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THE IMPACT OF THE 2023 KAHRAMANMARAŞ EARTHQUAKE ON BIST100 AND BIST BANK INDEX: EVIDENCE FROM TODA-YAMAMOTO CAUSALITY TEST

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ABSTRACT
Purpose- The effects of the Kahramanmaraş-centred earthquakes that occurred on 6-7 February 2023 on the Borsa Istanbul 100 index and the Banking index are examined.
Methodology- Between 06/02/2023 – 07/02/2023, econometric analysis was applied by using BIST 100, BIST BANK index and earthquake data consisting of 312 observations. To determine the degrees of stationarity of the variables, the PP and ADF tests were applied in the study. In the series in which Unit Root analysis was carried out, the VAR model was used to apply Toda-Yamamoto causality analysis. Additionally, techniques for impulse-response functions and variance decomposition were also used.
Findings- It has been discovered that the series' level difference is stationary. The Toda-Yamamoto Causality test findings demonstrate a causative link between earthquake magnitude, the BIST 100 index, and the BIST Banking index. In every time, the variations in BISTBANKA and BIST100 are largely self-explanatory.
Conclusion- These findings led to the conclusion that the Kahramanmaraş Earthquake had an impact on the decline of the Borsa Istanbul 100 index and banking index on the 6-7 February 2023.

Keywords: Earthquake, Borsa Istanbul, BIST100, BIST-BANKA, Toda-Yamamoto Causality Test
JEL Codes: G21, P45, Q54

1. INTRODUCTION

Depending on the scale of the catastrophe and the local economy, natural disasters lower the capacity for growth and development of nations. Different economic studies have been conducted on disastrous natural catastrophes such, fires floods, tsunamis and earthquakes. It demonstrates how the destruction of life, property, superstructure, and infrastructure brought on by natural catastrophes damages the employment, services, and production structures of economies throughout the short, medium, and long term. The results of studies on the impact and duration of economic loss demonstrate that these factors rely on the scale of the catastrophe, the country's economic situation at the time it happens, and institutional efficacy (Noy, 2009; Cavallo at al., 2013; Lackner, 2018; Hallegatte at al., 2022; Durose, 2023).

Two earthquakes with Mw 7.7 and 7.6 magnitudes struck the Pazarck and Elbistan districts of Kahramanmaras on February 6, 2023, leaving a trail of destruction and fatalities over 11 neighboring provinces. The earthquake caused high loss of life and property in eleven provinces, among them Adana, Adıyaman, Diyarbakır, Elazığ, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye, and Şanlıurfaurfa. As a consequence of the natural disaster, in which about 50,000 people lost their lives, a large group of people had to immigrate to other cities in Turkey (Cinar at al., 2023). People were transported to various cities by Turkish airlines and road transport businesses for free or at extremely reduced costs. Residents of the earthquake zone were provided with temporary settlements. The Turkish Treasury enhanced the credit warranty fund's guarantees and postponed the loan repayments for the companies doing business in the earthquake zone (AFAD, 2023).

Stock returns are affected by almost all economic, political and social events, although the degree of importance varies. One of these is natural disasters. Perhaps the most important of these disasters is the risk of earthquakes. Earthquakes, which occur unexpectedly, cause great loss of life and property, upset the economic development plans that are being implemented and disrupt the already problematic income distribution. completely destabilises it (Say ve Doğan, 2023: 91).

The earthquake also had a negative effect on the financial markets. BIST100 index fell around 10% of its value on the day of the first earthquake. Notwithstanding, the Istanbul Stock Market interrupted its operations on the 3rd day of the earthquake for a week (Gürsoy at al., 2023: 99).

