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Seismic activity and market efficiency

A case study of 2023 Turkish earthquakes

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ABSTRACT:

The occurrence of earthquakes presents a significant challenge, often resulting in high casualties and extensive damage. Beyond the immediate humanitarian impact, earthquakes also have far-reaching consequences for financial markets, which is seen as the barometer for economic resilience. In 2023, Türkiye experienced two earthquakes with magnitudes of 7.7 Mw and 7.6 Mw, occurring in close proximity causing a high number of casualties and economic damage.

The literature remains divided on the precise effects of earthquakes on stock markets, with some studies suggesting significant negative impacts, while others find no statistically significant effects. Against this backdrop, this thesis seeks to investigate the impacts of the 2023 earthquakes on the Turkish stock market. Employing an event study methodology, the analysis focuses on sectoral indices and individual stock returns constituting the market index. The findings of this study reveal that while the earthquakes did not yield statistically significant results on the event day, subsequent days witnessed fluctuating effects, with returns fluctuating between positive and negative. Consequently, cumulative abnormal returns also failed to demonstrate statistical significance.

However, studying at the sectoral level demonstrated a different picture. The results also showed that while many sectors experienced negative impacts initially, the dispersion of these effects throughout the event window was evident. Notably, sectors such as basic materials and non-metal products exhibited statistically significant positive abnormal returns. On the other hand, the insurance sector emerged as particularly vulnerable, bearing statistically significant negative impacts.

In conclusion, this thesis underscores the complex interplay between seismic events and financial markets, emphasizing the importance of sectoral analysis in understanding market dynamics during crises. While the overall market response may lack statistical significance, the differential impacts across sectors provide valuable insights for policymakers and investors alike. Also, further research and refinement of methodologies are essential for deepening our understanding of the relationship between earthquakes and financial markets.

KEYWORDS: efficient market hypothesis, event study, market model, earthquake, Türkiye

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1 Introduction

The prospect of forecasting future prices in the field of finance has long been a controversial topic. Numerous studies looks the examination of market anomalies, aiming to find out patterns that might enable reliable estimations. Advocates of this perspective argue that these anomalies could be used for constructing trustworthy predictions. However, an opposing view indicates that such anomalies, while occasionally identifiable, lack the consistent repetition and efficacy necessary for robust predictive models.

An early contribution to this discourse is the concept of efficient markets introduced by Fama (1970). This theory asserts that in efficient markets, there are no opportunities for abnormal gains using public information. Following studies have extensively investigated market efficiency through event studies, which covers a diverse range of topics from stock splits to natural disasters. Building on that, in this thesis, an event study methodology is applied to analyze the impact of earthquakes on the Turkish stock market.

The purpose of this thesis is to examine the effects of the 2023 Turkish earthquakes on the Turkish stock market and check if these effects are significant enough to yield statistical significance. Specifically, the study aims to determine whether the earthquakes have resulted in statistically significant negative or positive abnormal returns in sectoral indices and the stocks comprising the market index. Additionally, the research explores potential variations in reactions across different sectors.

The dataset for this thesis comprises daily closing prices of constituents of the Turkish stock market index. To conduct sector-specific analysis, data from 27 different sectoral indices are utilized. Methodologically, the event study approach is adopted, and normal returns are estimated using the market model proposed by Fama et al. (1969). This framework allows for a systematic examination of the impact of earthquakes on the Turkish stock market, shedding light on both sectoral and market-wide responses to seismic events.

This methodology operates under the assumption that markets are efficient. The efficient market hypothesis proposed by Fama (1970) indicates the impossibility of future predictions. According to Fama (1970) markets are efficient at different levels and the current price of assets already incorporate all the public, historical and even insider information. This hypothesis states that prices follow a random walk where the future price movements of financial assets are unpredictable and follow a random pattern. Malkiel (1999, p.166) describes the random walk approach as "*a blindfolded monkey throwing darts at the Wall Street Journal could select a portfolio that would do as well as the experts*". In compliance with this concept, each price change is independent of past movements, and therefore, attempting to predict future prices based on historical data is noneffective.

Following its development, the Efficient Market Hypothesis (EMH) has evolved into an extensively researched and frequently tested phenomenon within financial academia. One of the primary methodologies employed to test market efficiency is through event studies. These studies play an important role in assessing whether there exists a possibility of long-term abnormal returns following the disclosure of new information.

According to Shleifer (2000, p.7) event studies have emerged as the principal methodology of empirical finance, becoming the predominant approach to investigating the impact of various significant corporate events on market dynamics. These events encompass a broad spectrum, ranging from earnings and dividend announcements to takeovers, divestitures, share issuances, repurchases, and alterations in management compensation. The empirical evaluation of these events involves a meticulous examination of their effects on share prices, contributing valuable insights to our understanding of market efficiency.

