

## **APGARCH MODELING OF CDS RETURNS**

### **CDS GETİRİLERİNİN APGARCH MODELLEMESİ**

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### **ABSTRACT**

This paper considers the ability of the Generalized Asymmetric Power ARCH (APGARCH) model introduced by Ding, Granger and Engle (1993) to capture the stylized features of volatility in Credit Default Swap (CDS) returns for five countries (Brazil, Russia, China, South Africa and Turkey). We analyze these countries' daily CDS returns for the period January 27th, 2003 – November 4th, 2014. The results of this paper suggest that in the presence of asymmetric responses to innovations in the market, the APGARCH (1,1) Skewed Student-t model which accommodates both the skewness and the kurtosis of financial time series is preferred.

**Keywords:** APGARCH, Credit Default Swap (CDS), Asymmetry

**JEL Classification:** C22, C58, G15

### **ÖZ**

*Bu çalışmada, beş ülkenin kredi temerrüt takası (CDS) getirilerinde (Brezilya, Rusya, Çin, Güney Afrika ve Türkiye) farklı hata dağılımlarına bağlı olarak oynaklık yapılarını belirlemek üzere Ding, Granger and Engle (1993) tarafından ileri sürülen Genelleştirilmiş Asimetrik Üslü ARCH (APGARCH) modelinin uygulanabilirliği araştırılmıştır. Söz konusu ülkelerin 27 Ocak 2003 – 4 Kasım 2014 dönemine ait günlük CDS getirileri analiz edilmiştir. Çalışmanın bulguları, piyasalarda yaşanan gelişmelere karşı asimetrik etkilerin varlığında, finansal zaman serilerindeki çarpıklık ve basıklık özelliklerini birlikte ele alan çarpık Student-t dağılımlı APGARCH(1,1) modelinin tercih edilmesi gerektiği yönündedir.*

**Anahtar Sözcükler:** APGARCH, Kredi Temerrüt Takası (CDS), Asimetri

**JEL Sınıflandırması:** C22, C58, G15

## 1. Introduction

Credit default swaps (CDSs) are the most popular instrument in the rapidly-growing credit derivative markets. A CDS provides insurance against the default risk of a reference entity (usually a third party). The protection seller promises to buy the reference bond at its par value when a credit event (including bankruptcy, obligation acceleration, obligation default, failure of payment, repudiation or moratorium, or restructuring) occurs. In return, the protection buyer makes periodic payments to the seller until the maturity date of the CDS contract or until a credit event occurs. This periodic payment, which is usually expressed as a percentage (in basis points) of its notional value, is called CDS spread. Ideally, credit spread is a pure measure of the default risk of the reference entity.

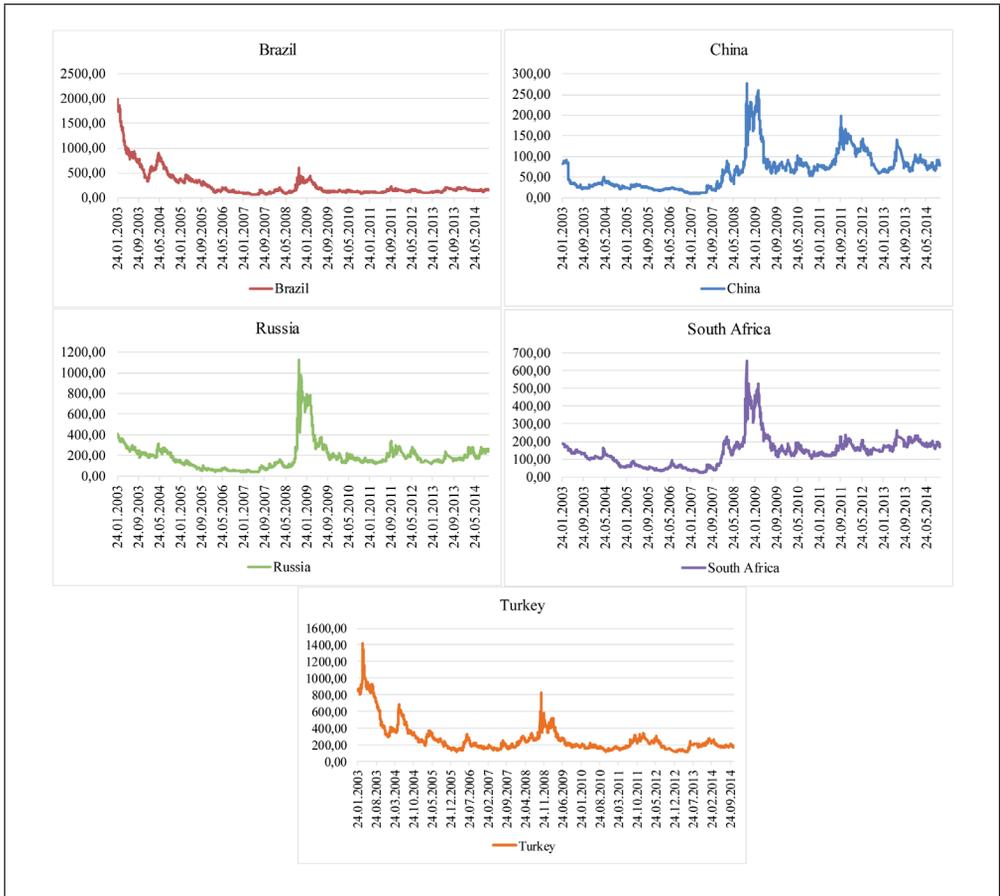
CDS risk premiums have several advantages. First, CDS risk premium is a relatively pure pricing of default risk of the underlying entity. Second, Blanco et al. (2005) and Zhu (2004) show that, in the short run the CDS risk premiums tend to respond more quickly to changes in credit conditions. Finally, using CDS risk premium can avoid the confusion on which proxy to be used as risk-free rates, since they are already quoted as the differences above swap rates.