In light of this, The sample of Turkey was used for the investigation. The study is one of the first ones looking into how the two significant earthquakes that hit Turkey on February 6, 2023 affected the financial markets. The BIST 100 index and the BIST BANK index were each examined separately to determine how the earthquake affected them. Toda-Yamamoto causality tests, PP unit root tests, and ADF are the methods that set this work apart from other investigations. The study is significant because it adds to the body of knowledge and offers fresh information regarding the impact of earthquakes upon the financial markets. In addition, while the studies in the literature are handled on a sectoral basis, this study covers multiple indexes and offers a broader perspective.

This research is divided into five components. In the introduction part, an attempt is made to communicate the study's purpose, significance, and motivation. The second section covers discussing the literature. The third section provides a detailed explanation of both the dataset and the methodology. The research findings are presented and discussed in the fourth section. In the finally part, the conclusions of the report, in which the findings are analysed in the comparison with the literature and suggestions are made, are included in the final chapter.

2. LITERATURE

There is a limited number of studies analysing the impact of earthquakes on financial markets in the literature. This section summarises the studies on the effects of earthquakes on financial markets in the national and international literature.

Shelor et al. (1990) investigated the impact of the 17 October 1989 earthquake in California, USA on the stock performance of real estate industry firms. In the study, the price reaction of stocks to the event was measured by using a market model. The expected post-event returns were estimated by using the pre-event market performance and the predicted returns were compared with the actual returns. The study's findings revealed that while companies based in other parts of the sector did not experience this effect, companies in the San Francisco region experienced a damaging effect regarding stock returns as a result of the earthquake.

Following the 1994 Los Angeles earthquake, researchers analyzed insurance company estimates, Lamb and Kennedy (1997) found that there was evidence of a favorable stock response.

Yamori and Kobayashi (2002) looked at how the 1995 Hanshin-Awaji earthquake in Japan affected stock prices for companies in the insurance sector. The study's findings emphasized that the earthquake had a detrimental impact on stock price movements and that Japanese stock markets were very good at evaluating information after the event.

Worthington and Valadkhani (2004) used ARMA models to analyze the effects of environmental concerns on the Australian stock market between December 31, 1982 and January 1, 2002. The results of the study indicate that earthquakes, fires, and cyclones all have a major impact on market returns. The day following the occurrence is when an earthquake's effects are the most pronounced, and they start to fade over the following few days.

Another study by Bolak and Süer (2007) used the event study approach to determine the impact of the Marmara earthquake, which was centered at Gölcük on August 17, 1999, on the stocks of enterprises involved in the stone and soil industry traded on the Borsa Istanbul exchange. The findings revealed that the stone and soil-based industrial companies' stock returns following the earthquake were above average and notably positive.

Worthington (2008) used GARCH model in the Australian market and examined the data for the period 01.01.1980-30.06.2003. The study's findings suggest that there is little correlation between natural disasters and stock market returns. This suggests that financial market shocks are not a systematic factor of risk and that financial diversification can help to lessen their consequences. Earthquakes and other natural disasters have a direct effect on more than just the world's financial markets. Additionally, household earnings are negatively impacted.

Scholtens and Voorhorst (2013) analysed more than 100 earthquakes that occurred in 21 countries between 1973 and 2011 using the event study method and concluded that they had an important and negative impact at the stock exchange value. As well, it is emphasised that these effects do not vary according to the severity of the earthquakes and the income status of the countries.

Using the discounted cash flow method, Takao et al. (2013) looked into how the Great East Japan Earthquake of March 11, 2011, affected non-life insurance companies. The results of the study provide credence to the assertion that insurance company stock prices declined after the earthquake and that Japan's earthquake insurance system stabilizes the stock market.

Using the event study approach, Ylmaz and Karan (2015) looked into how the Ceyhan, Marmara, and Van earthquakes, which struck Turkey on various dates, affected stock returns for companies listed on the Istanbul Stock Exchange and in various industries. The study's findings indicate that, in terms of aberrant returns, the Marmara earthquake had a negative effect on the banking, insurance and real estate investment trust sectors and a positive effect on the stone-earth sector, while the Van earthquake had a positive effect on the stone-earth sector and no effect on other sectors. In addition, it was stated that the Ceyhan earthquake did not have any effect on abnormal returns in these sectors.