When examining the foundational examples of event studies, it becomes evident that Eugene Fama also played a pioneering role in this domain. Fama not only formulated a hypothesis for testing but also contributed to the introduction of an approach, *the* *market model*, to estimate abnormal returns. In their seminal work, Fama et al. (1969) investigate the presence of unusual market behavior in security returns surrounding stock split events. The study utilizes data from 940 stock splits that occurred between January 1927 and December 1959. The findings of Fama et al. (1969) suggest that market prices of securities incorporate new information following the announcement of stock splits. This observation indicates a high level of market efficiency, as the adjustments occur almost immediately, supporting the notion that the market fully reflects the implications of the stock splits.

However, as said earlier, event studies extend beyond traditional financial events like stock splits and mergers; they are also employed in the analysis of phenomena such as natural disasters. Notably, the application of event study methodology to natural disasters, particularly earthquakes, introduces distinct considerations compared to its conventional usage.

In contrast to events like stock splits, acquisitions, or mergers, natural disasters are not susceptible to insider information. The unpredictable and uncontrollable nature of events like earthquakes excludes any attempts at forecasting when they might occur. This inherent unpredictability challenges the availability of insider information and the ability to make informed predictions. Therefore, in this paper, market efficiency is tested using semi-strong form.

In the context of earthquake studies, Shelor et al. (1990) can be seen as the pioneers. In their research, the effects of the 1989 San Francisco earthquakes on real estate stock prices are analyzed using the methodology proposed by Fama et al. (1969). Their study reveals that real estate firms located in San Francisco exhibits significant negative abnormal returns on the event day, whereas companies from other parts of California does not show the same trend. Finally, the cumulative abnormal returns does not exhibit any significant deviation from zero, implying no statistical significance neither for San Francisco firms nor other California firms. These results indicate that the market directly and successfully reflected the new information in the stock values of the earthquake area firms.

Building on these arguments, this study aims to find out how the earthquakes happened on 6^{th} February in Türkiye affected Turkish stock markets. By gathering data from Thomson Reuters One database for stock and indices of Borsa Istanbul, which is the only and the biggest stock market of Türkiye, this study investigates the sector-specific and market level differences in reaction to the earthquake.

1.1 Motivation

Earthquakes are unpredictable natural disasters that can have significant impacts on the economy, especially the stock market. Turkish economy is one of the largest and most dynamic in its region, making it an important player in the global economy. Therefore, understanding the impact of such a natural disaster on the Turkish stock market can provide insight into the resilience of the economy and its potential for recovery.

Examining the impacts on specific sectors can help identify potential vulnerabilities and inform future disaster management and risk mitigation strategies. This research aims to contribute to the understanding of the short-term effects of natural disasters on the stock market and contribute to the limited literature examining the effects of earthquakes on emerging markets.

Earlier studies have primarily concentrated on examining the overall impact of natural disasters on the stock market, often considering the market as a whole. These investigations have utilized various approaches, ranging from employing entire market indices (e.g., Worthington & Valadkhani, 2004; Worthington, 2008; Ferreira & Karali, 2015) to focusing on single sector indices (e.g., Shelor et al., 1990; Shelor et al., 1992; Yamori & Kobayashi, 2002; Wang & Kutan, 2013). While some research projects have studied sectoral analyses, they have been relatively limited in number (see Worthington & Valadkhani, 2005; Valizadeh et al., 2017). Consequently, there exists a gap in the existing literature regarding the examination of the Turkish stock market, the level of market efficiency in Türkiye and the sectoral impacts of natural disasters.

This thesis departs from prior literature in several aspects, aiming to fill gaps in the literature. One notable difference lies in the focus on a previously unstudied market and earthquake event, presenting new information of their interplay. While existing studies often aggregate data across multiple events spanning several years, such as those by Worthington and Valadkhani (2004), Worthington and Valadkhani (2005), Worthington (2008), and Ferreira and Karali (2015), this thesis concentrates on analyzing the effects of a singular event on the stock market. Even though investigating natural events altogether could be useful for making more general conclusions, it also carries the risk of including less significant events in the analysis. Furthermore, it also ignores the different characteristics of disasters.

Another departure from prior literature lies in the comprehensive exploration of sectoral impacts. Unlike studies such as Shelor et al. (1990), Shelor et al. (1992), and Yamori and Kobayashi (2002), which typically focus on a single sector, this research investigates the responses of 27 different sectoral indices. This broader scope allows for a deeper understanding of how various sectors within the market react to seismic events. While Worthington and Valadkhani (2005) and Valizadeh et al. (2017) also consider multiple sectors, this thesis expands upon their approach by examining a larger number of sectors and employing a different methodology. By doing so, it seeks to provide more thorough insights into sectoral reactions and their implications for market dynamics.

Moreover, the earthquakes studied in this thesis exhibit distinctive characteristics when compared to other types of disasters as the decision to close the markets was implemented not immediately after the earthquakes but rather two days later. This unique aspect allows for the direct observation of the market's initial reaction in the immediate aftermath of the earthquakes. The delayed closure of markets also introduces an interesting break in the timeline, providing an opportunity to discuss the effects of the closure itself on market efficiency.