In the past decade, the credit derivatives market has experienced rapid growth, and the CDS has become the most widely traded instrument for transferring credit risk (Hull, 2008). However, increasing CDS risk premiums may be a sign that the financial investors put them in the same basket with the developed ones in terms of risk level (see Figure 1).

The national and international economic, politic and/or social problems (shocks) affect especially the financial markets with high liquidity and increase the volatility of these markets. In analyzed countries CDS premiums have seen remarkable increase in their values. These countries are considered as the driving force for GDP growth of the emerging economies. Having a big source of labor, natural resources and geopolitical importance these countries play an important role of global policies and influence the global economy.

According to the International Swaps and Derivatives Association (ISDA), the CDS market has expanded extremely over the last decade, growing 40-fold from \$0.6 trillion of gross notional principal in 2001 to \$25.9 trillion at the end of 2011, yet it has received relatively little attention, compared with equity returns, in the econometrics literature. However, interest is growing, see Conrad, et al. (2011), Creal, et al. (2013), Christoffersen, et al. (2013) and Lucas, et al. (2014) for recent work on CDS data. We use our model of CDS returns to provide insights into systemic risk, as CDS spreads are tightly linked to the robustness of the underlying market.

There have been numerous developments in the ARCH literature to refine both the mean and variance equations, in order to better capture the stylized features of high frequency data. A common feature of the standard class of ARCH models is that they relate the conditional variance to lagged squared residuals and past variances. One recent development in the ARCH literature has focused on the power term by which the data is to be transformed. Ding, Granger and Engle (1993) introduced a new class of ARCH model called the Power ARCH model which estimates the optimal power term. They also found that the absolute returns and their power transformations have a highly significant long-term memory property as the returns are highly correlated.



**Figure 1.** Credit Default Swap Index of Sovereign Issuers

Another important innovation has been the development of ARCH model specifications to describe the asymmetry present in financial data. Financial returns data commonly exhibits an asymmetry in that positive and negative shocks to the market do not bring forth equal responses. This phenomenon is most commonly attributed to the leverage effect (see Black 1976, Christie 1982 and Nelson 1991). The applicability of the Power ARCH class of model to stock market data has been well documented in papers such as Ding, Granger and Engle (1993), Hentschel (1995), Giot and Laurent (2004) and, Pan and Zhang (2006).

The purpose of this study is to assign the effect of the global crisis among the CDS return volatilities in Brazil, Russia, China, South Africa and Turkey. Most of the studies examines the CDS volatility transmission mechanism among the markets by employing multivariate GARCH modeling. The contribution of our paper is to modeling the volatility dynamics of the CDS returns in the market base.

