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# ASSESSING THE INFLUENCE OF EARTHQUAKES ON SOVEREIGN CREDIT RISK: EVENT STUDY ON CDS MARKET DYNAMICS[1]

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## ABSTRACT

*This study analyzes the effects of earthquakes on sovereign credit default risk by examining whether 20 major earthquakes that occurred in five countries after 2010 have affected CDS markets using the event analysis method. The results indicate that the earthquakes increased uncertainty in CDS markets in all countries. These results prove that uncertainty about the ability of countries to repay their public debt has significantly changed compared to the past.*

***Keywords:*** *Natural Disasters, Earthquakes, CDS, Sovereign Default Risk.*

***JEL Codes:*** *E00, E62, Q54.*

# DEPREMLERİN ÜLKE KREDİ RİSKİ ÜZERİNDEKİ ETKİSİNİN DEĞERLENDİRİLMESİ: SEÇİLMİŞ ÜLKELERİN CDS PİYASASI DİNAMİKLERİ ÜZERİNE OLAY ÇALIŞMASI

## ÖZET

*Bu çalışma depremlerin ülke kredi temerrüt riski üzerindeki etkilerini analiz etmektedir. Çalışmada Türkiye, Meksika, Şili, Güney Afrika ve Yunanistan'da 2010 yılı sonrasında meydana gelen 20 büyük depremin CDS piyasaları üzerinde bir farklılık yaratıp yaratmadığı olay analizi yöntemiyle incelenmiştir. Sonuçlar depremlerin tüm ülkelerin CDS piyasalarındaki belirsizliği arttırdığına işaret etmektedir. Bu sonuçlar ülkelerin kamu borçlarını geri ödeyebilme yeteneğine dair belirsizliğin deprem öncesine göre önemli ölçüde değiştiğini kanıtlamaktadır.*

***Anahtar Kelimeler:*** *Doğal Afetler, Depremler, CDS, Ülke Temerrüt Riski.*

***JEL Kodları:*** *E00, E62, Q54.*

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## 1. INTRODUCTION

Earthquakes cause very serious economic, financial, and social problems for countries. The magnitude of an earthquake's intensity and destructiveness can cause a country's economy to decrease in material and human capital. The loss of working power, heavy damage to infrastructure and the economic and social sectors, and the burden on budget are negatives that arise after an earthquake. The public budget is crucial in removing negatives that require recovery or replacement while economic ruin and the strain on public finances are intensified by disasters occurring in areas that provide a nation's main income. The prognosis for the public budget is actually worsened by the increase in expenses associated with earthquakes. Budget deficits are mostly caused by cash or in-kind assistance for residents affected by an earthquake: new housing costs, low-interest loans from public banks to affected individuals, expenditures from local governments, and tax losses. Depending on an earthquake's magnitude and destructiveness, this rising influence changes over short, medium, and long terms.

The view on the sustainability of public debt could also change because of the damage that earthquakes bring to revenue and spending levels, which raises budget deficits.[2] According to Klomp (2015), public debt becomes less sustainable because of the rise in expenditures and reduction in revenues, hence raising the risk of default. Investors in debt markets also price default risk. Credit Default Swap (CDS) is a crucial measure of this. A country's CDS is a key measure used to evaluate its capacity to repay obligations. From this viewpoint, it can be examined whether the fiscal damage caused by earthquakes affects the debt market through CDS. The emergence of this study is based on this point with the study's objective being to determine whether earthquakes impact the perception of sovereign default risk. The analysis focuses on five countries—Türkiye, Mexico, Chile, South Africa, and Greece and 20 earthquakes. This study contributes to the literature by investigating whether earthquakes cause uncertainty in CDS markets. This study also possesses two objectives. The first is to examine the impact of natural disasters, specifically earthquakes, on sovereign credit risk. Second, as there are very few studies in this area, this research will be adding to the literature. Furthermore, this study stands out by analyzing the uncertainty introduced by earthquakes in CDS markets.

The study starts with related studies in the literature. Following after, the data and method are explained. Then after, the results of the analysis are presented. Lastly, the study concludes.