Ferreira et al. (2015) looked at the impact of earthquakes on the financial market over a 20-year period and demonstrated that every country experiences earthquakes at a different pace while also demonstrating that the financial markets worldwide are resilient to earthquake shock. Gignoux and Menéndez (2016) noted that although people had financial setbacks in the immediate aftermath of the earthquake, their financial situation began to improve between two and five years afterwards. It was discovered that over the long term, during the periods of 6 to 12 years, people grew their incomes and assets.

Earthquakes' shocking effects on the Republic of Turkey's stock index from 2000 to 2017 was studied by Yıldırım and Alola (2020). To evaluate the long-run association between the number of monthly earthquakes, the exchange rate, uncertainty on global economic policy (GEPU), and the Borsa Istanbul Real Estate Investment Trust Index (XGMYO), the autoregressive distributed lag (ARDL) model was chosen for the research.The study's findings indicate that variables including the frequency of earthquakes, the GEPU, and the stock market index is significantly and negatively affected over the long term by the exchange rate.

In a subsequent study by Hamurcu (2022), the effects of earthquakes on the stocks of companies in the insurance sector were examined by looking at how the BIST TUM index's insurance sector companies responded to the earthquake that struck Izmir on October 30, 2020, using the event study method. The findings show that across periods of 15, 30, 45, and 60 days, the earthquake had a negative effect on the cumulative returns of stocks in the insurance sector.

Say and Doğan (2023) looked into how the earthquake with its epicenter in Turkey's Kahramanmaraş on February 6 affected the stock prices traded in Borsa Istanbul. The possibility of obtaining abnormal returns during Turkey's earthquake period has been investigated. It was able to determine whether there had been an abnormal return by contrasting the stock market returns 15 days before and 15 days after the event day.

On a sectoral level, Gürsoy et al. (2023) looked at the financial markets' responses to Turkey's 6.2.2023 Kahramanmaraş earthquake. The results of the study, which employed the Fourier Volatility Dispersion test, show that each sector experienced different quake effects. In terms of volatility spillovers, it is discovered that the magnitude of the earthquake has no effect on the Borsa Istanbul's food, REIT, and mining sectors. The magnitude of the earthquake and the volatility of these indexes in the banking, intermediary institutions, IT, SME, and textile sectors, however, are causally related.

3. METHODOLOGY

The Vector Autoregressive Model (VAR) was employed in this study to examine how the Kahramanmaraş earthquakes affected the BIST 100 index and BIST banking index. The Granger causality tests can be applied and interpreted pretty easily. To utilize the Granger (1988) approach, The cointegration and integration of the non-stationary series must happen in the same order. The technique created by Toda and Yamamoto (1995) enables causality analysis for a series integrated without needing the presence of a cointegration connection, at the same or different degrees.

The data must be stationary to perform the Toda-Yamamoto cause and effect test. Unit root tests handle the stationarity analysis. The unit root test was analyzed in this work using the Augmented Dickey Fuller (ADF) method (Dickey and Fuller, 1979: 427–431) and the Philips Perron (PP) method (Philips and Perron, 1988: 335–346). The MacKinnon 5% critical value (MacKinnon, 1996) is compared to the test for stationarity.

Given that the test approach is trustworthy for the cointegration and integration processes, Toda and Yamamoto (1995) suggest a simple method using augmented VAR estimation that ensures the Wald statistic's asymptotic distribution (asymptotic $\chi 2$ -distribution).