The remainder of this paper proceeds as follows. The section 2 details the general model and discusses how various ARCH models are nested within this APGARCH structure. The section 3

describes the CDS returns data to be used in this study and presents the empirical results. The robustness of these findings is assessed using the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and log-likelihood (LL) values. The section 4 contains some concluding remarks.

## 2. Methodology

The Generalized Asymmetric Power ARCH (APGARCH) model, which was introduced by Ding, Granger and Engle (1993), is presented in the following framework:

$$y_t = c_0 + \varepsilon_t \quad (1)$$

$$\varepsilon_t = z_t \sigma_t \quad (2)$$

$$z_t \stackrel{i.i.d.}{\sim} f(0,1) \quad (3)$$

$$\sigma_t^\delta = \omega_0 + \sum_{i=1}^p \alpha_i (|\varepsilon_{t-i}| - \gamma_i \varepsilon_{t-i})^\delta + \sum_{j=1}^q \beta_j \sigma_{t-j}^\delta \quad (4)$$

where  $c_0$  is a constant parameter,  $\varepsilon_t$  is the innovation process,  $\sigma_t$  is the conditional standard deviation,  $z_t$  is an independently and identically distributed (i.i.d.) process.  $f(\cdot)$  is the probability density function (PDF) and  $F(\cdot)$  is the cumulative density function (CDF) with  $\omega_0 > 0$ ,  $\alpha_i \geq 0$ ,  $\beta_j \geq 0$ ,  $\delta \geq 0$  and  $|\gamma_i| \leq 1$ . Here  $\alpha_i$  and  $\beta_j$  are the standard ARCH and GARCH parameters,  $\gamma_i$  is the leverage parameter and  $\delta$  is the parameter for the power term. A positive (resp. negative) value of the  $\gamma_i$  means that past negative (resp. positive) shocks have a deeper impact on current conditional volatility than past positive (resp. negative) shocks.

The model imposes a Box and Cox (1964) transformation in the conditional standard deviation process and the asymmetric absolute innovations. In the APGARCH model, good news ( $\varepsilon_{t-i} > 0$ ) and bad news ( $\varepsilon_{t-i} < 0$ ) have different predictability for future volatility, because the conditional variance depends not only on the magnitude but also on the sign of  $\varepsilon_t$ .

To put Equation (4) into operation we need to specify the lag structure and in this paper a first order lag structure is adopted for both the ARCH and GARCH terms:

$$\sigma_t^\delta = \omega + \alpha_1 (|\varepsilon_{t-1}| - \gamma \varepsilon_{t-1})^\delta + \beta_1 \sigma_{t-1}^\delta \quad (5)$$

where  $\omega, \alpha_1, \gamma, \beta_1$  and  $\delta$  are additional parameters to be estimated. Equation (5) shall hereafter be referred to as a Generalized Asymmetric Power ARCH (APGARCH) model to reflect the inclusion of the  $\beta$  term. Thus, we are able to distinguish this model from a version in which  $\beta_1 = 0$ , that we shall refer to as an Asymmetric Power ARCH (APARCH) model.

In the influential paper of Engle (1982), the density function of  $z_t$ ,  $f(\cdot)$  was the standard normal distribution. Bollerslev (1987) tried to capture the high degree of leptokurtosis that is presented in high frequency data and proposed the Student- $t$  distribution in order to produce an unconditional distribution with fat tails. Lambert and Laurent (2001) suggested that not only the

conditional distribution of innovations may be leptokurtic, but also asymmetric and proposed the Skewed Student-t densities function.

According to Lambert and Laurent (2001) and provided that  $v > 2$ , the innovation process  $z_t$  is said to be (standardized) Skewed Student-t (in short SKST) distributed, i.e.  $z_t : SKST(0, 1, \xi, v)$ , if:

$$f(z_t | \xi, v) = \begin{cases} \frac{2}{\xi + \frac{1}{\xi}} sg [\xi (sz_t + m) | v] & \text{if } z_t < -\frac{m}{s} \\ \frac{2}{\xi + \frac{1}{\xi}} sg [(sz_t + m) / \xi | v] & \text{if } z_t \geq -\frac{m}{s} \end{cases} \quad (6)$$

where  $g(. | v)$  is a symmetric (unit variance) Student-t density and  $\xi$  is the asymmetric term. In short,  $\xi$  models the asymmetry, while  $v$  accounts for the tail thickness. Parameters  $m$  and  $s^2$  are, respectively the mean and the variance of the non-standardized Skewed Student-t density:

$$m = \frac{\Gamma\left(\frac{v-1}{2}\right) \sqrt{v-2}}{\sqrt{\pi} \Gamma\left(\frac{v}{2}\right)} \left( \xi - \frac{1}{\xi} \right) \quad (7)$$

and

$$s^2 = \left( \xi^2 + \frac{1}{\xi^2} - 1 \right) - m^2 \quad (8)$$

Following Ding, Granger and Engle (1993), if it exists, a stationary solution of Equation (5) is given by:

$$E(\sigma_t^\delta) = \frac{\omega_0}{1 - \alpha_1 E(|z| - \gamma z)^\delta - \beta_1} \quad (9)$$

which depends on the density of  $z$ . Such a solution exist if  $V = \alpha_1 E(|z| - \gamma z)^\delta + \beta_1 < 1$ . The  $V$  coefficient may be viewed as a measure of volatility persistence.

Ding, Granger and Engle (1993) derived the expression for  $E(|z| - \gamma z)^\delta$  for the Gaussian case. We can also show that for the standardized Skewed Student-t distribution is given as follows:

$$E(|z| - \gamma z)^\delta = \left\{ \xi^{-(1+\delta)} (1 + \gamma)^\delta + \xi^{(1+\delta)} (1 - \gamma)^\delta \right\} \frac{\Gamma\left(\frac{\delta+1}{2}\right) \Gamma\left(\frac{v-\delta}{2}\right) (v-2)^{\frac{1+\delta}{2}}}{\left(\xi + \frac{1}{\xi}\right) \sqrt{(v-2)} \pi \Gamma\left(\frac{v}{2}\right)} \quad (10)$$

It is possible to nest a number of the more standard ARCH and GARCH formulations within this Asymmetric Power GARCH model by specifying permissible values for  $\alpha, \beta, \gamma$  and  $\delta$  in Equation 4. Table 1 summarizes the restrictions required to produce each of the models nested within this APGARCH model. From Table 1, where  $\alpha_i$  is free,  $\delta = 2$  and both  $\beta_j$  and  $\gamma_i = 0$ , this model reduces to Engle's (1982) ARCH model. Further, when we extend this model to allow both  $\alpha_i$  and  $\beta_j$  to take on any value, we get Bollerslev's (1986) GARCH model. The GJR-ARCH model of Glosten, Jagannathan and Runkle (1993) is obtained where  $\delta = 2$  and  $\beta_j = 0$  however,  $\alpha_i$  is specified as  $\alpha_i(1 + \gamma_i)^2$  and leverage term is restricted to  $-4\alpha_i\gamma_i$ . The Threshold ARCH (TARCH) model of Zakoian (1994) is defined where  $\alpha_i$  is free,  $\delta = 1$ ,  $|\gamma_i| \leq 1$  and  $\beta_j$  is restricted to be 0. The Nonlinear ARCH model (NARCH) of Bera and Higgins (1993) is obtained where  $\delta$  and  $\alpha_i$  are free, and both  $\beta_j$  and  $\gamma_i$  are 0. If we extend this NARCH model to allow  $\beta_j$  to also being free, then a Power GARCH (PGARCH) specification is the result.

**Table 1.** Taxonomy of ARCH/GARCH Model Specifications

Model	$\alpha_i$	$\beta_j$	$\gamma_i$	$\delta$
ARCH	Free	0	0	2
GARCH	Free	Free	0	2
GJR-ARCH	$\alpha(1 + \gamma_i)^2$	0	$-4\alpha_i\gamma_i$	2
GJR-GARCH	$\alpha(1 + \gamma_i)^2$	Free	$-4\alpha_i\gamma_i$	2
TARCH	Free	0	$ \gamma_i  \leq 1$	1
TGARCH	Free	Free	$ \gamma_i  \leq 1$	1
NARCH	Free	0	0	Free
PGARCH	Free	Free	0	Free
APARCH	Free	0	$ \gamma_i  \leq 1$	Free
APGARCH	Free	Free	$ \gamma_i  \leq 1$	Free