In addition, observing the market response both before and after the closure presents an opportunity to find out whether the delayed market shutdown influenced investor behavior, trading patterns, or the efficiency of price adjustments. This approach for analyzing the features of earthquake-caused disruptions contributes to a better understanding of the complexities in studying financial market reactions to natural disasters.

In earlier literature, researchers underscores the need to recognize the custom impacts of earthquakes, emphasizing that these effects can vary depending on the country and the sector (Yamori & Kobayashi, 2002; Brounen & Derwall, 2010). This perspective advocates for domestic investigations to provide a deeper understanding of the unique dynamics at play. In this context, there is an absence of studies analyzing the Turkish stock market's response to events occurring within Türkiye. Given that the Turkish economy stands as one of the largest and most dynamic in its region, having significant influence in the global economy, this research gains a heightened importance.

1.2 Hypotheses

The majority of earlier studies have consistently demonstrated that the overall impact of disasters on the event day is statistically significantly negative, indicating an adjustment of prices in response to new information (e.g., Shelor et al., 1990; Lamb, 1998; Yamori & Kobayashi, 2002; Chen & Siems, 2004; Chesney et al., 2011; Scholtens & Voorhorst, 2013; Valizadeh et al., 2017). Building upon these established findings, this study anticipates that when an earthquake occurs in Türkiye, the stock markets are likely to exhibit a negative reaction on the very day of the event. The presence of a significant and negative Average Abnormal Return (AAR) would suggest that the markets are actively responding to this new and distressing information. Therefore, the first hypothesis is formulated as follows:

Hypothesis 1. Earthquakes have a negative and significant impact on the AARs of the stocks of Turkish market on the event day.

However, a subset of researchers (e.g., Shelor et al., 1990; Lamb, 1998; Yamori & Kobayashi, 2002; Bash & Alsaifi, 2019) has uncovered evidence suggesting that abnormal returns following a natural disaster may not exhibit statistical significance in the days immediately following the initial shock. If this observation holds true, it implies that the combined impact of an earthquake might not extend beyond the initial day. Consequently, the prediction is that the Cumulative Average Abnormal Returns (CAAR) in the subsequent days after an earthquake should statistically not be different than zero. In simpler terms, this means that any overall effects on the stock markets after the earthquake should settle relatively quickly pointing at market efficiency. Therefore, the second hypotheses is as follows:

Hypothesis 2. Earthquakes do not have a negative and significant effect on the CAARs of the stocks of Turkish market.

Moreover, considering the patterns observed in the event window stock movements, it is plausible to anticipate that certain sectors, such as the construction and real estate sectors, might experience positive effects in the aftermath of earthquakes. Earlier literature has shown evidence in this manner (Shelor et al. 1990; Valizadeh et al. 2017).

Also, it is possible to assume that earthquakes could lead to increased demand for construction services due to the need for rebuilding and infrastructure development. Similarly, the real estate sector may benefit as reconstruction efforts and the restoration of damaged properties could stimulate property transactions.

Therefore, the last two hypotheses are as follows:
Hypothesis 3. Earthquakes have a positive and significant impact on the ARs of the selected Turkish sector specific indices on the event day.

Hypothesis 4. Earthquakes do not have a negative and significant effect on the CARs of the Turkish sector specific stock indices.

1.3 Limitations and assumptions

The daily stock returns regarding the estimation window and event windows are obtained from reliable sources. However, some errors regarding the daily return data or other details about the earthquakes chosen for this research might also be present. In addition, since earthquakes can also cause other influence, it is possible that the observed prices are not entirely caused by these earthquakes but are affected by other factors, making it difficult to interpret the outcome.

Also, this study acknowledges the potential presence of selection bias in the events under examination. This bias implies that certain events with negligible impacts on the market might be included, while others with substantial effects could be inadvertently excluded. Even though these acknowledged challenges and biases could affect the results of the study, the conventional event study approach is employed widely in the previous literature (e.g., Brown and Warner, 1985; MacKinlay, 1997). Therefore, it remains a robust and applicable methodology to comprehensively analyze all the selected events.

Some studies in the literature advocates for the employment of estimation windows larger than 200 days. However, this thesis utilizes a comparatively shorter window of 120 days. While earlier studies caution that standard deviation estimates can be affected by downward bias caused by shorter estimation periods (Kothari & Warner, 2007), the deliberate choice of a shorter window in this study serves a specific purpose. Given that Türkiye is a politically active country and that the year 2022 still exhibited late effects of the COVID-19 pandemic, the decision to use a 120-day window is significant for preventing other major events from contaminating the results. This shorter timeframe aims to capture a more focused period around the event, minimizing the risk of interference from unrelated market movements. Also, MacKinlay (1997) supports the use of a 120-

day window for estimating market model parameters before the event, further justifying the chosen approach.

