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Revealing Volatility Spillover Effects Between CDS Premiums and Equity Markets in Developed and Developing Countries: VAR-BEKK-GARCH Model Approach

Ülke CDS Primi ile Hisse Senedi Piyasası Arasındaki Oynaklık Yayılımları Gelişmiş ve Gelişmekte Olan Ülkelerde Farklılaşmakta mıdır? VAR-BEKK-GARCH Modeli Yaklaşımı

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ABSTRACT

This study aims to analyze volatility spillover effects between stock and sovereign credit default swap (CDS) markets by adopting the VAR-BEKK-GARCH(1,1) model. The research questions can be expressed as follows. Does a significant volatility spillover exist between equity and CDS markets? Does a difference in volatility spillovers occur between developed and developing countries? Do the correlations between the stock market and CDS market differ in developed and developing countries? The empirical findings demonstrate a weak cross-market spillover between the stock and CDS markets. In other words, the volatility observed in the stock and CDS markets is subject to past shocks more than cross-market spillovers. The lagged volatility in both stock and CDS markets has a substantial effect on the current period conditional volatility. In addition, no volatility spillovers were detected from the CDS market to the stock market. The information outflow about financial markets is priced initially in the stock market and then gets reflected onto the CDS market. The correlations and covariance relationships between CDS premiums and stock indices change over time. The correlations and covariance relationships show significant changes during periods of financial turmoil.

JEL Classification: C58; G15

Keywords: Credit Default Swaps, Stock Market, Volatility Spillover, VAR-BEKK-GARCH(1, 1) Model

ÖZ

Bu çalışmada hisse senedi ve CDS (Kredi Temerrüt Swapı) piyasaları arasındaki oynaklık yayılımı etkileri VAR-BEKK-GARCH(1,1) modeli ile analiz edilmektedir. Piyasalar arasında yayılma etkisi olup olmadığı, varsa gelişmiş ve gelişmekte olan ülkelerde bu etkilerin farklılaşıp farklılaşmadığı ve piyasalar arasındaki korelasyon ilişkileri incelenmiştir. Genel olarak hisse senedi ve CDS piyasaları arasında çapraz şok geçişgenliğinin zayıf olduğu tespit edilmiştir. Yani hisse senedi ve CDS piyasasında gözlemlenen oynaklık, çapraz şok geçişlerinden ziyade kendi geçmiş dönem şoklarından kaynaklanmaktadır. Hem hisse senedi hem de CDS piyasasındaki geçmiş dönem oynaklığının cari dönem koşullu oynaklığı üzerinde etkili olduğu anlaşılmaktadır. Ayrıca, genel olarak CDS piyasasından hisse senetleri piyasasına oynaklık yayılımı olmadığı tespit edilmiştir. Finansal piyasalarla ilgili haber akışı öncelikle hisse senedi piyasasında fiyatlanmakta, ardından CDS piyasasına yansımaktadır. CDS primleri ile hisse senedi endeksleri arasındaki korelasyon ve kovaryans ilişkileri zamana bağlı olarak değişim göstermektedir. Korelasyon ve kovaryans ilişkilerinin finansal piyasalarda stres seviyesinin arttığı dönemlerde önemli değişimler gösterdiği gözlenmiştir.

JEL Sınıflandırması: C58; G15

Anahtar Kelimeler: Kredi Temerrüt Swapı, Hisse Senedi Piyasası, Oynaklık Yayılımı, VAR-BEKK-GARCH(1, 1) Modeli

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Introduction

Country risk is a well-known and prevalent risk factor on pricing behaviors in stock markets. Since the seminal work of Merton (1974), a substantial empirical literature has emerged examining the bilateral relationship between firm value and credit risk. The liberalization of capital movements and the principle of international diversification, which investors are increasingly adopting has made country risk a followed indicator in asset allocation, portfolio selection, and risk management decisions. The exclusive dynamics of developing countries make this risk factor even more important for local and international investors, because the performance of companies invested in such countries is more closely related to macroeconomic factors compared to developed countries.

In the case of Turkey as an emerging market, I believe country risk has a relatively greater effect on stock prices. As a matter of fact, credit default swaps (CDS), which can be considered a complex instrument for ordinary people and one of the determinants of country risk, are observed to be on the agenda of investors, and changes in CDS premiums as a result of adverse events are followed by a substantial part of society. The fact that country CDS premiums, which are not followed extensively by investors in other markets, are unusually popular in Turkey is remarkable.

When generally evaluating the literature on CDS markets, one will realize the relative scarcity with which the relationships between the CDS market and the stock market have been examined. In addition, most research has focused on developed countries, and I realized that the required concern has not been given to developing countries in the literature, especially to the Turkish market. Previous studies have inferred the dynamics between the CDS market and the stock market to show remarkable differences between developed and developing countries. Revealing these dynamics will have crucial implications for both investors and policymakers. This study aims to fill this gap and provide up-to-date empirical findings on the nexus, inclusive of the Turkish market.

The CDS contracts that emerged in the late 1990s reflect how market participants perceive the financial situation of the issuing company or government. CDS premiums have become an important indicator that investors follow, especially after the European debt crisis and the global financial crisis, and have also become an indicator of country risk (Badaoui et al., 2013). The phenomenon of volatility spillover between stocks and CDS markets in emerging markets where country risk remains vital shows asset allocation, risk management, and construction of efficient portfolios to have critical relevance for investor decisions. In times of turbulent market conditions, volatility in financial markets increases. The predictability of the effects of volatility on financial markets is an essential factor that regulatory agencies should take into account in their policy decisions.

This study aims to reveal the volatility spillover effects between stock and CDS markets by employing the VAR-BEKK-GARCH(1,1) methodology. The main purpose of the research is to determine whether volatility spillover occurs between the markets and whether spillover effects differ between developed and developing countries, as well as to reveal the correlations between the CDS and stock markets. The research questions can be expressed as follows. Does a statistically significant volatility spillover exist between equity and CDS markets? If so, does a difference exist in volatility spillovers between developed and developing countries? In other words, does country risk exhibit different pricing behaviors in developed and developing markets? Do the correlations between the stock market and CDS market differ in developed and developing countries?

Section 2 of the study will review the literature related to the subject and summarize the findings obtained in previous studies. Section 3 introduces the dataset and includes visual graphics and descriptive statistics related to the data that are used. Section 4 of the study is devoted to the introduction of the econometric methodology employed. In Section 5, I present the empirical findings and the interpretations, with Section 6 finishing up by providing conclusions and recommendations.