To investigate the impact on BIST100 and BISTBANKA following Yamada (1998), a VAR (m + dmax) composed of BIST 100 index, BIST Bank index, and earthquake intensity variables will be utilized. After the unit root test, the following associated equations are used to analyze the Toda-Yamamoto causality test:

$$Y_t=\overline{w}+\sum_{i=1}^{k} a_{1i}X_{t-i}+\sum_{i=1}^{k} \beta_{1i}Y_{t-i}+\sum_{j=m+1}^{d_{max}} \delta_{1i}X_{t-i}+\sum_{j=m+1}^{d_{max}} \vartheta_{1i}Y_{t-i}+\varepsilon_{1t} \quad (1)$$

$$X_t=\partial+\sum_{i=1}^{k} a_{2i}X_{t-i}+\sum_{i=1}^{k} \beta_{2i}Y_{t-i}+\sum_{j=m+1}^{d_{max}} \delta_{2i}X_{t-i}+\sum_{j=m+1}^{d_{max}} \vartheta_{2i}Y_{t-i}+\varepsilon_{2t} \quad (2)$$

The model has $\varepsilon 1t$ and $\varepsilon 2t$ as independent errors as well as, ω, θ's, δ's, ψ's, ϕ's, β's as a model parameter. There are two steps in putting the analysis into practice. Choosing the maximum level of integration for the system's variables (dmax) comes in the second stage after the length of the lag (m) is determined in the first.

4. FINDINGS

The two days (6 February and 7 February 2023) of stock market trades after the 7.7-magnitude earthquake at the midnight of 6 February were covered by the data. The quakes that happened during these two days and the related index values make up the utilised data. In this framework, a totally 312 momentary Observations were determined in 2 days. BIST 100 index and BIST BANK index are used on the basis of the index. While The Matriks Data Information Distribution Services platform was used to continuously monitor the stock market indices, the regional earthquake-tsunami monitoring and assessment center (KRDAE), which is located in Kandilli, collected the seismic datasets from its public domain database.

Table 1 below lists the study's parameters in detail.

Table 1: Variables

XU100	Borsa Istanbul 100 Index
XBANK	Borsa Istanbul Bank Index
EM	Earthquake Magnitude

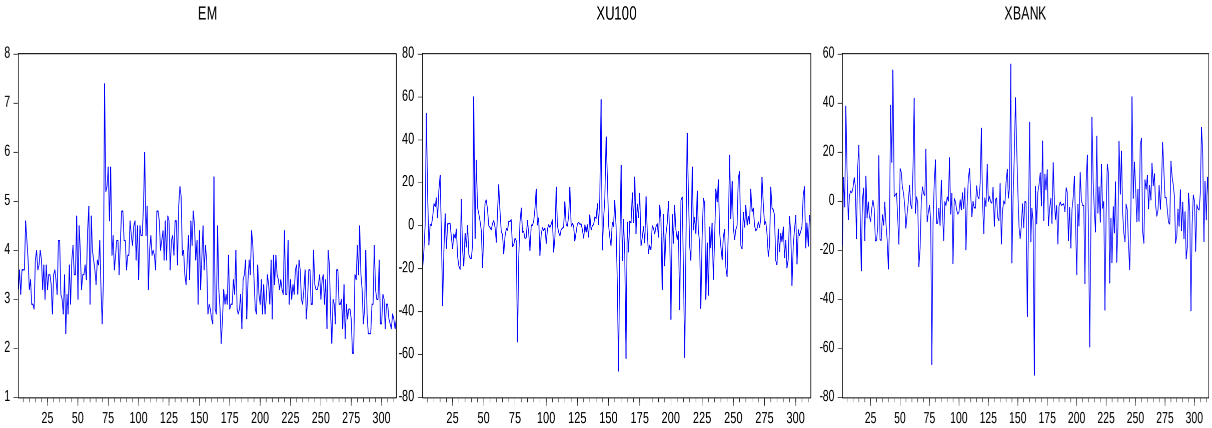
Table 2 provides an overview of the statistical data for the variables.