## 2. LITERATURE

Many studies have analyzed the impact of a specific event (credit rating announcements, terrorist incidents, etc.) on CDS premiums (Ismailescu & Kazemi, 2010; Kaya et al., 2015; İskenderoğlu & Balat, 2018; Uçarkaya et al., 2022). Studies have also examined the impact of natural disasters on public expenditures, public revenues, and public debt. Similarly, there are studies examining the effects of

[2] For example, the 2004 natural disaster in Grenada triggered the country's default (Asonuma, 2018: 68).

natural disasters on a country's inability to repay its debts (sovereign risk) and default risk (sovereign default). However, relatively few studies have investigated the impact of earthquakes or natural disasters (natural shocks) on CDS markets.

Lis and Nickel (2009) examined the impact of extreme weather events and natural disasters on budgets from 1985 to 2007 using panel data from 138 countries. The findings revealed that the impact of natural catastrophes on budgets differed by country group and measure. As the results indicate, disasters have a larger fiscal effect on developing nations with weaker institutions and poor governance. However, this differs for EU (European Union) and OECD (Organisation for Economic Co-operation and Development) countries. Based on the study results, the authors stated that the need for countries to achieve and maintain sound fiscal positions has increased.

Borensztein et al. (2009) investigated the vulnerability of Belize's public finances to natural disasters and the potential impact of insurance instruments on reducing this vulnerability. The results showed that natural disaster insurance is a significant positive contributor to Belize's debt sustainability. Therefore, the authors suggested that insurance coverage should be increased.

Noy and Nualsri (2011) studied the fiscal consequences of natural disasters experienced by 22 developed and 20 developing countries between 1990 and 2005. The results demonstrated that developed countries pursue countercyclical fiscal policies after a natural disaster, whereas developing countries pursue procyclical fiscal policies.

Ouattara and Strobl (2013) analyzed the fiscal consequences of natural disasters (e.g., Hurricane Katrina) that occur across Caribbean countries and found that natural disasters between 1970 and 2006 increased public spending and worsened budget deficits.

Melecky and Raddatz (2015) investigated the response of fiscal policy to natural disasters. The authors examined whether a fiscal policy response could be achieved by developing the debt market and expanding the private insurance industry. They conducted their research over 1975–2008, according to a country's income groups. According to the results, countries with well-developed debt markets can increase their public expenditures by approximately 55% after natural disasters. Therefore, countries with an efficient and effective debt market may potentially cope with the economic consequences of natural disasters through the funds they can mobilize. Furthermore, lower budget deficits and less fiscal harm from natural disasters occur in nations with high insurance rates. Consequently, these findings suggest that governments' ability to lessen shocks is significantly enhanced by their advanced fiscal structure.

Klomp (2015) analyzed the impact of 380 natural disaster events that occurred in 40 developing countries between 1999 and 2010 on public debt sustainability. The author used monthly changes in CDS premiums as an indicator of public debt sustainability and stated that CDSs are a measure of sovereign default risk. Additionally, because of short-term dynamics, for Klomp (2015), it is more

appropriate to use the CDS premium rather than changes in public debt or deficit to analyze the impact of a natural disaster on debt sustainability. The study indicates that natural disasters raise the possibility of sovereign default and decrease the sustainability of government debt.

Başkaya et al. (2016) analyzed the 1999 Marmara earthquake as an exogenous financial shock on the risk of government default and its effect on banks holding Turkish government bonds. They found that banks with a high share of government bonds in their balance sheets experienced an increased default risk, reducing credit supply. The authors emphasized the importance of the bank balance sheet channel in the earthquake's reduction of economic activity by raising the country's default risk.

Mallucci (2022) investigated whether natural disasters experienced by Caribbean countries affect sovereign default risk and welfare. Accordingly, natural disasters restrict the ability of governments to issue debt. It was also examined whether disaster clauses can mitigate the impact of natural disasters on government borrowing conditions with the author concluding that, including coupon suspension and debt reduction, clauses have positive effects on both default risk and welfare. Indeed, debt reduction clauses are more effective than coupon suspension clauses because these clauses allow governments to restart immediately after a natural disaster.