Literature

Merton (1974)'s seminal work played a pioneering role in developing the literature on credit risk pricing. Many researchers after Merton continued to work on issues related to such things as the term structure of interest rates, corporate defaults, and firm value. Defining credit risk as the difference between bond yields and the risk-free rate, Collin-Dufresne et al. (2001) revealed CDS premiums to be a more convenient indicator of credit risk, as well as studies such as Campbell and Taksler (2003), Blanco et al. (2005), and Ericsson et al. (2009). As a matter of fact, recent studies have used CDS premiums more extensively as a credit risk indicator.

Norden and Weber (2009), Blanco et al. (2005), and Zhang et al. (2009) examined the relationships between CDS premiums and stock returns. According to these studies' findings, changes in stock returns lead to adjustments in CDS and bond premiums. The CDS market has been claimed to be more sensitive than the stock market and co-movements to increase in companies with low credibility and high bond issuance. The CDS market has also been concluded to lead the pricing of credit risk more than the bond market and price discovery to occur in the CDS market. The source of the volatility observed in CDS premiums has additionally been revealed to be caused by changes in stock returns.

Recent studies have had a greater interest in sovereign CDS compared to corporate CDS due to the outcomes from the global financial crisis and the European debt crisis. Blommestein et al. (2016) and Ho (2016) focused on the determinants of CDS premiums. According to their studies, balance of payments, external debt, and international reserves are explanatory variables with regard to sovereign CDS premiums. The positive long-term effect of international reserves on CDS premiums is greater than balance of payments. In addition, the financial stress that occurred in international financial markets as well as the contagion effects and the decisions taken by the European monetary union have been demonstrated to be more influential on CDS premiums.

Pavlova et al. (2018), Cheuathonghua et al. (2022), and Feng et al. (2021) examined the volatility spillover between the CDS market and other financial markets. Feng et al. (2021) determined a significant correlation and volatility spillovers to exist between the CDS market and exchange rate markets and demonstrated these effects to be dynamic. The spillover effect from the exchange rate market to the CDS market is stronger than the spillover effects from the CDS market to the exchange rates. Pavlova et al. (2018) examined spillovers between the oil market and the CDS market. According to their study, significant spillovers were observed from oil prices to CDS premiums. These effects are particularly evident in oil-exporting countries such as Venezuela, Colombia, Russia, and Mexico. Meanwhile, Cheuathonghua et al. (2022) examined the spillover effects between commodity indices and the CDS market. Commodity exports significantly affect the volatility in CDS premiums. However, they found that effect of CDS premium volatility on commodity indices' volatility to be insignificant.

Mateev (2019) analyzed the relationship between CDS premiums and stock returns of 109 investment-grade companies in the European Union region using the dynamic conditional correlation (DCC) model and the BEKK-GARCH model. That research covered the period between 2012-2016, and the dataset consisted of daily observations. According to that study, the covariance relationships and correlations between CDS and stock markets change over time, revealing a bidirectional volatility spillover to be present between the markets.

Da Fonseca and Gottschalk (2020) examined the co-movements and interactions between CDS and stock markets in their sample of four countries (i.e., Australia, Japan, Korea and Hong Kong) in the Asia-Pacific region using a vector autoregression (VAR) model. They performed econometric analyses at both the stock and index level, examining a total of 85 stocks from four countries. According to the lead-lag analysis findings, stock returns lead to changes in CDS premiums (lead role). According to the results from Diebold and Yılmaz's (2014) model, realized volatility measured at the firm level and implied volatility measured at the index level are the main sources of intermarket volatility spillover.

Fei et al. (2017) analyzed the relationship between the iTraxx Europe, iTraxx Europe Autos, and iTraxx Europe Subordinated Financials CDS indices and the Dow Jones Stoxx Europe 600, Stoxx Europe 600 Financials, and Stoxx Europe 600 Automobiles & Parts stock indices using the Markov switching model. Their analysis period covered the years 2005-2011, with their data set consists of 1,308 daily observations. According to their empirical findings, a significant negative relationship exists between CDS premiums and stock indices. They also showed that this relationship changes over time and has a nonlinear feature.

Ibhagui (2021) analyzed the interactions among the CDS, stock, and cross-currency basis swap (CCBS) markets using the VAR model. That analysis period covered the years 2008-2019. In the study, CDS premiums and stock index returns (FTSER 100, Euro Stoxx 50, Nikkei 225, and S&P/ASX 200) and CCBS series with a daily frequency (2,826 observations) were used in the UK, Japan, Australia, and Eurozone. According to Ibhagui's findings, a feedback mechanism exists that provides interaction between the markets, with an increase in CDS premiums causing a decrease in CCBS premiums and stock index returns. Positive shocks in CCBS premiums also reduced CDS premiums and increased stock index returns. Positive shocks in the stock market index returns caused a decrease in both CCBS and CDS premiums.

Sun et al. (2020) examines volatility spillover among the CDS, stock, oil, and gold markets in six developed and five developing countries. They adopted the VAR-based forecast error variance decomposition method introduced by Diebold and Yılmaz (2009, 2012). Their analysis period covered May 2009-December 2017. According to their study's findings, the average spillover effects from the CDS market to the stock market in developing countries are greater than in developed countries. However, the average spillover effects from stock markets to CDS markets are stronger in developed countries. Economic or financial developments, which have a significant impact on the total spillover index, significantly change the effects of inter-market spillovers, with the stock market generally having a dominant character. However, CDS and commodity markets also occasionally become dominant.

Da Fonseca and Wang (2016) analyzed the interactions between two CDS indices (the S&P 500 and fear index [CBOE Volatility Index, or VIX]) using a VAR and Markov switching VAR model. Their research covered the years 2004-2012, with data being used at a weekly frequency. According to their empirical findings, structural changes in the relationships between the markets showed the characteristics of a two-regime Markov process. A shock that occurred in the CDS market affected other markets simultaneously, but shocks that occurred in other markets did not affect the CDS market to the same extent. As volatility increased in money markets, volatility in other markets also tended to increase.

To evaluate the literature on CDS premiums in general, the interactions between the CDS market and the stock market can be concluded as having been less studied. In addition, most of the studies focused on developed countries, with the case of developing countries and Turkey in particular not being given their due importance. The findings in the literature indicate the dynamics between the CDS market and the stock market to be able to differ considerably in developed and developing countries. Revealing these dynamics will have important implications for both investors and policymakers. As such, this study aims to fill this gap and provide an up-to-date perspective on the subject and includes the case of Turkey.