Table 2: Summary of Statistical Information of Variables

	XU100	XBANK	EM
Mean	-1.199.103	-1.005.160	3.533.333
Median	-0.690000	-1.030.000	3.500.000
Maximum	6.022.000	5.592.000	7.400.000
Minimum	-6.777.000	-7.103.000	1.900.000
Std. Dev.	1.483.847	1.540.188	0.762829
Skewness	-0.249622	-0.281257	0.785757
Kurtosis	8.034.963	6.886.218	4.669.906
Jarque-Bera	3.328.012	2.004.484	6.835.714
Probability	0.000000	0.000000	0.000000

A basic understanding of normality can be seen in the tables' skewness and kurtosis variables. The distribution's symmetry in reference to the means is expressed by the skewness value. The kurtosis value depicts a bulging or straightening. The distribution is kurtosis if the values are less than 3, according to statistics. Jarque-bera measures show the result of the distribution test. Probability values indicate that the null hypothesis "H_0: Error terms are normally distributed" is acceptable in every series.

Figure 1: XU100, XBANK, EM Series



Time series do not exhibit movement around their average ratios. The series may have a unit root as a result of this condition. In this respect, false regression must be avoided by subjecting the series to the PP and ADF unit root tests mentioned in Table 3.

Table 3: Test results for unit roots

	ADF TEST		PP TEST		Unıt Root Results
	Test Stat.	P.V	Test Stat.	P.V	
XU100	-14,521050	0,0000	-14,522400	0,0000	I(0)

XBANK	-15,676182	0,0000	-15,687828	0,0000	I(0)
EM	-4,924853	0,0000	-12,405638	0,0000	I(0)

The level values of the XU100, XBANK, and EM series are less than the MacKinnon 5% significance levels, the t-statistics and probability values in Table 3 are compared to that value. This demonstrates that the series is stable and devoid of a unit root.

The most popular Akaike information criterion (Akaike, 1974) was utilized in the study as the lag duration. According to the Schwarz Information Criterion (SIC), Akaike's Final Prediction Error (FPE) criterion, and the sequential modified LR test statistic (each test at 5% level), Table 4 demonstrates that the series has a delay of 5.

Table 4: Criteria for Lag-Order Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2.591.836	NA	5.206.489	1.707.129	1.710.797	1.708.597
1	-2.542.877	9.663.060	4.002.898	1.680.840	**16.95513***	1.686.709
2	-2.521.250	4.225.684	3.683.893	1.672.533	1.698.210	**16.82805***
3	-2.512.222	1.746.343	3.683.370	1.672.514	1.709.196	1.687.188
4	-2.505.245	1.335.640	3.733.050	1.673.846	1.721.531	1.692.921
5	-2.493.387	**22.46846***	**3664.003***	**16.71965***	1.730.655	1.695.442
6	-2.489.691	6.930.105	3.794.861	1.675.454	1.745.149	1.703.334
7	-2.482.088	1.410.437	3.830.954	1.676.374	1.757.073	1.708.655
8	-2.475.489	1.211.371	3.893.321	1.677.953	1.769.656	1.714.637

The greatest degree of integration (k+dmax) for a 5 lag is 5. Consequently, the XU00 variable equation;

XU100 = C(1)*XU100(-1) + C(2)*XU100(-2) + C(3)*XU100(-3) + C(4)*XU100(-4) + C(5)*XU100(-5) + C(6)*XBANK(-1) + C(7)*XBANK(-2) + C(8)*XBANK(-3) + C(9)*XBANK(-4) + C(10)*XBANK(-5) + C(11)*EM(-1) + C(12)*EM(-2) + C(13)*EM(-3) + C(14)*EM(-4) + C(15)*EM(-5) + C(16) (3)

Thus, the equation of XBANK variable;

XBANK = C(17)*XU100(-1) + C(18)*XU100(-2) + C(19) *XU100(-3) + C(20)*XU100(-4) + C(21)*XU100(-5) + C(22) *XBANK(-1) + C(23)*XBANK(-2) + C(24)*XBANK(-3) + C(25) *XBANK(-4) + C(26)*XBANK(-5) + C(27)*EM(-1) + C(28) *EM(-2) + C(29)*EM(-3) + C(30)*EM(-4) + C(31) *EM(-5) + C(32) (4)

Lag length 5 is employed in the study since key criteria like Akaike and the final prediction error criterion point to this value. The (k+dmax) value is then calculated to be 5. Table 5 displays the outcomes of the Toda-Yamamoto causality test.