Di Tommaso et al. (2023) analyzed the impact of 92 natural disasters that occurred in 17 European countries between 2007 and 2021 on CDS markets using the event analysis method. The authors calculated the abnormal returns of countries using 5-year CDS premiums with the market model and analyzed the impact of natural disasters on CDS markets in different event windows. The results showed that a natural disaster increases country-wide risk, and this increase varies across regions. Moreover, the effects of an earthquake on CDS markets could spill over to other countries. The authors found that the response of the CDS market to natural disasters disappears after 10 days, implying that investors gradually adjust their decisions to the default of the affected country.

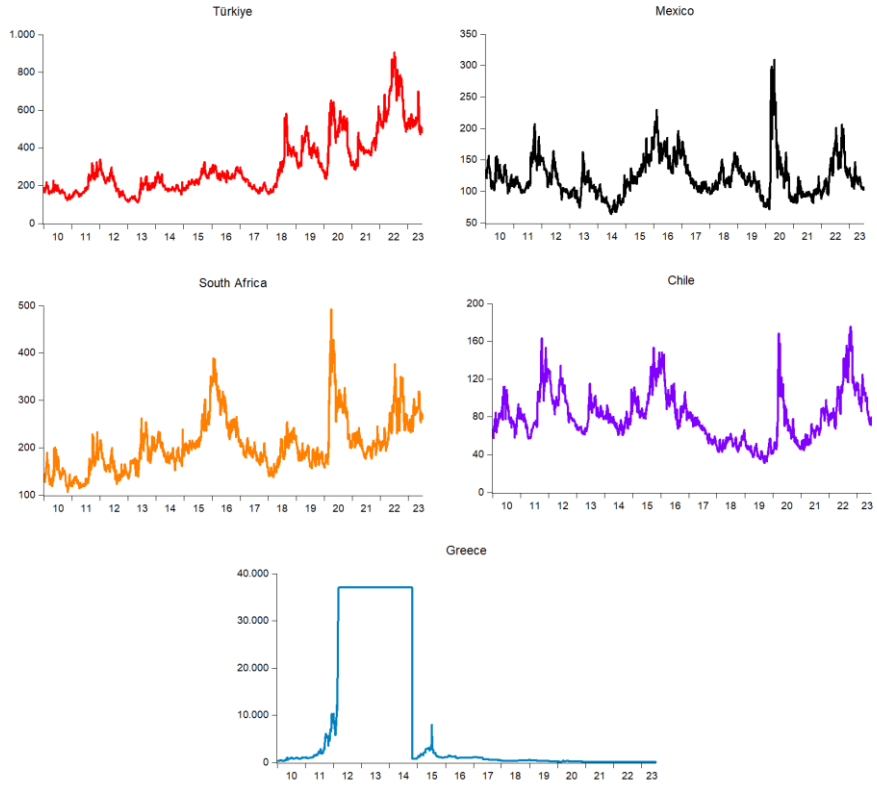
As shown above, natural disasters increase the risk of repayment of public debt and sovereign default risk. These risks are reflected in the CDS market.

## 3. METHODOLOGY

### 3.1. Data and Method

This study examines how earthquakes in Türkiye, Mexico, South Africa, Chile, and Greece after 2010 affected CDS markets. The CDS premium, which is an indicator of country risk, provides investors with relevant information concerning the non-repayment risk of public debt (Kasal & Tosunoğlu, 2022: 17). We prefer to use the CDS indicator because this study aims to analyze whether the fiscal burden caused by earthquakes increases the risks associated with debt. We obtained daily five-year sovereign CDS data for the five countries from Thomson & Reuters Datastream.

**Figure 1. Time Series Graphs of Countries' CDS Premiums**




**Source:** Datastream.

We obtained earthquake data from https://public.emdat.be/data. The EM-DAT emergency database was created in 1988 by the Center for Research in Disaster Epidemiology and the World Health Organization. It contains over 26,000 records of natural disasters worldwide since 1900 and covers from January 1, 2010 to July 10, 2023. Figure 1 displays charts that illustrate the trend in CDS premiums for countries over time.