Data Set

This study analyzes the benchmark stock market indices and sovereign CDS premiums of developed and developing countries. Developed markets are represented by the G7 countries, and emerging markets are represented by the BRICS+T countries. The G7 countries are Germany, the United States (USA), the United Kingdom (UK), France, Italy, Japan, and Canada. The BIRCS+T countries consist of Brazil, Russia, India, China, South Africa, and Turkey. The local currency benchmark stock indices are used for each country. The analysis period covers the period of 9/30/2011-9/30/2021, with the data set consisting of 2,610 daily observations. All the data were compiled from Thomson Reuters DataStream.

The following indices represent the benchmark stock market indices in their respective developed countries: USA - S&P500, Germany - DAX, UK - FTSE100, France - SBF120, Italy - FTSE MIB, and Japan - Nikkei 225 index. For emerging markets, BOVESPA, MOEX, Shanghai SE A Share, FTSE JSE All Share, and BIST100 respectively represent the benchmark stock market indices for Brazil, Russia, China, South Africa, and Turkey. Daily closing prices of all CDS premiums and stock indices were used. CDS premiums consist of benchmark series with a maturity of 5 years, calculated based on the US dollar. Canada and India were excluded from the analysis due to missing values. All series have been converted into logarithmic return series using the following equation:

$$R_{i,t} = 100 * log\left(\frac{P_{i,t}}{P_{i,(t-1)}}\right) \tag{1}$$

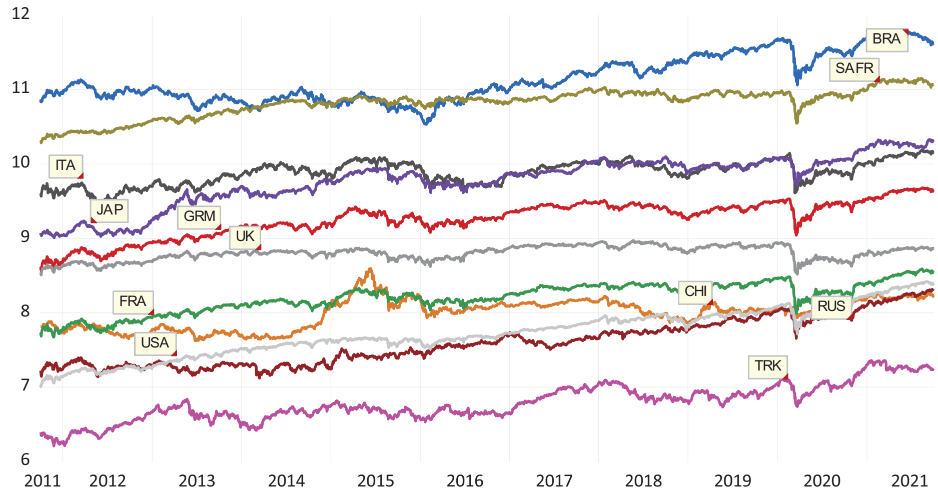

Figure 1.
Benchmark Indices.
Note: *Series are shown in logarithmic form. GER: Germany, USA: United States, UK: United Kingdom, FRA: France, ITA: Italy, JAP: Japan, BRA: Brazil, RUS: Russia, CHI: China, SAFR: South Africa, TUR: Turkey.*

where $P_{i,t} =$ daily closing price of series *i* on day *t* and $R_{i,t} =$ the return from series *i* on day *t*.

Figure 1 presents the time series of the nominal benchmark stock indices. The co-movements between the indices are quite remarkable. Along with the fluctuations in 2015-2016, the price movements experienced in March 2020 from the COVID-19 pandemic affected all markets in a similar way. CDS premium time series are presented in Figure 2. The first striking point in CDS premiums is that the series have quite sharp fluctuations. In addition, the G7 and BRICS+T countries, which were very close to each other in terms of level in 2011-2012, have recently and note worthily diverged quite significantly. In addition, the CDS premiums of G7 countries follow a clear downward trend.

Table 1 presents the descriptive statistics. The mean for the benchmark stock index returns varies between 1.24% and 5.12%. The standard deviation of change in stock indices varies between 0.98 and 1.56. Due to the stock indices being expressed in local currency, inter-country comparisons will not yield reliable results with the current data. CDS premiums are in a downward trend for most countries. Thus, the average returns are seen to have negative values. In addition, the CDS series are clearly understood from the standard deviation values to show much higher volatility compared to stock indices. The skewness coefficients for the stock indices have negative values, which is expected. In other words, the variables are skewed to the left. For the CDS series, skewness values are positive and generally greater than 1. This indicates the CDS series are skewed to the right. The kurtosis values were calculated to have positive values in all series. The series has a steeper curve than the normal distribution, meaning they are leptokurtic. The kurtosis and skewness values are confirmed by the Jarque-Bera statistics, and the series is observed to not follow a normal distribution.

Methodology

VAR-BEKK-GARCH(1,1) model

Volatility and correlation analyses are among the research methods frequently used in the literature on portfolio theory. In particular, the autoregressive conditional heteroskedasticity (ARCH) family of variance models have significant advantages