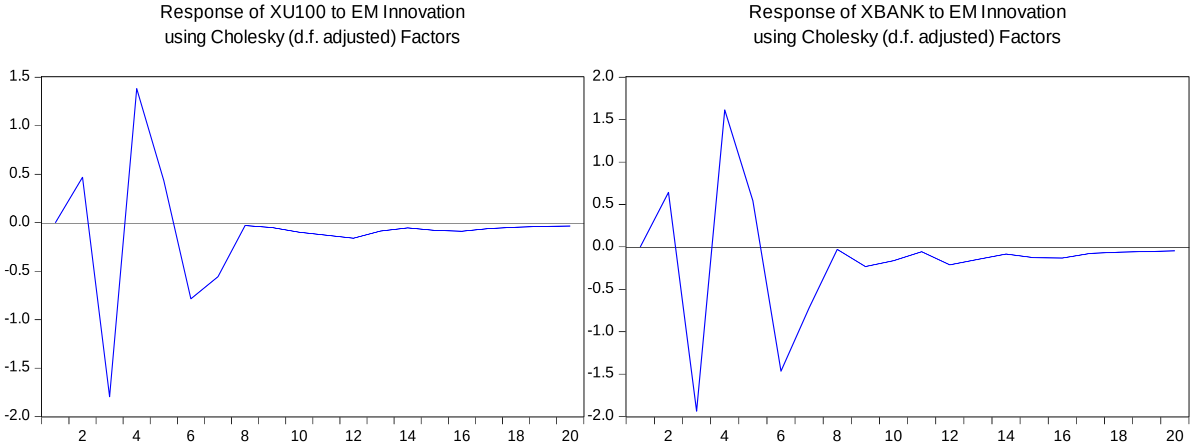
Table 5: Results of the Toda-Yamamoto Causality Test

	Lag (k)	Lag (k+dmax)	Chi-square	Prob.	Results
EM→XU100	5	5+0	12,27159	0,0313	There is causality.
EM→XBANK	5	5+0	16,32997	0,0060	There is causality.

The Toda-Yamamoto causality test study shows that the EM index (an independent variable) has an impact on the dependent variables XU100 and XBANK. As a result, there is a causal connection between the chosen data.

Figure 2 depicts the BIST 100 and BIST BANK index's (dependent variable) impulse-response functions in relation to the earthquake. The vertical axes in the representation of these functions reflect the reaction of the pertinent variant, while the horizontal axes show the time that has passed since the shock for each variable. As observed in the graph, the influence of the earthquake on BIST 100 and BIST BANKA variables starts to decline at the end of my 8th term.

Figure 2: Impulse-Response Functions of XU100 and XBANK



After examining the impulse response functions, a variance decomposition analysis is carried out to determine the reason why the variables changed. The variance decomposition analysis reveals the proportion of variation in the model's variables that is attributable to the variables themselves and the remainder that is attributable to other factors.