To answer the question of this study, the event analysis method was chosen because it is more suitable for analyzing the relationship between frequent and infrequent variables (Emine et al., 2015: 563).

The event analysis method is used by economists to investigate the impact of a specific economic or financial event on a firm or asset. However, the analysis method is used in many research areas. For example, the effects of announcements of macroeconomic variables such as mergers and acquisitions, profit announcements of companies, new debt and equity issues, or foreign trade deficits can be analyzed by event analysis (MacKinlay, 1997: 13). In event analysis, to measure an event's economic impact, the actual return observed during the event and the expected or normal return are compared with the expected return in the absence of the event. Then, whether the event has created an unexpected or abnormal return on that specific asset is analyzed (MacKinlay, 1997 as cited in Uçarkaya et al., 2022: 145). In other words, event analysis aims to determine whether the realized events cause abnormal or

excessive changes in the market and whether an abnormal change is obtained between the realized and expected (normal) change (Schweitzer, 1989 as cited in İskenderoğlu & Balat, 2018: 52).

According to MacKinlay (1997: 14–15), the event analysis method consists of four steps. First, a specific event is identified; second, the estimation and event window are determined; third, abnormal returns are calculated to evaluate the impact of the event; and fourth, statistical methods are used to test whether the event makes a difference in returns.

We selected 20 earthquakes experienced by five countries after 2010 as specific events. These earthquakes severely affected the countries in loss of life and property. Then the 14-day period before the events was determined as the estimation window.[3] As for the event window, different windows were determined by following the literature, but assuming that the effect of earthquakes on CDS markets would be shorter (Uçarkaya et al., 2022: 145), thus three- ([−3, +3]) and seven-day ([−7, +7]) periods before and after the events were used[4]. Next, the average and cumulative abnormal returns of return volatilities were calculated. Returns are logarithmic daily differences. The GARCH (1, 1) method was used to calculate the volatility of returns on CDS premiums. The average return approach was used to compare the estimation window with the event window. The reason for taking volatilities into account is to understand whether the uncertainty about the probability of default of the country has changed compared to the pre-earthquake period. An important factor affecting the cost of public borrowing is uncertainty (Kasal & Tosunoğlu, 2022: 16), and CDS premiums reflect this uncertainty. Lastly, we use paired sample t-test to examine whether earthquakes affect CDS markets. This test statistically measures whether there is a difference between the means of two samples under the null and alternative hypotheses.

### 3.2. Empirical Results

Table 1 presents the findings where the first column includes countries, the second column includes earthquakes, and the third and fourth columns display the probability values of the paired samples t-test statistics for volatilities, showing whether earthquakes affect the variables for volatilities.

[3] Following Di Tommaso et al. (2023), 150 days [−150; 0] were used as the estimation window, and the results did not change.
[4] Different event windows were determined as the event window, and it was observed that the most important realizations were in the [-3, +3] and [-7, +7] event windows.

**Table 1. Paired Samples T-Test**

| | | **Probability values of the t-statistics of volatility averages** | |
|---|---|---|---|
| **Countries** | **Earthquakes** | **[−3] [+3]** | **[−7] [+7]** |
| **Türkiye** | 05/19/2011-Kütahya Earthquake | 0.011** | 0.000*** |
| | 10/23//2011-Van Earthquake | 0.013** | 0.000*** |
| | 01/24/2020-Elâzığ Earthquake | 0.427 | 0.449 |
| | 10/30/2020-İzmir Earthquake | 0.005*** | 0.000*** |
| | 02/06/2023-K.maraş Earthquake | 0.004*** | 0.000*** |
| **Mexico** | 04/04/2010-Mexicali Earthquake | 0.000*** | 0.017** |
| | 03/20/2012-Guerrero, Oaxaca, Mexico Earthquake | 0.000*** | 0.011** |
| | 07/07/2014-Chiapas Earthquake | 0.000*** | 0.010** |
| | 09/08/2017-Oaxaca, Chiapas, Tabasco Earthquake | 0.000*** | 0.009*** |
| | 09/18/2017-Puebla Earthquake | 0.000*** | 0.015** |
| | 02/16/2018-Oaxaca Earthquake | 0.000*** | 0.010** |
| | 06/23/2020-South Oaxaca (Mexico) Earthquake | 0.003*** | 0.073* |
| | 09/08/2021-South Guerrero Earthquake | 0.000*** | 0.009*** |
| | 09/18/2022-Colima, Michoacán, Jalisco Earthquake | 0.000*** | 0.012** |
| | 09/22/2022-Mexico; Coalcomán; Colima, Guerrero Jalisco Earthquake | 0.000*** | 0.009*** |
| **South Africa** | 08/05/2014-Orkney Earthquake | 0.000*** | 0.008*** |
| **Chile** | 03/25/2012-Parral, Santiago, Biobio Earthquake | 0.000*** | 0.011** |
| | 04/01/2014-Arica y Painacota, Alto Hospicio Earthquake | 0.000*** | 0.013** |
| **Greece** | 03/03/2021-Larissa Earthquake | 0.000*** | 0.010** |
| | 09/27/2021-Arkalochori Earthquake | 0.000*** | 0.010** |