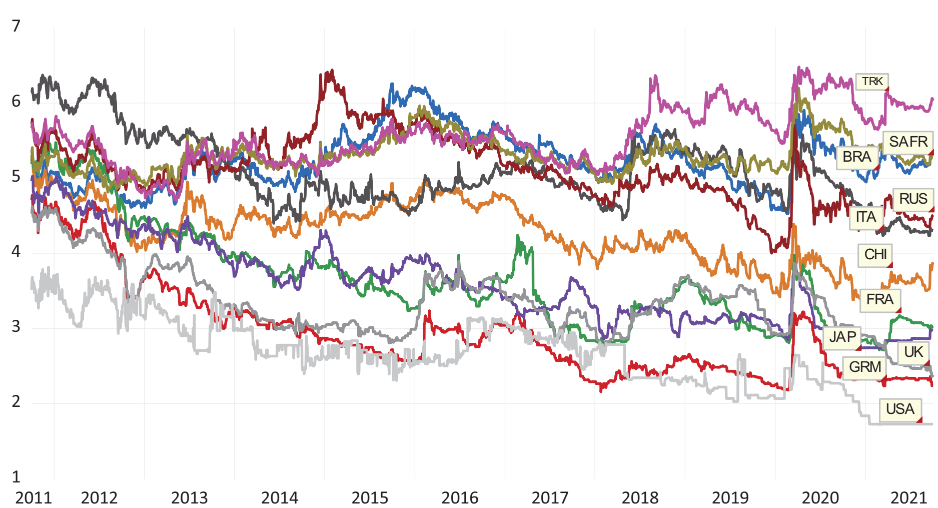

Figure 2.
CDS Premiums.
Note: *Series are shown in logarithmic form.*

Table 1.
Descriptive Statistics

		Mean	SD	Skewness	Kurtosis	J-B	Probability
GER	Index	.0391	1.2303	-.5596	12.6304	10218.34	.0000
	CDS	-.0948	2.4936	1.0889	25.8268	57159.46	.0000
USA	Index	.0512	1.0396	-.9219	23.9113	47905.84	.0000
	CDS	-.0684	6.5010	.3167	18.7104	26874.53	.0000
UK	Index	.0124	.9897	-.7738	15.8300	18154.62	.0000
	CDS	-.0824	2.4213	1.7221	30.9874	86440.11	.0000
FRA	Index	.0309	1.1870	-.7645	13.7895	12909.19	.0000
	CDS	-.0838	2.8939	.1395	60.6137	360847.60	.0000
ITA	Index	.0210	1.5179	-1.1892	16.6606	20901.25	.0000
	CDS	-.0708	3.3379	1.0253	18.9335	28055.68	.0000
JAP	Index	.0467	1.2679	-.2682	7.8357	2573.29	.0000
	CDS	-.0761	2.3957	1.2159	20.9872	35814.11	.0000
BRA	Index	.0288	1.5648	-.8793	16.3308	19654.64	.0000
	CDS	.0017	3.3188	.7396	15.5081	17245.67	.0000
RUS	Index	.0421	1.1646	-.8192	12.3913	9879.50	.0000
	CDS	-.0473	3.6103	1.0862	18.5340	26744.75	.0000
CHI	Index	.0159	1.2939	-1.0051	10.6520	6804.55	.0000
	CDS	-.0529	3.1912	.6757	12.1793	9358.28	.0000
SAFR	Index	.0296	1.0368	-.7570	12.4625	9982.91	.0000
	CDS	.0004	2.7925	.4616	8.4891	3368.02	.0000
TUR	Index	.0328	1.3755	-.7527	8.3948	3410.15	.0000
	CDS	.0148	3.0529	1.6031	21.5889	38681.39	.0000

Note: The series covers the time period between 9/30/2011-9/30/2021 (2,610 daily observations) and are shown as logarithmic return series. GER = Germany, USA = United States, UK = United Kingdom, FRA = France, ITA = Italy, JAP = Japan, BRA = Brazil, RUS = Russia, CHI = China, SAFR = South Africa, and TUR = Turkey.

in modeling financial time series, and this has paved the way for researchers to prefer these models more. The most important reason why multivariate generalized autoregressive conditional heteroskedasticity (MGARCH) models are preferred, especially in studies investigating the effects of volatility spillovers, is that these models allow the size and sources of spillover effects to be clearly seen (Liu et al., 2017).

As the first MGARCH model, the VECH specification was developed by Bollerslev et al. (1988). Although this model allows volatility and conditional variance to be modeled together, it has significant practical difficulties due to the high parameter estimation requirements. In order to eliminate this difficulty, the BEKK model was developed by Baba, Engle, Kraft, and Kroner (Engle and Kroner, 1995). This model is essentially a specialized version of the VECH model that requires less parameter estimations and ensures a positive estimated covariance matrix. Contrary to the constant conditional correlation (CCC) model developed by Bollerslev (1990), the model that allows conditional correlations to change over time provides a more convenient analysis framework for detecting volatility spillover effects.

I preferred the bivariate BEKK-GARCH(1,1) model for analyzing the volatility spillover effects in present study. Developed by Engle and Kroner (1995), this model has been widely used over a large body of literature (Wen et al., 2020; Belhassine, 2020; Baklacı et al., 2020) for analyzing volatility spillover effects. The VAR-BEKK-GARCH(1,1) approach combines the VAR and BEKK-GARCH models. Thus, volatility spillovers, conditional correlations, and conditional covariances between benchmark stock indices and CDS premiums can be analyzed.

In the VAR model, all variables are considered endogenous, and a system of equations is defined by using the lagged values of the variables. A VAR(k) model can be represented as:

$$R_{1,t} = \mu_1 + \sum_{i=1}^{k} \gamma_{1,i} R_{1,t-i} + \sum_{i=1}^{k} \theta_{1,i} R_{2,t-i} + \varepsilon_{1,i} \tag{2}$$

$$R_{2,t} = \mu_2 + \sum_{i=1}^{k} \gamma_{2,i} R_{1,t-i} + \sum_{i=1}^{k} \theta_{2,i} R_{2,t-i} + \varepsilon_{2,i} \tag{3}$$

where $\gamma_{1,i}$, $\theta_{1,i}$, $\gamma_{2,i}$, and $\theta_{2,i}$ are estimated coefficients; $\varepsilon_{1,i}$ and $\varepsilon_{2,i}$ represent the error terms; and *K* indicates the lag length. The lag length in VAR models is determined according to the final prediction error (FPE), Akaike (AIC), Schwarz (SC), and Hannan-Quinn information criteria.

The BEKK-GARCH model assumes the mean-variance model to satisfy the following condition:

$$\varepsilon_t / I_{t-1} \sim N\left(0, H_t\right), H_t = \begin{vmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{vmatrix} \tag{4}$$

where, $\varepsilon_t = [\varepsilon_{1,t}, \varepsilon_{2,t}]'$ represents the error terms obtained from the VAR model, and I_{t-1} represents the information reached in the market at time $t-1$.

The conditional variance equation of the BEKK-GARCH(1,1) model can be written as:

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon_{t-1}' + B'H_{t-1}B \tag{5}$$

where H is the conditional variance-covariance matrix of error terms, C is the constant coefficient matrix, A is the $(2x2)$ ARCH parameters matrix, and B is the $(2x2)$ GARCH parameters matrix. The diagonal ARCH parameters $(\alpha_{11}\ and\ \alpha_{22})$ show the effect from past shocks in the relevant market on the current period conditional volatility, and the parameters α_{12} and α_{21} show the effect from the past shock that emerged in one market on the current period conditional volatility of the other market. The diagonal GARCH parameters $(\beta_{11}$ and $\beta_{22})$ express the effect from past period volatility on current period conditional volatility in the relevant market and volatility persistence, while the parameters β_{12} and β_{21} express the volatility spillover effect between markets. If both parameters α_{12} and α_{21} are statistically significant, this means a cross-shock transition occurs between the markets, and if β_{12} and β_{21} are both significant, this means a bidirectional volatility spillover occurs. In the literature, statistically significant ARCH parameters are interpreted as short-term persistence, while statistically significant GARCH parameters are interpreted as long-term persistence. GARCH parameters calculated at a level higher than ARCH parameters mean that past period volatility has a stronger effect on current period conditional volatility compared to ARCH effects.