Furthermore, other studies in prior literature studying the relationship between major events and financial markets, such as Shelor et al. (1990), Lamb (1998), Yamori and Kobayashi (2002), Chen and Siems (2004) and Brounen and Derwall (2010), employ shorter estimation windows. Therefore, the selection of 120-day estimation window aligns with these established practices in the literature as these studies successfully demonstrates the reliability and efficacy of such an approach. By following these earlier practices, this thesis ensures consistency with well-regarded practices in the field and emphasizes the importance of a focused analysis when investigating the impact of specific events on stock markets.

Statistical models rely on the assumption that returns adhere to a normal distribution and are independent and identically distributed over time (MacKinlay, 1997, p.17). Although this assumption may initially seem restrictive, models based on normal returns often exhibit resilience and robustness to deviations from the normal distribution. This is because such deviations typically do not pose methodological problems, given that the assumption of normality is empirically rational (MacKinlay, 1997, p.17). Additionally, Brown and Warner (1985, p.25) suggest that the non-normality of daily returns does not significantly affect event studies. MacKinlay (1997) further notes that as the number of securities in the sample increases, there is evidence to suggest that the sample mean converges to normality, in accordance with the law of large numbers. This convergence underscores the reliability of statistical models in capturing market behaviors, even in the presence of deviations from normality.

For testing the results, this study utilizes a t-test as described by MacKinlay (1997). While other studies in the prior literature may opt for non-parametric tests in cases of deviation from normality, Brown and Warner (1985, p.25) demonstrate that parametric tests, such as the student’s t-test, are well-suited for assessing the significance of Average Abnormal

Returns (AAR) and Cumulative Average Abnormal Returns (CAAR), even when dealing with small sample sizes. This research methodology offers robustness in evaluating the statistical significance of abnormal returns, contributing to the reliability of findings despite potential deviations from normal distribution assumptions.

When analyzing sectoral indices, the acquisition of only one observation per day from a single index can present challenges in achieving reliable results. Nevertheless, earlier literature includes studies that methodologically utilize a single index and one observation. For instance, Nikkinen and Vähämaa (2010) explores the effect of terrorism on stock market sentiment using only one index and one observation. Similarly, Valizadeh et al. (2017) utilizes sectoral indices with single observations per day to investigate the sector-specific impacts of the 2011 Japanese earthquake.

Finally, the estimation of abnormal returns may be influenced by the selection of different approaches, such as the Capital Asset Pricing Model (CAPM), the market model, or the mean-adjusted model. While this variation in methodology could potentially yield differing results in terms of abnormal returns, MacKinlay (1997) suggests that these models generally produce similar findings. In addition to the choice of model, other factors such as the selected dataset, sample size, and the selection of the market portfolio can also impact the accuracy of estimations.

Despite these limitations and potential biases associated with event studies. Their simplicity, accuracy, and adaptable nature makes them an effective tool for researchers in finance. This design facilitates the identification of abnormal returns, as emphasized by MacKinlay (1997).

1.4 Structure of the paper

The structure of this research is organized into seven chapters to systematically explore and present insights on the effects of earthquakes on financial markets. Introductory chapter one lays the foundation by introducing the research topic, presenting key studies in the field, explaining the purpose of the paper, and highlighting the potential contributions to existing literature. This chapter also serves as the platform for presenting the research hypotheses.

Chapter two provides an overview of the damage and casualties resulting from the 2023 Turkish earthquakes. Additionally, it delves into general information regarding the potential economic effects of earthquakes and global seismic risk. This contextual background sets the stage for the subsequent research. Chapter three focuses on relevant theories and issues related to the study, establishing a theoretical framework to guide the exploration of earthquake-induced market dynamics. This section aims to provide a complete understanding of the conceptual foundation that inform the subsequent empirical analysis.

In chapter four, the focus shifts to a thorough review of prior research on the broader impacts of earthquakes on the economy and stock markets. This chapter not only synthesizes existing studies but also incorporates insights from other event studies with diverse perspectives, enriching the understanding of the subject matter. Chapter five details the data sources and methodologies employed to address the research hypotheses, presenting a transparent account of the analytical framework. The inclusion of alternative methodologies enhances the robustness of the study's approach.

The empirical findings are discussed in chapter six, providing a detailed analysis of the research outcomes. This section presents the observed effects of earthquakes on financial markets, offering valuable insights into market reactions and dynamics during seismic events. Finally, the empirical findings are synthesized to draw meaningful conclusions in chapter seven. Also, the implication of the study is discussed, acknowledging its limitations, and suggesting avenues for future research.

2 Background of the event

Türkiye, situated in a seismically active region, has a history of susceptibility to earthquakes, as evidenced by 269 recorded seismic events between the years 1900 and 2023 (SBB, 2023). One of the most recent and catastrophic earthquakes occurred on February 6th 2023, in Kahramanmaraş, a city located in southern Anatolia. The earthquake, characterized by magnitudes of 7.7 Mw and 7.6 Mw, struck at 04:17 and 13:24, respectively, leaving a lasting impact on a total of eleven provinces. The aftermath of this tragic event has resulted in a staggering loss of over 48,000 lives as of April 20 (SBB, 2023).