**Source:** Brooks et al., 2000:380.

The models nested so far have assumed a symmetrical response of volatility to innovations in the market. However, empirical evidence suggests that positive and negative returns to the market of equal magnitude will not generate the same response in volatility. Glosten, Jagannathan and Runkle (1993) provided one of the first attempts to model asymmetric or leverage effects with a model which utilizes a GARCH type conditional variance specification. In this GJR-GARCH model,  $\delta = 2$  and  $\beta_j$  is free however,  $\alpha_i$  is specified as  $\alpha_i(1 + \gamma_i)^2$  and leverage term is restricted to  $-4\alpha_i\gamma_i$ . The Generalized TARCH (TGARCH) model is derived by allowing  $\beta_j$  being free. Lastly, if  $\alpha_i, \beta_j$  and  $\delta$  are free, and  $|\gamma_i| \leq 1$ , then an Asymmetric Power GARCH specification is the result. Full details and proofs of this nesting process may be found in Ding, Granger and Engle (1993).

### 3. Data and Empirical Results

The section shows the empirical results of models. The CDS returns of five countries are analyzed. Computations were performed with G@RCH 6.1 which is Ox package designed for the estimation of various time series models. The characteristics of the data are presented in the

first subsection. The second subsection shows the estimated results of APGARCH (1,1) Skewed Student-t model specifications and the corresponding qualification tests. The APGARCH (1,1) model produced highly significant test statistics and contained either a significant asymmetry term or a power term which was significantly different from two.

### 3.1. Data

In this study, we used the Brazil, Russia, China, South Africa and Turkey's daily CDS returns; namely Brazil (BRA), Russia (RUS), China (CHN) and South Africa (SOA) and Turkey (TUR), for the period January 27<sup>th</sup>, 2003 – November 4<sup>th</sup>, 2014. These countries are considered as the driving force for GDP growth of the emerging economies. Having a big source of labor, natural resources and geopolitical importance these countries play an important role of global policies and influence the global economy. The CDS returns are calculated by log return  $r_t = \ln(p_t/p_{t-1})$  of the closing values. The data used in the study is obtained from the Borsa İstanbul. Table 2 presents the descriptive statistics for each return series.