The expression of the conditional variance equation in matrix form for the BEKK-GARCH(1,1) model is as follows:

$$h_t = C_0'C_0 + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}, \varepsilon_{2,t-1} \\ \varepsilon_{1,t-1}, \varepsilon_{2,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix}' H_{t-1} \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \tag{6}$$

Empirical Findings

The unit root test findings for the benchmark stock indices and CDS premium series are presented in Tables 2 and 3. According to the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, no unit root is present in the logarithmic return series.

Table 2.
Unit Root and ARCH-LM Test Statistics of Benchmark Indices

		ADF Test		PP Test		ARCH LM Test	
		T Statistics	Prob.	T Statistics	Prob.	F Statistics	Prob.
G7 Countries							
GER	C	-51.5315	.0001	-51.5323	.0001	66.5231	.0000
	C+Trend	-51.5346	.0000	-51.5362	.0000		
USA	C	-16.5875	.0000	-59.8614	.0001	244.1489	.0000
	C+Trend	-16.5842	.0000	-59.8514	.0000		
UK	C	-51.6967	.0001	-51.7436	.0001	105.9872	.0000
	C+Trend	-51.6969	.0000	-51.7465	.0000		
FRA	C	-51.1872	.0001	-51.2003	.0001	95.1747	.0000
	C+Trend	-51.1813	.0000	-51.1946	.0000		
ITA	C	-35.6971	.0000	-54.9451	.0001	51.0140	.0000
	C+Trend	-35.6905	.0000	-54.9346	.0000		
JAP	C	-34.7941	.0000	-53.4961	.0001	40.3147	.0000
	C+Trend	-34.7945	.0000	-53.4918	.0000		
BRICS+T Countries							
BRA	C	-56.9653	.0001	-56.6848	.0001	227.3336	.0000
	C+Trend	-56.9580	.0000	-56.6788	.0000		
RUS	C	-51.9414	.0001	-51.9377	.0001	29.5047	.0000
	C+Trend	-51.9494	.0000	-51.9482	.0000		
CHI	C	-49.4012	.0001	-49.4438	.0001	69.9802	.0000
	C+Trend	-49.3920	.0000	-49.4347	.0000		
SAFR	C	-52.6927	.0001	-52.7105	.0001	268.7116	.0000
	C+Trend	-52.6981	.0000	-52.7198	.0000		
TUR	C	-52.1119	.0001	-52.1205	.0001	16.7620	.0000
	C+Trend	-52.1025	.0000	-52.1115	.0000		

Note: In the ADF unit root tests, the lag length was chosen as 27 according to the Schwarz criterion. In the PP test, the bandwidth was determined as 8 according to the Newey-West method. The null hypothesis in the ARCH LM test is that no ARCH effect is present. The test was performed using 5 lag lengths for models estimated with the AR(1) model. Augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) tests.

Table 3.
Unit Root and ARCH-LM Test Statistics of CDS Premiums

		ADF Test		PP Test		ARCH LM Test	
		T Statistics	Prob.	T Statistics		T Statistics	Prob.
G7 Countries							
GER	C	-26.0712	.0000	-48.7997	.0001	28.8114	.0000
	C+Trend	-26.1001	.0000	-48.7923	.0000		
USA	C	-47.0663	.0001	-84.7727	.0001	19.6001	.0000
	C+Trend	-47.0573	.0000	-84.7518	.0001		
UK	C	-33.0148	.0000	-50.2016	.0001	17.6071	.0000
	C+Trend	-33.0119	.0000	-50.1922	.0000		
FRA	C	-32.0735	.0000	-46.4036	.0001	6.4522	.0000
	C+Trend	-32.0892	.0000	-46.3983	.0000		
ITA	C	-46.4773	.0001	-46.5017	.0001	46.0230	.0000
	C+Trend	-46.4696	.0000	-46.4937	.0000		
JAP	C	-25.5215	.0000	-46.7525	.0001	38.8757	.0000
	C+Trend	-25.5376	.0000	-46.6843	.0000		
BRICS+T Countries							
BRA	C	-46.5549	.0001	-46.4396	.0001	159.7881	.0000
	C+Trend	-46.5462	.0000	-46.4307	.0000		
RUS	C	-47.8137	.0001	-47.9403	.0001	110.6900	.0000
	C+Trend	-47.8045	.0000	-47.9314	.0000		
CHI	C	-47.4015	.0001	-47.2731	.0001	57.7972	.0000
	C+Trend	-47.3999	.0000	-47.2714	.0000		
SAFR	C	-46.7513	.0001	-46.5712	.0001	54.1078	.0000
	C+Trend	-46.7425	.0000	-46.5617	.0000		
TUR	C	-46.1822	.0001	-46.0165	.0001	13.2238	.0000
	C+Trend	-46.1818	.0000	-46.0130	.0000		

Note: In the ADF unit root tests, the lag length was chosen as 27 according to the Schwarz criterion. In the PP test, the bandwidth was determined as 8 according to the Newey-West method. The null hypothesis in the ARCH LM test is that no ARCH effect is present. The test was performed using 5 lag lengths for models estimated with the AR(1) model. Augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) tests.

In other words, all series satisfy the condition of first-order stationarity. The ARCH LM test was applied to determine whether heteroscedasticity is present in the series. According to the test statistics, a strong ARCH effect is found in both the benchmark stock index series and CDS premium series. The important factors behind this phenomenon are as follows: the daily frequency of the return series and the sensitivity of analyzed series to information flow regarding financial markets.

Table 4 introduces the optimal lag lengths determined in accordance with the information criteria. The optimal lag length for VAR models is determined according to the final prediction error (FPE), Akaike (AIC), Schwarz (SC), and Hannan-Quinn (HQ) information criteria. In series where information criteria show different lag lengths, determining the lag lengths was preferred using the FPE and AIC criteria.

Table 5 presents the coefficient estimates for the BEKK-GARCH(1,1) model. The diagonal ARCH parameters show strong ARCH effects in the stock and CDS markets for all countries. The values for the α_{12} and α_{21} parameters are significantly smaller than the diagonal parameters. However, the α_{12} parameter is not statistically significant for Russia or China. Likewise, the α_{21} parameter is not statistically significant for Germany, USA, UK, Italy, Japan, or Brazil. These findings imply that the cross-market spillover between equity and the CDS markets is weak. In other words, the volatility observed in the stock and CDS markets is mostly due to past shocks rather than cross-market volatility spillovers.