Table 6: Variance Decomposition of XU100

Period	XU100	XBANKA	SIDDET
1	100,0000	0,00000	0,00000
2	99,63697	0,25799	0,10504
3	97,86966	0,51058	1,61977
4	96,90291	0,62326	2,47383
5	96,83116	0,62244	2,54640
6	96,15049	1,06456	2,78495
7	96,01261	1,07466	2,91273
8	96,01052	1,07800	2,91148
9	95,99927	1,08912	2,91160
10	95,99475	1,08964	2,91561
11	95,98806	1,08979	2,92215
12	95,97085	1,09582	2,93334
13	95,96759	1,09595	2,93647
14	95,96639	1,09596	2,93765
15	95,96337	1,09618	2,94045
16	95,95985	1,09635	2,94380
17	95,95828	1,09633	2,94539
18	95,95737	1,09631	2,94632
19	95,95674	1,09630	2,94696
20	95,95617	1,09632	2,94752

Table 6 shows the variance decomposition of the variables used in the model for 20 periods according to XU100 XUBANK and EM ranking. In every time, BIST100's variations can mostly be accounted for by itself.

Table 7: Variance Decomposition of XUBANK

Period	XU100	XBANKA	SIDDET
1	0,00000	100,0000	0,00000
2	1,35125	98,46390	0,18485
3	2,23727	95,95275	1,80998
4	2,48273	94,63381	2,88346
5	2,80172	94,20701	2,99127
6	4,78206	91,43227	3,78567
7	4,79411	91,22812	3,97778
8	4,89111	91,13531	3,97358
9	4,93531	91,07226	3,99244
10	4,93776	91,06004	4,00221
11	4,93746	91,05997	4,00257
12	4,95222	91,02846	4,01932
13	4,95244	91,02011	4,02745
14	4,95213	91,01773	4,03015
15	4,95229	91,01126	4,03645
16	4,95205	91,00464	4,04332
17	4,95237	91,00201	4,04562
18	4,95252	91,00033	4,04715
19	4,95249	90,99918	4,04834
20	4,95245	90,99837	4,04919

Table 7 shows the variance decomposition of the variables used in the model for 20 periods according to XU100 XUBANK and EM ranking. In all periods, XUBANK's variations may be largely accounted for by itself.

5. CONCLUSION

An earthquake is called a trembling vibration caused by the energy that emerges suddenly due to fractures in the earth's crust and spreads in waves and creates trembling vibrations in the environments and the earth's crust. Considered as one of the most important disasters for Turkey, earthquakes have had damaging effects of different magnitudes from past to present. Depending on the severity of the earthquake, the damage done, and the earthquake zone, there are significant economic impacts following the earthquake in addition to the loss of life.

In this study, the effects of the Kahramanmaraş-centred earthquakes that occurred on 6-7 February 2023 on Turkey BIST 100 and BIST Bank indices are analysed. In this context, econometric analysis is applied using BIST 100 index, BIST Bank index and earthquake intensity data consisting of 312 minute observations between 06/02/2023 - 07/02/2023.

The impulse-response and variance decomposition approaches were also employed to support the Toda-Yamamoto causality test, which was the study's main econometric tool. The Toda-Yamamoto causality test results show that the earthquake had an impact on both the BIST100 index and the BIST Bank index.

The influence of earthquake intensity on the BIST 100 index and BIST Bank index does not drop fast in a short period of time and finishes at the end of the eighth period as a result of the impulse-response functions. To identify the cause of the change in variables, variance decomposition analysis is carried out after the examination of the impulse-response functions. The variables were decomposed into their component parts throughout 20 periods. The variables underwent a variance decomposition test lasting 20 days. The variations of the study's primary variables, the BIST100 index and BIST Bank index, are mostly self-explanatory across all time periods.

This study exclusively evaluates the problem in terms of the BIST 100 index and the BIST Bank index. First, the BIST 100 and BIST Bank firms should be used to understand the results. Therefore, it will be crucial for more studies to be undertaken in this area to examine the quake's aftereffects in services and goods marketplaces where the direct quake's aftereffects are felt. Studies that consider the socio-economic issues associated with post-earthquake house building and migration will also offer clearer and more convincing evidence when evaluating the situation. Future research may also analyze the short- or long-term consequences of the earthquake on the price of gold, foreign exchange, commodities, or another sector.

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