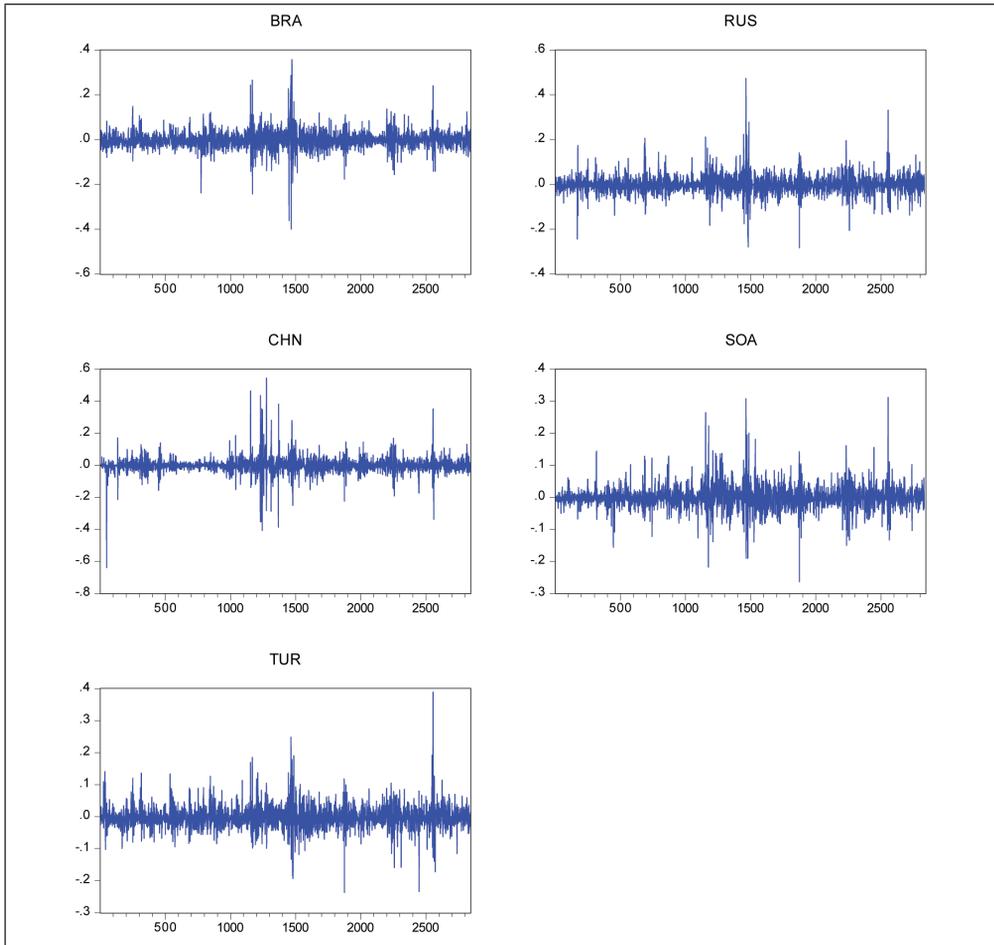
**Table 2.** Descriptive Statistics

	<b>BRA</b>	<b>RUS</b>	<b>CHN</b>	<b>SOA</b>	<b>TUR</b>
<b>Mean</b>	-0.00088	-0.00015	-0.00002	-0.00003	-0.00056
<b>Minimum</b>	-0.39945	-0.28354	-0.63861	-0.26348	-0.23677
<b>Maximum</b>	0.35707	0.47361	0.54498	0.31178	0.38901
<b>Standard Deviation</b>	0.039615	0.04140	0.04866	0.03614	0.03555
<b>Skewness</b>	0.19817	-0.87170	0.015182	0.76489	0.68195
<b>Excess Kurtosis</b>	13.936	13.0660	32.9670	10.1390	10.3510
<b>Jarque-Bera (p-value)</b>	23036.71 (0.000)	20587.22 (0.000)	128838.6 (0.000)	12465.28 (0.000)	12922.30 (0.000)
<b>ADF-Test (C, 0)*</b>	-47.43	-47.54	-59.59	-48.12	-47.32

**Notes:** Brazil (BRA), Russia (RUS), China (CHN) and South Africa (SOA) and Turkey (TUR).

\* (C, 0) indicates that there is a constant but no trend in the regression model with lag=0. All Augmented Dickey Fuller (ADF) test statistics reject the hypothesis of a Unit Root at the 1% level of confidence. MacKinnon critical value at the 1% confidence level is -3.44.

According to descriptive statistics, volatility, as measured by standard deviation is highest in CHN. The volatility range is between 0.04866 (CHN) and 0.03555 (TUR). It is not surprising that these series exhibit asymmetric and leptokurtic (fat tails) properties. All of the CDS return series have positive skewness except RUS, and the kurtosis exceeds three indicating fat tails and leptokurtotic distribution. Thus, the return series of these CDS returns are not normally distributed. Additionally, by Jarque-Bera statistic and corresponding p-value we reject the null hypothesis that returns are well approximated by the normal distribution. For this reason, in this study we used the Skewed Student-t distribution, which takes into account fat tail problem and asymmetric structure. As well as descriptive statistics, examining the CDS return graphs in Figure 2 shows the volatility clustering in several periods especially in the global crisis period. Volatility clustering which means that there are periods of large absolute changes tend to cluster together followed by periods of relatively small absolute changes.



**Figure 2.** Daily CDS Return Graphs

### 3.2. Estimation Results

In this subsection, the APGARCH (1,1) model is estimated for each CDS return series under Normal, Student-*t*, GED (Generalized Error Distribution) and Skewed Student-*t* distributions. The standard of model selection is based on in-sample diagnosis including Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), log-likelihood (LL) values, and Ljung-Box Q and Q<sup>2</sup> statistics on standardized and squared standardized residuals respectively. Under every distribution, the model which has the lowest AIC and SIC or highest LL values and passes the Q-test simultaneously is adopted. In summary, ranking by AIC, SIC and LL favors the APGARCH (1,1) Skewed Student-*t* specification in all CDS return series except CHN (Student *t*).

Table 3 presents the results of this estimation procedure and from this table one can see that all of the ARCH and GARCH coefficients are statistically significant at the 1% level. Further,  $\beta_1$  is close to 1 but significantly different from 1 for all series, which indicates a high degree of volatility persistence.  $\beta_1$  takes values between 0.7908 (RUS) to 0.8874 (BRA) suggesting that there are

substantial memory effects. Furthermore, in all cases the APGARCh models are stationary in the sense that  $V$  coefficient is lower than 1.