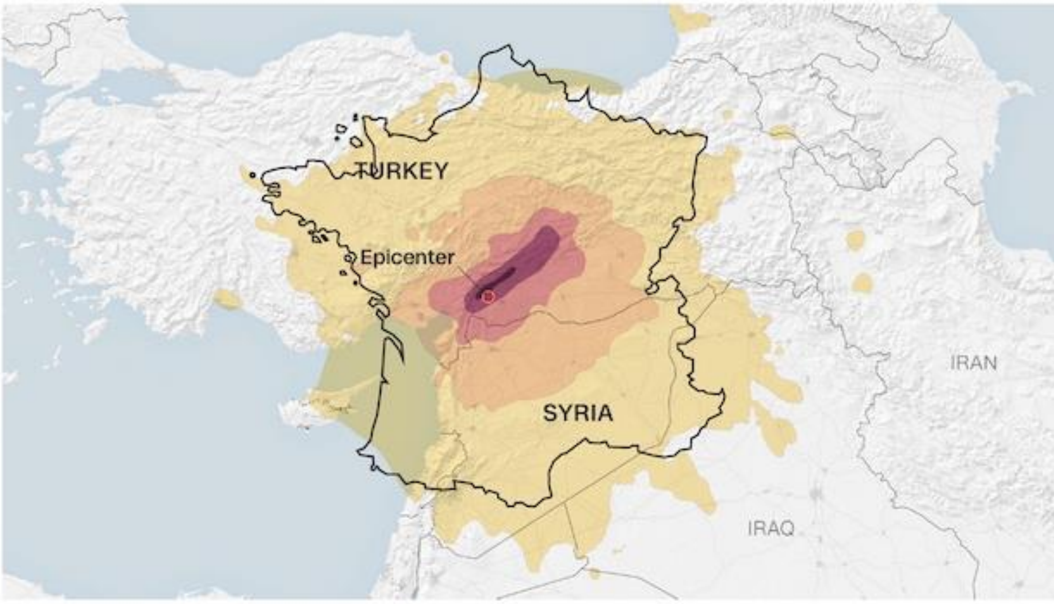

Figure 1. Sphere of influence of the earthquakes (Laleoğlu, 2023)

Figure 1 visually conveys the extensive impact of earthquakes by comparing the affected area to the size of France, thereby emphasizing the magnitude of these disasters. Evidently, seismic events have a far-reaching influence, affecting a broad region that spans at least three countries, namely Iraq, Syria and Türkiye. This illustration serves to underscore the substantial geographical reach of earthquakes and their potential implications on multiple nations in the vicinity.

The affected regions in Türkiye, encompassing various cities, collectively house a population of 14,013,196, constituting 16.4% of the entire country's population (SBB, 2023). The consequences of these earthquakes extend beyond immediate human casualties, spreading through the socioeconomic fabric of the affected areas, demanding comprehensive efforts in relief, recovery, and rebuilding. Türkiye's ongoing vulnerability to seismic activity underscores the imperative for proactive measures in earthquake preparedness and mitigation to minimize the impact of future events on both life and infrastructure.

A thorough report (see SBB, 2023) conducted by Strategy and Budget Office of Turkish Ministry of Environment and Urbanization and Climate Change has brought to light the scale of destruction caused by the recent earthquake in Türkiye. The findings reveal a significant impact on infrastructure, with a total of 1,929,313 buildings reported as damaged, of which 518,009 are categorized as severely damaged or completely destroyed. The financial impact of this disaster is also substantial, as the estimated cost incurred in the housing sector alone is $66 billion, underscoring the magnitude of the economic impact.

The consequences of this seismic catastrophe extend beyond the immediate structural damage, casting a long shadow over important industrial zones in the affected cities, including Gaziantep, Adana, and Hatay. Particularly Hatay stands out as a significant port city with integral importance to the nation's economic activities. The direct and indirect losses, coupled with the supply chain disruptions caused by this notable disaster, are profound. However, determining the full extent of these effects is a complex task due to the complex interplay of various socio-economic factors and the inherent uncertainty within the system.

Attempting to measure the impacts on the nation's economy, the study examines the stock market's response to the earthquake. Commonly regarded as a barometer of the economy, the stock market's reactions serve as a tangible indicator of investor sentiment and confidence in the aftermath of such a disaster. Understanding and analyzing these market dynamics provide valuable insights into the resilience and adaptability of the economy in the face of unforeseen challenges, shedding light on the broader economic landscape impacted by this seismic event.

2.1 Earthquakes and economies

The geographical location of Türkiye places it squarely within a seismic hotspot, as depicted in Figure 2. The susceptibility to earthquakes is a longstanding reality, with historical data revealing 269 recorded earthquakes between 1900 and 2023. The reoccurrence of seismic events underscores the inevitability of future earthquakes, emphasizing the crucial need to proactively address their potential economic impacts.