The diagonal GARCH parameters indicate a strong GARCH effect to be present in all markets. In other words, the past period volatility in both the stock and CDS markets has an effect on the current period's conditional volatility. As expected, the β_{12} and β_{21} parameters have lower values than the diagonal parameters. However, the β_{21} parameter is not statistically significant for the USA, Germany, England, France, Italy, Brazil, Russia, South Africa, or Turkish markets. This finding shows no volatility spillover to exist from the CDS market to the stock market. β_{12} is both statistically significant and larger than β_{21} in all cases. These findings generally point to the existence of volatility spillover from the equity market to the CDS market. As expected, the GARCH parameters that have been calculated at a higher level than the ARCH parameters show the past period volatility in both the stock and CDS markets to have a stronger effect on current period conditional volatility compared to the ARCH effects. The Portmanteau test results, Q and Q^2 statistics show no autocorrelation problem to exist in the models. The calculated AIC, SC, and HQ information criteria for the models have values between 6 and 8.

Table 4.
Determining the Optimal Lag Length in VAR(p,q) Models

	G7 Countries						BRICS+T Countries				
	GER	**USA**	**UK**	**FRA**	**ITA**	**JAP**	**BRA**	**RUS**	**CHI**	**SAFR**	**TUR**
LR	15	19	20	20	20	12	19	17	20	18	12
FPE	15	13	11	7	5	6	15	5	6	7	6
AIC	15	13	11	7	5	6	15	5	6	7	6
SC	2	2	1	1	1	1	1	1	0	1	1
HQ	2	9	8	2	1	3	7	2	1	1	3
Optimal Lag	15	13	11	7	5	6	15	5	6	7	6

Note: The maximum lag length was selected as 20.

Figure 3 presents the conditional correlations between the benchmark stock indices and CDS premium return series. Correlation coefficients generally take values between 0 and -0.25 in the G7 countries, with Italy being the exception to this finding. The correlation coefficient between the stock index and the CDS premium in the Italian market is higher (between -0.50 and -0.75) compared to other G7 members. In the USA, the change in the correlation coefficient between the markets resembles a white noise series and fluctuates around zero.

The level of correlations in developing countries is markedly distinct from G7 countries. With the exception of China, developing countries have substantially higher correlation levels between the equity and CDS markets, with the correlation coefficients being observed to fluctuate around -0.50 to -0.75, especially in the Brazilian and Turkish markets. In the Chinese market, as in many G7 countries, the correlation coefficient was calculated around -0.25.

Figure 4 presents the variation of conditional covariance between CDS and stock market over time. During periods of financial distress in markets, the time course of conditional covariance shows significant changes, as does the conditional correlation coefficients. In other words, the interaction between markets grows stronger and the level of co-movement increases in times of financial distress.

The findings obtained in this study are generally compatible with the literature. As Merton (1974) predicted, a negative relationship was seen to exist between CDS premiums and stock index returns. Sun et al. (2020), Fonseca and Gottschalk (2020), and

Table 5.
BEKK GARCH Model Coefficient Estimations

	G7 Countries						BRICS+T Countries				
	GER	**USA**	**UK**	**FRA**	**ITA**	**JAP**	**BRA**	**RUS**	**CHI**	**SAFR**	**TUR**
$c_{1,1}$	.1596*	.2069*	.1772*	.2198*	.2085*	.2807*	.3017*	.2175*	.1352*	.1555*	.4629*
$c_{2,1}$	-.1999**	-.0233	-.1745*	-.3241*	-.2922*	**.0806**	-.6052*	-.2392*	-.5159*	**-.2114**	-.5805*
$c_{2,2}$	.6042*	1.4913*	.6822*	.5187*	.5631*	.7238*	.4044*	.6068*	.8171*	.8379*	.4520*
$\alpha_{1,1}$	.2482*	.4091*	.3096*	.3507*	.3024*	.2948*	.2516*	.2389*	.2279*	.2569*	.0794*
$\alpha_{1,2}$	-.0502*	-.2198*	-.0947*	-.1762*	-.0749*	-.1799*	-.1826*	**-.0130**	**-.0356**	-.2306*	.3522*
$\alpha_{2,1}$	-.0153**	.0030**	-.0151**	-.0157*	**.0084**	**.0048**	**-.0103**	-.0170*	-.0164*	-.0171*	-.0871*
$\alpha_{2,2}$	.3204*	.2916*	.4156*	.4583*	.3763*	.3287*	.3422*	.2935*	.3649*	.2388*	.5385*
$\beta_{1,1}$	.9585*	.8861*	.9317*	.9171*	.9413*	.9123*	.9509*	.9480*	.9679*	.9512*	.8979*
$\beta_{1,2}$	-.1083*	-.3264*	-.1509*	-.2933*	-.0429*	-.1919*	-.1175*	-.0766*	-.0871*	-.0914*	-.2253*
$\beta_{2,1}$	**.0045**	**-.0015**	.0062***	**.0030**	**-.0055**	-.0284*	**.0084**	**.0016**	.0051***	**.0033**	**-.0113**
$\beta_{2,2}$	.8975*	.9215*	.8548*	.8551*	.8979*	.8404*	.8614*	.9265*	.8661*	.8898*	.7943*
$Q(6)$	20.7937	17.4187	36.5234**	32.1750	32.1552	12.5869	35.7218***	23.0622	19.2165	21.1185	22.3410
$Q(12)$	44.1553	54.3190	57.8926	60.6019	57.2409	22.4910	63.6178***	41.9316	45.7414	41.7946	50.6695
$Q^2(6)$	20.8242	17.4355	36.5651**	32.2165	32.2006	12.6022	35.7656***	23.0896	19.2390	21.1488	22.3721
$Q^2(12)$	44.2651	54.459	58.0098	60.7451	57.3761	22.5419	63.7661***	42.0265	45.8522	41.9002	50.8052
AIC	7.3359	8.6098	6.7814	7.4372	8.0626	7.3493	8.0991	7.9141	7.9106	7.2592	7.8799
SC	7.3698	8.6437	6.8153	7.4710	8.0964	7.3831	8.1330	7.9479	7.9444	7.2930	7.9137
HQ	7.3482	8.6221	6.7937	7.4495	8.0748	7.3615	8.1114	7.9264	7.9229	7.2714	7.8922

Note: The BEKK-GARCH (1,1) model was estimated using the normal (Gaussian) distribution with the Bollerslev-Wooldridge robust estimator for all bivariate variables. *, **, *** indicate the z-test statistic is significant at 1%, 5%, and 10%, respectively. Akaike (AIC), Schwarz (SC), and Hannan-Quinn (HQ)