The APGARCh model includes a leverage term ( $\gamma$ ) which allows positive and negative shocks of equal magnitude to elicit an unequal response from the market. Table 3 presents details of this leverage term and reveals that for all models fitted; the estimated coefficient was negative and statistically significant. This means that positive shocks lead to higher subsequent volatility than negative shocks (asymmetry in the conditional variance). Such a result was expected since response asymmetry is generally attributed solely to CDS data. The highest shock effects are occur respectively in TUR (-0.3551) and BRA (-0.2592).

**Table 3.** APGARCh (1,1) Skewed Student- $t$  Model Estimation Results

	<b>BRA</b>	<b>RUS</b>	<b>CHN</b>	<b>SOA</b>	<b>TUR</b>
<b>m</b>	-0.0018 [-3.234]	-0.0011 [-1.865 <sup>b</sup> ]	-0.0009 [-2.441 <sup>a</sup> ]	-0.0009 [-1.924 <sup>b</sup> ]	-0.0013 [-2.368 <sup>a</sup> ]
<b>w</b>	0.0002 [1.239 <sup>†</sup> ]	0.0007 [1.385 <sup>†</sup> ]	0.0472 [1.896 <sup>b</sup> ]	0.0001 [1.724 <sup>b</sup> ]	0.0009 [1.322 <sup>†</sup> ]
<b>a</b>	0.1028 [6.965]	0.1911 [7.871]	0.2303 [4.871]	0.2040 [5.289]	0.1331 [6.931]
<b>b</b>	0.8874 [55.430]	0.7908 [33.670]	0.8107 [25.280]	0.8399 [29.420]	0.8402 [36.940]
<b>g</b>	-0.2592 [-3.268]	-0.1843 [-3.149]	-0.1021 [-1.487]	-0.2007 [-2.746]	-0.3551 [-4.102]
<b>d</b>	1.4403 [6.671]	1.3845 [6.457]	0.6986 [4.103]	1.0009 [5.845]	1.2111 [5.521]
<b>x</b>	0.0528 [2.049 <sup>a</sup> ]	0.0632 [2.5360]	-	0.0299 [1.454 <sup>†</sup> ]	0.0675 [2.575 <sup>a</sup> ]
<b>u</b>	6.1155 [8.445]	4.4072 [11.521]	-	3.0658 [14.250]	4.5687 [11.530]
<b>V</b>	0.9768	0.9455	0.95976	0.9732	0.9478
<b>LL</b>	5,788.85	5,663.49	5,808.63	6,188.18	5,964.95
<b>AIC</b>	-4.0667	-3.9785	-4.0813	-4.3476	-4.1906
<b>SIC</b>	-4.0500	-3.9618	-4.0667	-4.3309	-4.1739
<b>Q(20)</b>	76.7149 (0.000)	60.6167 (0.000)	19.4642 (0.492)	48.3348 (0.000)	66.1447 (0.000)
<b>Q<sup>2</sup>(20)</b>	21.4021 (0.260)	8.7960 (0.964)	0.2524 (1.000)	22.6849 (0.203)	18.2802 (0.437)
<b>ARCH(5)</b>	0.7976 (0.551)	0.6185 (0.686)	0.0029 (1.000)	0.4790 (0.792)	1.0907 (0.363)
<b>P(60)</b>	86.6588	88.8537	157.0633	262.8389	82.6068

**Notes:** Brazil (BRA), Russia (RUS), China (CHN) and South Africa (SOA) and Turkey (TUR).

$a, b$  denotes 5% and 10% significance level respectively;  $†$  not significant;  $V = \alpha_1 E(|z| - \gamma z)^\delta + \beta_1$  as a measure of volatility persistence,  $t$ -statistics of corresponding tests in brackets. LL is the value of the maximized log-likelihood, AIC-Akaike Information Criterion, SIC-Schwarz Information Criterion.  $Q(20)$  and  $Q^2(20)$  are the Ljung-Box statistics for remaining serial correlation in the standardized and squared standardized residuals respectively using 20 lags with  $p$ -values in parenthesis. ARCH(5) denotes the ARCH test statistic with lag 5.  $P(60)$  is the Pearson goodness-of-fit statistic for 60 cells.