***, **, * refer to statistically significant values of 1%, 5%, and 10%, respectively.

According to the Table 1 results, a statistically significant difference exists between the averages of the cumulative abnormal change ratios obtained for volatility values for the specified event windows in all countries. According to the probability values in the third and fourth columns, in all countries (except for the Elâzığ earthquake), uncertainty in CDS markets was higher after the earthquake than before. High uncertainty reflects investor perceptions about the ability of countries to repay their debts and markets' uncertainty about the future.

Unexpected large shocks create uncertainty in markets. This uncertainty causes investors to be more cautious about the risk of countries defaulting on their debts. Therefore, the increase in uncertainty after an earthquake suggests that these events may make people more cautious about lending to

countries. In short, the table results suggest that earthquakes create more uncertainty in markets. This uncertainty helps us understand how earthquakes can affect CDS markets and sovereign debt sustainability.

Our results support the few studies that investigate the impact of earthquakes or natural disasters (natural shocks) on CDS markets. Indeed, the results support the likes of Klomp (2015), Mallucci (2022), and Di Tommaso et al. (2023). Klomp (2015), Mallucci (2022), and Di Tommaso et al. (2023) find evidence that earthquakes negatively affect CDS premiums. Our empirical results are consistent with the results in the literature.

## 5. CONCLUSION

Natural disasters result in less economic activity and a greater fiscal burden on the government. Furthermore, government expenses on businesses and households affected by earthquakes contribute to the burden on public finances, alongside the loss of tax revenues due to the reduction in the workforce and the loss of income. Governments are pushed into the borrowing market by the rise in their budget's income-expenditure imbalance. This also raises doubts about governments' ability to pay their current debt. An increase in uncertainty increases the likelihood of a sovereign default. Massive, severe, and devastating earthquakes undermine investors' expectations of the country's ability to fulfill its financial obligations. In this context, CDS is a very strongly representative indicator.

This study examines the impact of earthquakes on volatility in the CDS markets of five countries over 2010–2023 using the event analysis method. The study's findings indicate that after earthquakes, CDS market uncertainty rose across all countries, suggesting that there was a rise in uncertainty about the repayment of public debt. The findings highlight the role of natural shocks in influencing the sustainability of public debt. Consequently, earthquakes possess a detrimental short- and medium-term impact on public finances and raise the possibility of sovereign default on governments.

These results call for various fiscal policy measures for governments. First of all, governments should work on disaster preparedness and create an emergency fund to mitigate the impact of natural disasters. Second, public revenues need to be diversified. This ensures a more stable revenue structure. Finally, there is a need to adopt prudent public debt management practices. Such policies prevent governments from being adversely affected by markets. As a result, governments can build debt capacity that is resilient to natural disasters by developing policies within the framework of these fiscal policies. Thus, negative effects on sovereign default risk and financial stability are minimized.