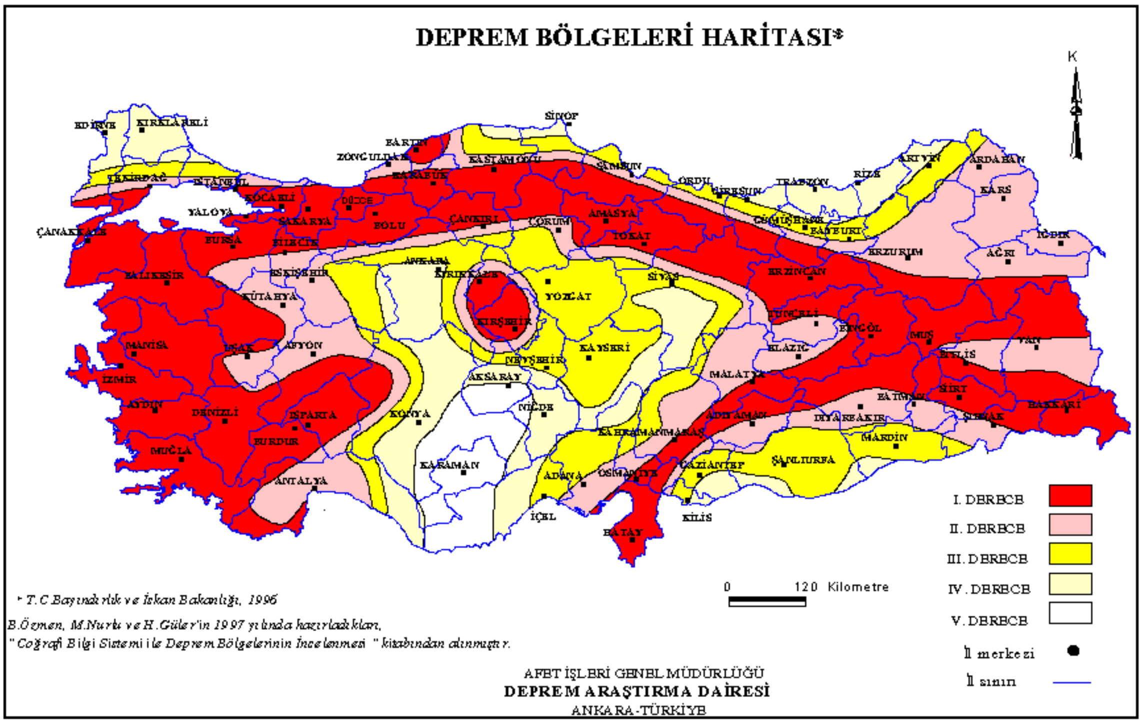

Figure 2. Earthquake Risk Map of Türkiye (Özmen et al., 1997, p.9)

Given the inability to prevent earthquakes, the focus shifts towards mitigating the adverse impact on the economy. The economic well-being of a nation serves as a linchpin not only for the purchasing power of its citizens but also as a cornerstone for initiating and sustaining critical search and rescue operations in the aftermath of disasters. Moreover, a robust economy is pivotal in providing essential support, shelter, sustenance, and rehabilitation for survivors.

Recognizing the multifaceted role of economic health in disaster management is paramount. The financial resources generated by a strong economy become instrumental in swiftly mobilizing resources and personnel for emergency responses. Funding search and rescue operations, providing immediate aid, and offering sustained assistance to survivors all hinge on the economic resilience of a nation. Therefore, fostering economic strength assumes a dual significance: enhancing the overall quality of life for citizens during normal times and fortifying the nation's ability to effectively respond to and recover from unforeseen disasters.

In essence, while the inevitability of earthquakes prevails, strategic efforts to minimize their economic impact become imperative. By strengthening its economic structures and mechanisms, a nation not only reinforces the day-to-day well-being of its population but also ensures a more prepared and responsive approach when confronted with the challenges posed by seismic events. This holistic perspective underscores the integral role of economic stability in the broader context of disaster preparedness, response, and recovery.

Examining the data presented in Figure 3 underscores the wide and recurrent nature of earthquakes, extending their impact across vast geographical regions from Far Asia to the Balkans and beyond. This reality highlights the significance of understanding how stock markets respond to seismic events, as such knowledge holds relevance not only for the directly affected country but also for neighboring nations that may encounter similar challenges in the future. Unveiling the dynamics of stock market reactions to earthquakes is not merely a localized concern; it serves as a crucial source of information for key components within the broader financial system.