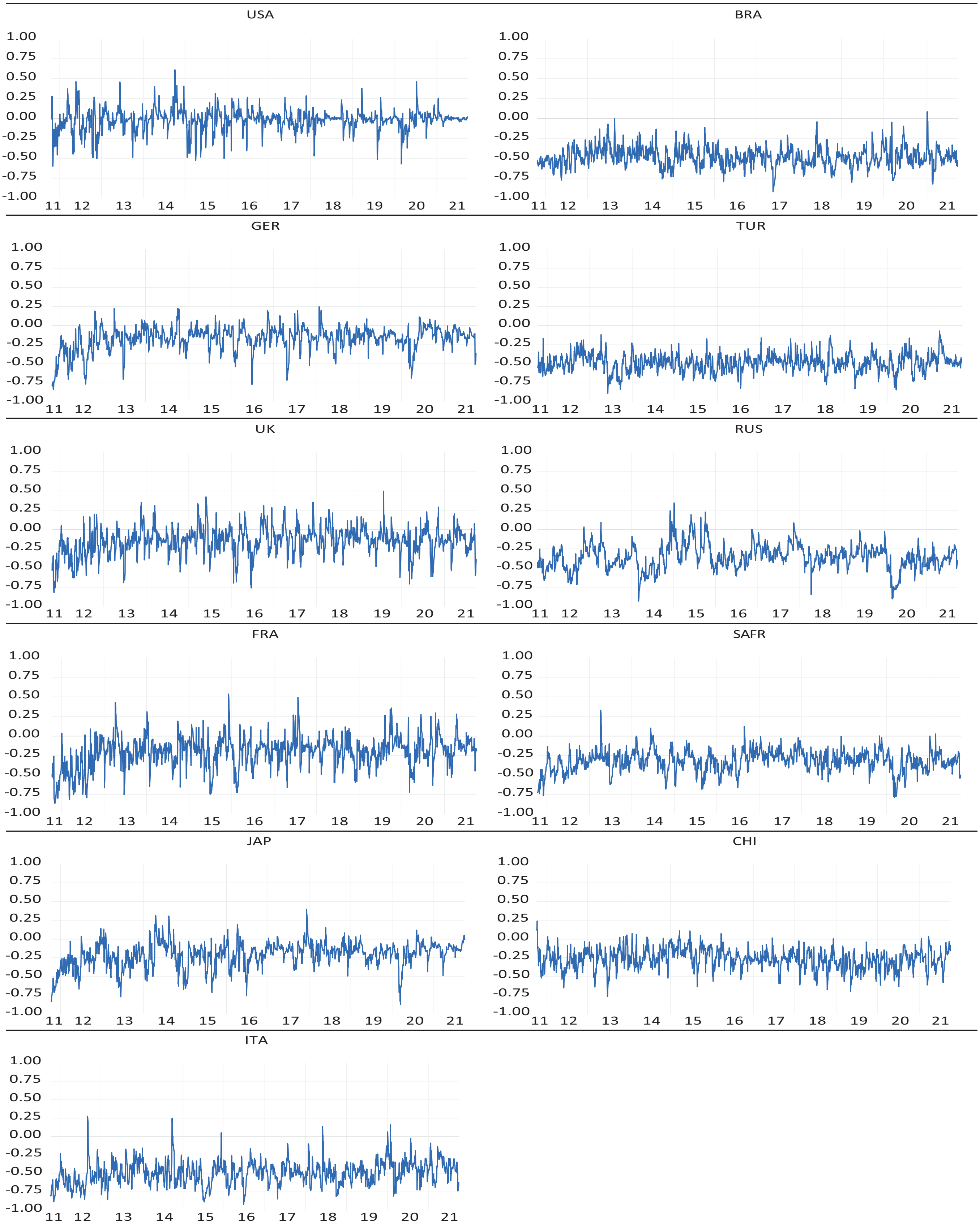

Figure 3.
Conditional Correlations.

Figure 4.
Conditional Variances and Covariances.

Ibhagui (2021) concluded in their studies that the stock market has a more dominant role over the CDS and commodity markets and that stock volatility (actual or implied) is an important transmitter of volatility spillovers to other asset classes. The current study determined significant volatility spillovers from stock indices to CDS premiums. One important finding from Sun et al. (2020) is that volatility spillovers are stronger in developing countries compared to developed countries. The current study does not support this finding. The main factors behind this phenomenon may have been due to it using a different analysis method and time period. As an example of these phenomena, many studies are found that have revealed the relationships between financial markets to be able to change over time (Yunus, 2020; Tachibana, 2022). In addition, studies are found showing model preferences to be an important factor in investigating the relationships among variables (Kanas, 2005; McMillan, 2009).

Fei et al. (2017) and Mateev (2019) emphasized that the correlations and covariance relationships between markets change over time and concluded that CDS and stock markets have nonlinear interactions with each other. This study determined the covariance relationships and correlations to change over time and time-varying relationships to have been revealed between the markets in the examined cases.

Conclusion and Recommendations

Understanding the interactions between financial markets is crucial in many aspects, from risk management, asset allocation, and the construction of efficient portfolios to the design of policy decisions taken by regulatory and supervisory authorities for ensuring the stability of financial markets. When making decisions, regulatory authorities should take into account the possible effects from the volatility that may be caused by information outflow, especially during periods of increased financial distress. The results of the study show the volatility spillover between financial markets to emerge as a critical factor that should be taken into account in decision-making processes for both investors and regulatory authorities. This study has investigated the volatility spillovers between stock and CDS markets using the VAR-BEKK-GARCH(1,1) model to analyze whether or not a spillover effect occurs between the markets and whether these effects differ in terms of developed and developing countries if they do occur.

Strong ARCH effects were identified in the CDS and stock markets of all the studied countries. In general, the cross-market volatility spillover between the equity and CDS markets was found to be weak. In other words, the volatility observed in the stock and CDS markets is mostly due to their own individual past shocks rather than cross-market interactions. Again, the presence of a strong GARCH effect was striking in all cases. In particular, the past period volatility in both the stock and CDS markets was observed to have an effect on the current period conditional volatility. For the most part, no volatility spillover was observed to occur from CDS markets to stock markets. However, the empirical findings point to significant volatility spillover effects from the stock market to the CDS market. Compared to the ARCH effects, the past period volatility in both the stock market and the CDS market has a stronger effect on the current period conditional volatility in these markets. The information outflow about financial markets in particular gets priced in the stock market before it spreads to other markets and then gets reflected onto the CDS market.

