alternative Investments, 11*(1), 43-61. https://doi.org/10.3905/jai.2008.708849.

Kajurová, V. (2015). The Determinants of CDS Spreads: The Case of UK Companies. *Procedia Economics and Finance, 23*, 1302-1307. https://doi.org/10.1016/S2212-5671(15)00433-5.

Lake, A., Apergis, N., 2009. *Credit Default Swaps and Stock Prices: Further Evidence within and Across Markets from Mean and Volatility Transmission with a MVGARCH-M Model and Newer Data*. https://doi.org/10.2139/ssrn.1330011

Longstaff, F. A., Mithal, S., & Neis, E. (2003). *The Credit Default Swap Market: Is Credit Protection Priced Correctly?* Working paper, Anderson School, UCLA, August.

Mateev, M. (2019). Volatility Relation between Credit Default Swap and Stock Market: New Empirical Tests. *Journal of Economics and Finance, 43*(4), 681-712. https://doi.org/10.1007/s12197-018-9467-5

Mateev, M., & Marinova, E. (2019). Relation between Credit Default Swap Spreads and Stock Prices: A Non-linear Perspective. *Journal of Economics and Finance, 43*(1), 1-26. https://doi.org/10.1007/s12197-017-9423-9

Meng, L., Gwilym, O., & Varas, J. (2009). Volatility Transmission among the CDS, Equity, and Bond Markets. *Journal of Fixed Income, 18*(3), 33-46. https://doi.org/10.3905/JFI.2009.18.3.033

Merton, R. C. (1974). On the Pricing of Corporate Debt: The Risk Structure of Interest Rates. *Journal of Finance*, *29*(2), 449-470. https://doi.org/10.2307/2978814.

Narayan, P. K. (2015). An Analysis of Sectoral Equity and CDS Spreads. *Journal of International Financial Markets, Institutions and Money, 34*(C), 80-93. https://doi.org/10.1016/j.intfin.2014.10.004.

Narayan, P., Sharma, S., & Thuraisamy, K. (2014). An Analysis of Price Discovery from Panel Data Models of CDS and Equity Returns. *Journal of Banking & Finance, 41*(1), 167-177. https://doi.org/10.1016/j.jbankfin.2014.01.008

Ratner, M., & Chiu, C. C. (2013). Hedging Stock Sector Risk with Credit Default Swaps. *International Review of Financial Analysis, 30*, 18-25. https://doi.org/10.1016/j.irfa.2013.05.001.

Trutwein, P., & Schiereck, D. (2011). The Fast and the Furious--Stock Returns and CDS of Financial Institutions Under Stress. *Journal of International Financial Markets, Institutions and Money, 21*(2), 157-175. https://doi.org/10.1016/j.intfin.2010.10.003

Zhang, G. (2005). *Intra-Industry Credit Contagion: Evidence from the Credit Default Swap Market and the Stock Market*. EFMA 2004 Basel Meetings Paper. https://doi.org/10.2139/ssrn.492682

Zhang,Y. B., Zhou, H., & Zhu, H. (2009). Explaining Credit Default Swap Spreads with the Equity Volatility and Jump Risks of Individual Firms. *The Review of Financial Studies, 22*(12), 5099-5131. https://doi.org/10.1093/rfs/hhp004

Note

Note 1. The dynamic analysis can be made available upon request.

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