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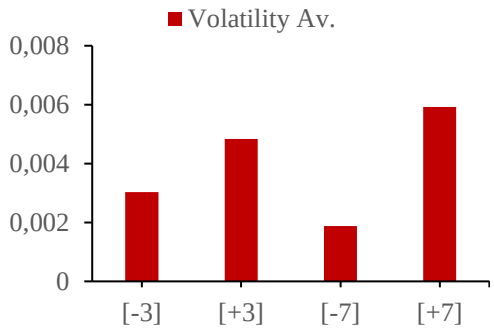
## APPENDIX

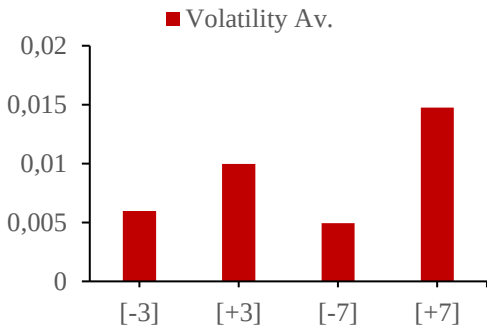
**Figure 2. CDS Volatility Averages Before and After Türkiye Earthquakes**

**Türkiye**

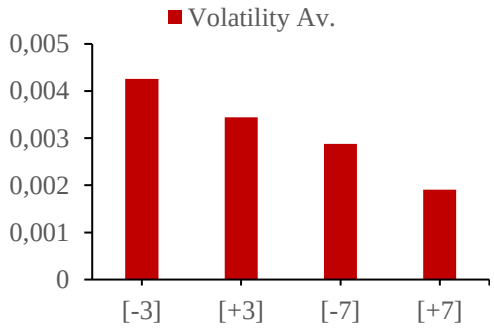
**05/19/2011-Kütahya Earthquake**



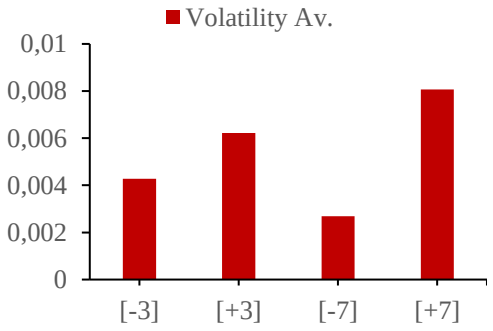

**10/23//2011-Van Earthquake**



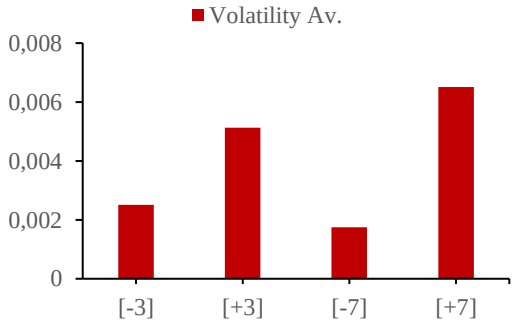

**01/24/2020-Elâzığ Earthquake**




**10/30/2020-İzmir Earthquake**

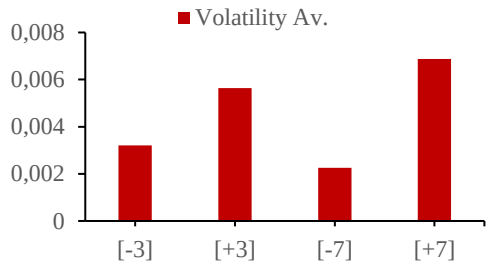
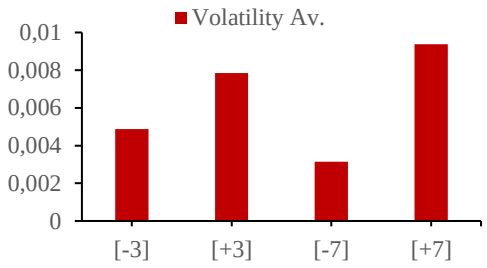
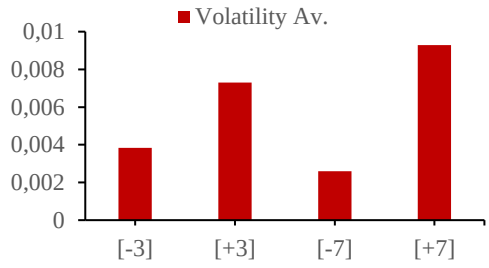
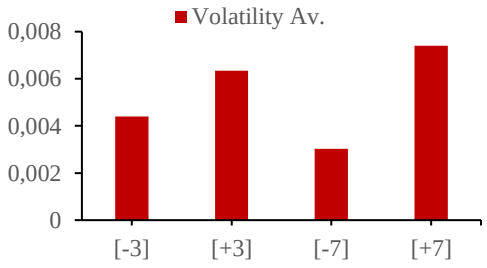
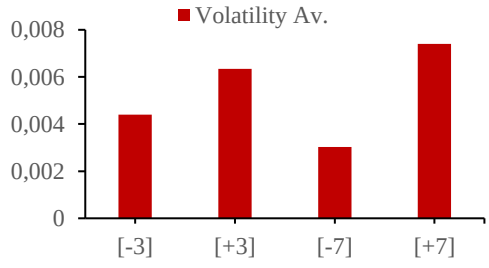