The correlation and covariance relationships between CDS premiums and stock indices change over time. The correlation coefficients between the markets in G7 countries are negative and very close to zero, with the exception to this finding being the Italian market. The correlation coefficient between the stock index and the CDS premium in the Italian market is higher compared to other G7 members. In the USA, the change in the correlation coefficient between the CDS and stock markets resembles white noise and fluctuates around zero. The level of the correlation coefficient in BRICS+T countries is markedly different from G7 countries. With the exception of China, the level of correlation between the equity and CDS markets is significantly higher in BRICS+T countries. In the Brazilian and Turkish markets especially, the correlation coefficients fluctuate around -0.50 to -0.75. Similar to many G7 countries, the correlation coefficients in the Chinese market are negative and very close to zero.

As a result, realizing the source and direction of the spillover effects between markets will facilitate the decision-making processes of investors and portfolio managers and shed light for regulators on the steps to take to ensure the stability of markets in times of increased financial distress. The fact that the correlation and covariance relationships between the markets show a time-varying feature indicates the interactions between these markets to be able to be examined more successfully with models such as Markov switching or copula models. This study recommends future studies be carried out with larger samples and with econometric models that are able to examine nonlinear relationships.

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Genişletilmiş Özet

Bu çalışma hisse senedi ve CDS piyasaları arasındaki oynaklık yayılımı etkilerini VAR-BEKK-GARCH(1,1) modeli ile ortaya koymayı amaçlamaktadır. Piyasalar arasında oynaklık yayılımı olup olmadığı, varsa gelişmiş ve gelişmekte olan ülkelerde bu etkilerin farklılaşıp farklılaşmadığı ve piyasalar arasındaki korelasyon ilişkilerinin ortaya konması araştırmanın temel hedefleri arasındadır. Çalışmanın odaklandığı araştırma soruları şöyle ifade edilebilir. Hisse senedi ve CDS piyasaları arasında anlamlı oynaklık yayılımı var mıdır? Eğer varsa oynaklık yayılımları gelişmiş ve gelişmekte olan ülkelerde farklılaşmakta mıdır?

Bu çalışmada volatilite yayılım etkilerinin analiz edilmesi amacıyla iki değişkenli BEKK-GARCH(1,1) modeli tercih edilmiştir. Engle ve Kroner (1995) tarafından geliştirilen bu model oynaklık yayılımı etkilerinin analiz edilmesinde yaygın olarak kullanılmaktadır. VAR modelini ve BEKK-GARCH modelini birleştiren VAR-BEKK-GARCH(1,1) yaklaşımıyla incelenen piyasalardaki gösterge hisse senedi endeksleri ile CDS primleri arasındaki oynaklık yayılımları, koşullu korelasyonlar ve koşullu kovaryanslar analiz edilebilmektedir.

Çalışmada gelişmiş ve gelişmekte olan ülkelere ait gösterge hisse senedi piyasası endeksleri ve CDS primleri kullanılmıştır. Gelişmiş piyasaları G7 grubu, gelişmekte olan piyasaları ise BRICS+T ülkeleri temsil etmektedir. G7 ülkeleri Almanya, Amerika Birleşik Devletleri, İngiltere, Fransa, İtalya, Japonya ve Kanada'dan; BIRCS+T ülkeleri ise Brezilya, Rusya, Hindistan, Çin, Güney Afrika ve Türkiye'den oluşmaktadır.

İncelenen tüm ülkelerde CDS ve hisse senetleri piyasalarında güçlü ARCH etkilerine rastlanmıştır. Genel olarak hisse senedi ve CDS piyasaları arasında çapraz şok geçişgenliğinin zayıf olduğu tespit edilmiştir. Yani hisse senedi ve CDS piyasasında gözlemlenen oynaklık, çapraz şok geçişlerinden ziyade daha çok kendi geçmiş dönem şoklarından kaynaklanmaktadır. Yine tüm ülke örneklerinde güçlü GARCH etkisinin varlığı göze çarpmaktadır. Yani hem hisse senedi hem de CDS piyasasındaki geçmiş dönem oynaklığının cari dönem koşullu oynaklığı üzerinde etkili olduğu gözlenmektedir. Genel olarak, CDS piyasasından hisse senetleri piyasasına oynaklık yayılımı olmadığı tespit edilmiştir. Bununla birlikte, elde edilen ampirik bulgular hisse senetleri piyasasından CDS piyasasına olan anlamlı oynaklık yayılımı etkilerine işaret etmektedir. Hem hisse senedi piyasasında hem de CDS piyasasındaki geçmiş dönem oynaklığının, ARCH etkilerine kıyasla, bu piyasalardaki cari dönem koşullu oynaklığı üzerindeki etkisinin daha güçlü olduğu ortaya çıkmıştır. Yani finansal piyasalarla ilgili haber akışı diğer piyasalara yayılmadan önce hisse senedi piyasasında fiyatlanmakta, ardından CDS piyasasına yansımaktadır.

CDS primleri ile hisse senedi endeksleri arasındaki korelasyon ve kovaryans ilişkileri zamana bağlı olarak değişim göstermektedir. G7 ülkelerinde genel olarak piyasalar arasındaki korelasyon değerleri negatif işaretli ve sıfıra oldukça yakındır. İtalyan piyasasında hisse senedi endeksi ile CDS primi arasındaki korelasyon düzeyi diğer G7 üyelerine kıyasla daha yüksektir. ABD'de ise CDS ve hisse senedi piyasaları arasındaki korelasyon düzeyindeki değişim beyaz gürültü serisini andırmakta, sıfır etrafında dalgalanma göstermektedir. Gelişmekte olan BRICS+T ülkelerindeki korelasyon düzeyi G7 ülkelerinden belirgin şekilde farklıdır. Bu ülkelerde, Çin istisnası dışında, hisse senedi ve CDS piyasaları arasındaki korelasyon düzeyi belirgin şekilde daha yüksektir. Özellikle Brezilya ve Türkiye piyasalarında korelasyon katsayılarının -0.50 ila -0.75 civarında dalgalanma gösterdiği gözlenmiştir. Çin piyasalarında ise birçok G7 ülkesinde olduğu gibi korelasyon katsayıları negatif işaretli ve sıfıra oldukça yakın değerler almıştır.

CDS ve hisse senedi piyasaları arasındaki yayılma etkilerinin kaynağının ve yönünün bilinmesi yatırımcıların ve portföy yöneticilerinin karar alma süreçlerini kolaylaştıracak ve regülatörler açısından finansal stresin arttığı dönemlerde piyasaların istikrarını sağlamaya yönelik atılması gereken adımlara ışık tutacaktır.