From Table 3, the evidence of long memory process could be also found in the results of the model estimation because the power term ( $\hat{\delta}$ ) of APGARCh models range in value from 0.6986 in the case of CHN to 1.4403 in the case of BRA. The average power term across all of the models estimated was 1.1471. For all models estimated the power term was significantly different from two. This means that for all models estimated, the optimal power term has some value other than unity or two which would seem to support the use of a model which allows the power term to be estimated. The APGARCh models the conditional variance for all CDS return series.

For the Skewed Student- $t$  distribution, the asymmetric terms are negative ( $\xi > 0$ ) and statistically significant for all CDS return series except SOA. Note that G@RCh does not estimate  $\xi$  but  $\log(\xi)$  to facilitate inference about the null hypothesis of symmetry (since the Skewed Student- $t$  equals the symmetric Student- $t$  distribution when  $\xi = 1$  or  $\log(\xi) = 0$ ). The sign of  $\log(\xi)$  indicates the direction of the skewness. The third moment is positive, and the density is skewed to the right, if  $\log(\xi) > 0$ . On the contrary, the third moment is negative, and the density is skewed to the left, if  $\log(\xi) < 0$ . We can confirm that the density distributions of all series are skewed to the right side due to these significantly positive asymmetric terms.

The tail term ( $\nu$ ) is much larger for the BRA CDS returns than for the other series. This means that daily returns of the BRA CDS premiums display a much larger kurtosis and exhibit fatter tails than returns for the RUS, SOA and TUR premiums. Besides, the evidences show that fat-tail phenomenon is strong because the student or tail terms ( $\nu$ ) are significantly different from zero for all series under Skewed Student- $t$  distribution.

The results given in Table 3 show that the APGARCh succeeds in taking into account all the dynamical structure exhibited by the returns and volatility of the returns as the Ljung-Box statistics for up to 20 lags on the standardized residuals (Q) non-significant at the 5% level (except BRA, RUS, SOA and TUR CDS return series) and the squared standardized residuals (Q<sup>2</sup>) non-significant at the 5% level for all CDS return series. Also, there is no evidence of remaining ARCH effects according to the ARCH test statistic with lag 5. In addition, goodness-of-fit test statistics for 60 cells P(60) verify again the relevance of Skewed Student- $t$  distribution for all CDS returns. Thus, the Skewed Student- $t$  distribution can be used to capture the tendency of CDS return distribution referring to leptokurtosis.

## 4. Conclusion

Most of the studies examines the CDS volatility transmission mechanism among the markets by employing multivariate GARCH modeling. The contribution of our paper is to modeling the volatility of the CDS returns separately for each market.

A recent development in the ARCH literature has been the introduction of the Power ARCH class of models which allow a free power term rather than assuming an absolute or squared term in their specification. Accordingly, the purpose of the paper is to consider the applicability of the Generalized Asymmetric Power ARCH (APGARCh) model to the selected CDS returns for five emerging markets. The CDS returns are investigated by using the APGARCh (1,1) model under Normal, Student- $t$ , GED and Skewed Student- $t$  distributions. We found that the Skewed Student- $t$  distribution is the most efficient. To capture the long memory property exhibited in the conditional variance, the power term ( $\hat{\delta}$ ) estimates of APGARCh model is in the interval between 0.6986 and 1.4403. It indicates that the return series of all CDS premiums are skewed

distributed and have fat tails by the significant coefficients of  $\xi$  (not significant for SOA) and  $\nu$  in the results of model estimation.

The estimation results indicate that strong leverage effects are present in CDS return data especially for TUR and BRA. Further, once these leverage effect are modeled in a GARCH framework, the inclusion of a power term is a worthwhile addition to the specification of the model. Also, in these emerging economies the volatility persistence is higher. Thus, shocks in the CDS return series have substantial memory effects. Because of the tail term is higher, the CDS returns display larger kurtosis and exhibit fatter tails.

The CDS returns' volatility has increased during the global crisis period. The most affected countries are seen as Russia and Brazil. Especially after global crisis, the CDS market has become important in more recent years globally, especially for emerging countries where sovereign risk is an important indicator to foreign investors in assessing risks of their foreign direct investment and portfolio investments. In a well-functioning financial market, the CDS returns reflects the riskiness of the underlying event.

Consequently, in this paper, the ability of the APGARCH model is analyzed so as to present the volatility characteristics of five emerging markets. However internal dynamics of each market are different, it is concluded that for all CDS returns the positive shocks lead to higher subsequent volatility and also contain long memory process.

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