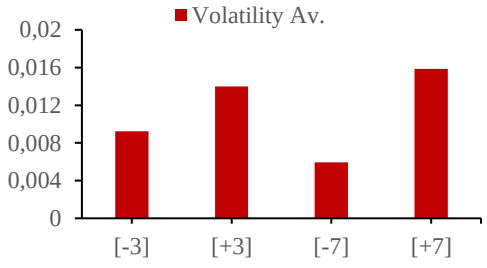



**02/06/2023-K.Maraş Earthquake**




**Source: Authors' own estimates.**

**Figure 3. CDS Volatility Averages Before and After Mexico Earthquakes**

| Mexico | 04/04/2010-Mexicali Earthquake | 03/20/2012-Guerrero, Oaxaca, Mexico Earthquake |
|---|---|---|
| |  |  |
| | **07/07/2014-Chiapas Earthquake** | **09/08/2017-Oaxaca, Chiapas, Tabasco Earthquake** |
| |  |  |
| | **09/18/2017-Puebla Earthquake** | **02/16/2018-Oaxaca Earthquake** |
| |  |  |
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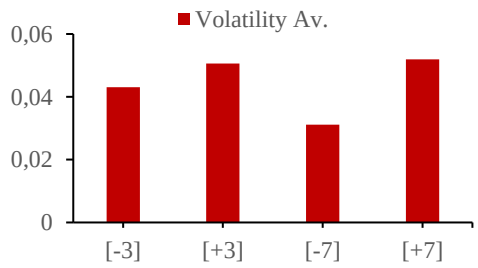
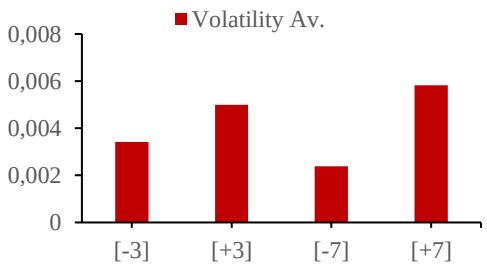
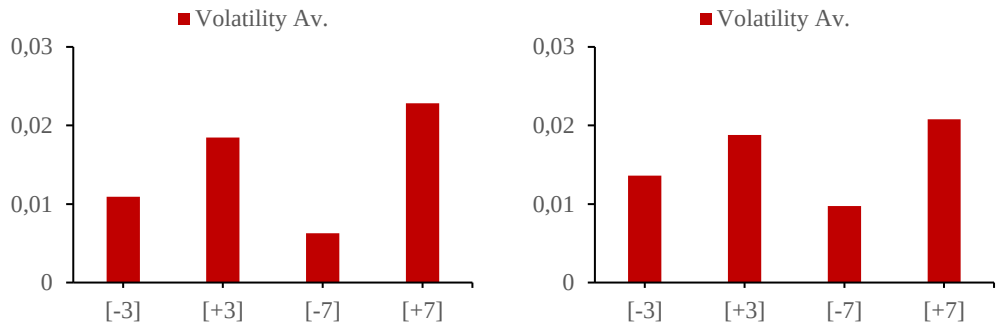
| |  |  |