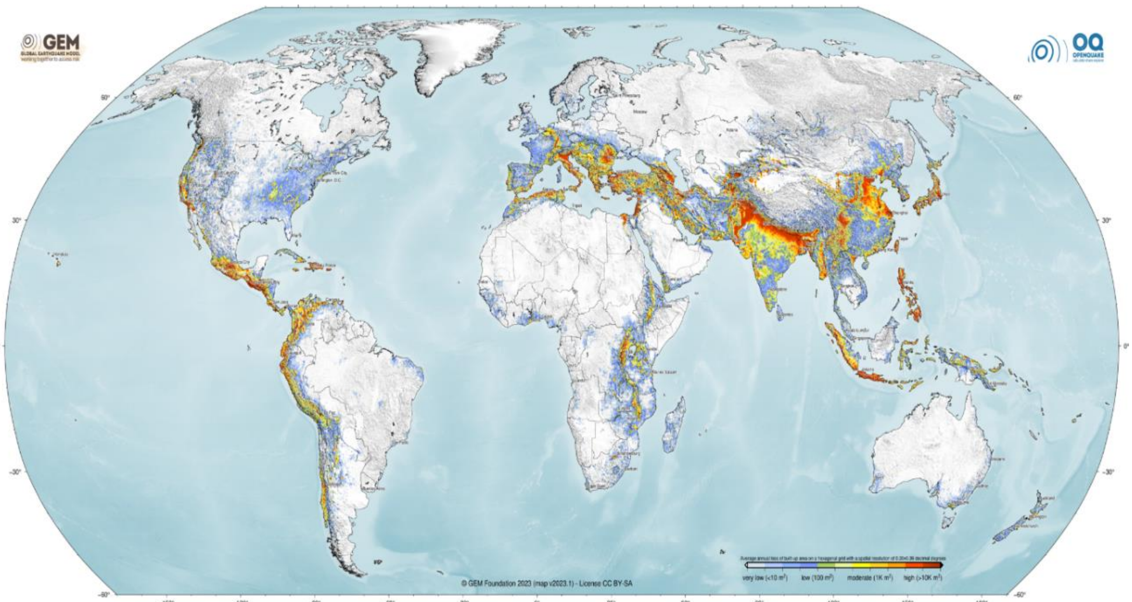

Figure 3. Global Seismic Risk Map (Silva et al., 2023)

The implications of seismic events transcend national borders, reaching far beyond the immediate affected area. A case in point is the Turkish earthquake, which not only had a profound impact on the economies of Türkiye but spread globally, attracting attention on an international scale. This global awareness and interconnectedness were further substantiated by the actual market reactions that followed the seismic activity.

In the aftermath of the Turkish earthquakes, public expectations mirrored the anticipation that these catastrophic events would not only influence the economies of the directly affected nations but would also cast a shadow on the global economic landscape. These expectations materialized swiftly, as evidenced by the significant drop in the main index of Istanbul's stock exchange, registering a sharp decline of approximately 7% within a day of the earthquakes (Hogg, 2023). This immediate market response underscores the vulnerability of financial systems to natural disasters and their ability to transmit shockwaves far beyond the epicenter.

In conclusion, the reoccurrence of earthquakes on a global scale requires an examination of how financial markets respond to such events. The insights gained from such analyses not only benefit the directly affected nations but also contribute valuable information to enhance the resilience and preparedness of financial systems worldwide in the face of seismic challenges.

3 Theoretical Framework

The event study methodology, which will be discussed in detail in chapter 5, is a theoretical framework that operates under the fundamental assumption that markets function efficiently. This assumption is explained by Fama (1970) as Efficient Market Hypothesis (EMH), is a theoretical background serving as a foundation for this research.

According to Fama (1970), the price in an efficient market is assessed to all the new information, therefore it is not possible to make abnormal gains. According to this hypothesis, market prices do not follow a pattern, therefore it is unpredictable and random. However, this does not imply market irrationality. Markets are rational in a way that they only react to new and unpredictable information rather than making valuations depending on the historical price (Bodie et al., 2014, p. 345).

Nevertheless, in the context of research examining how market prices move, there is a long history predating Fama's hypothesis. Although the efficient market theory was proposed by Fama in 1970, one of the first studies in this field emerged in the 19th century. Regnault (1863), in his study on financial assets, examines the relationship between the time the asset is held and the size of the gain or loss and concludes that the gain or loss increases as the square root of the holding period.

Thirty-seven years later, Bachelier (1900) conducts a study on the price movements of options and futures. His findings leads him to conclude that the best predictor of future prices is the current price. Consequently, he argues that the expected gains of speculators should be zero. Bachelier's work is regarded as a foundational paradigm in modern finance, paving the way for many other research in this field as Fama (1965, p.41) considers this research as "the first complete development of a theory of *random walks* in security prices".

In his study, Cowles (1933) evaluates the performance of 45 different professional agencies in predicting the movements of the market between the years 1928 and 1932. He divides the sample into two groups, the first one consisting of 20 insurance companies and 16 financial institutions while the second one is only made up of 25 financial publications. The results indicates that financial institutions and fire insurance companies performed 1.43% and 1.20% worse than the common stock respectively and failed to demonstrate any kind of investment skill related gain, suggesting that chance governed their performance.