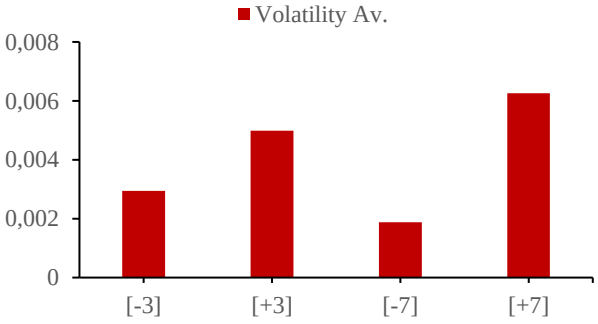
| | 09/18/2022-Colima, Michoacán, Jalisco Earthquake | 09/22/2022-Mexico; Coalcomán; Colima, Guerrero Jalisco Earthquake |
|---|---|---|




**Source: Authors' own estimates.**

**Figure 4. CDS Volatility Averages Before and After South Africa Earthquakes**

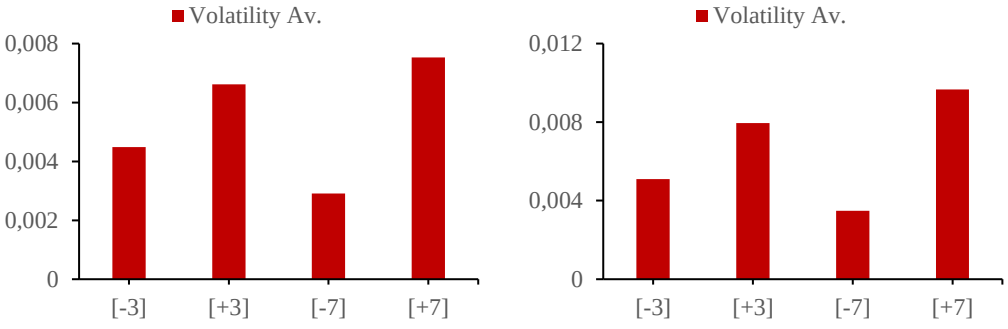
| South Africa | 08/05/2014-Orkney Earthquake |
|---|---|




**Source: Authors' own estimates.**

**Figure 5. CDS Volatility Averages Before and After Chile Earthquakes**

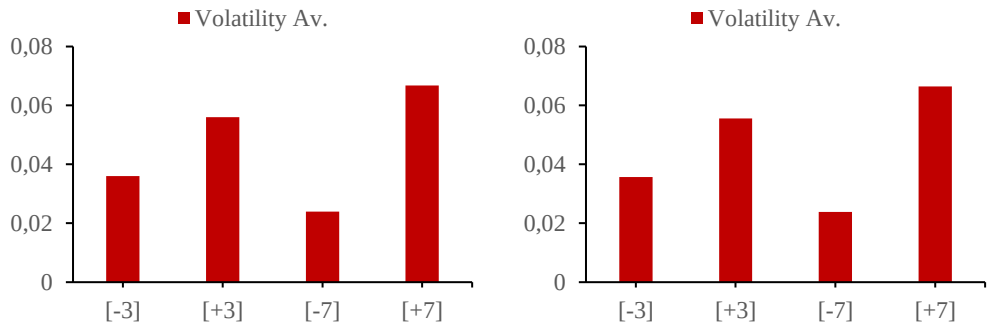
| Chile | 03/25/2012-Parral, Santiago, Biobio Earthquake | 04/01/2014-Arica y Painacota, Alto Hospicio Earthquake |
|---|---|---|




**Source: Authors' own estimates.**

**Figure 6: CDS Volatility Averages Before and After Greece Earthquakes**

| Greece | 03/03/2021-Larissa Earthquake | 09/27/2021-Arkalochori Earthquake |
|---|---|---|




**Source: Authors' own estimates.**

| **KATKI ORANI / *CONTRIBUTION RATE*** | **AÇIKLAMA / *EXPLANATION*** | **KATKIDA BULUNANLAR / *CONTRIBUTORS*** |
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