In his extension of the earlier study, Cowles (1944) utilizes data spanning over 15 years, covering 11 financial service providers from 1928 to 1943. The research reveals that none of the providers succeeded in predicting market movements. Moreover, Cowles (1944) identifies the best-performing agency and extended the time period to 40 years. In this extended analysis, the results indicates that the agency consistently outperformed the market index by 3.3% annually, representing a statistically significant achievement. Cowles also emphasizes that employing inertia as an investment strategy during the considered period would have resulted in substantial gains.

In their study, Kendall and Hill (1953) examines the stock price movements by analyzing economic time series comprising 22 industrial indices. They discover no discernible patterns in stock prices. The fluctuations appear to follow a random walk, with prices being just as likely to increase as they were to decrease on any given day, irrespective of past performance. The data fails to offer any reliable means of predicting the direction of price movements.

Fama (1965) conducts a study on the price movements of thirty companies, revealing that twenty-three of them exhibited positive serial correlation. However, these correlations were notably small, suggesting a weak probability of abnormal returns. Fama (1965) also emphasizes that prices adjust promptly to changes in intrinsic value. Consequently, this observation not only aligns with but also provides strong evidence in support of the random walk theory.

Ultimately, Fama (1970) examines previous literature and proposes a hypothesis. According to this new hypothesis, in an efficient market, prices fully and quickly incorporate all available information, leaving no room for investors to consistently exploit mispricing and earn abnormal profits.

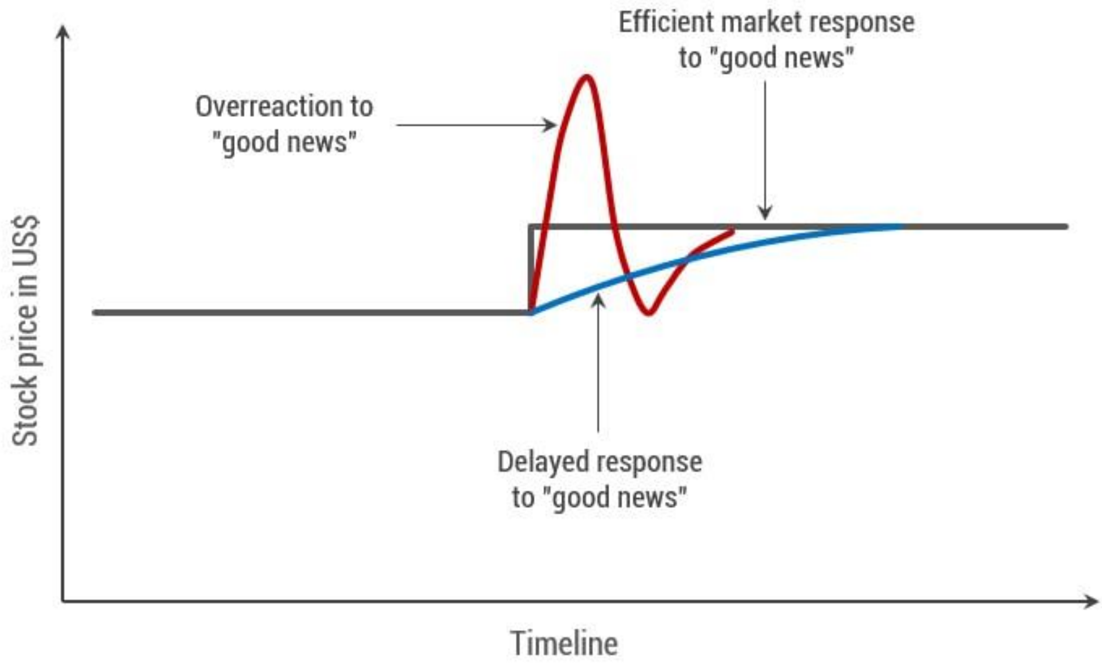

Figure 4. Differing market response to new information (Smirnov, 2020)

Figure 4 illustrates the diverse market reactions to positive news. Following the EMH, the market should ideally exhibit neither long-term overreactions nor underreactions. Such deviations from efficient price could create abnormal return opportunities for other investors. According to the EMH, any over or underreactions should promptly be seized upon by arbitrageurs, ensuring that the market swiftly adjusts to the true value of the asset. The grey line in the figure serves as a representation of how an efficient market should price the asset in light of the new information.

Following the announcement of new information, the market price undergoes an adjustment, aligning itself with the perceived real value of the asset. The efficiency of the market is evident in the swift and accurate incorporation of this new information into the asset's pricing. Importantly, the grey line signifies the theoretical balance point that an efficient market would reach after processing the latest information. Once this adjustment occurs, further market corrections become unnecessary until newer information emerges.

3.1 Basic principles of Efficient Market Hypothesis

According to Shleifer (2000, pp. 2-5), there are three assumptions in the core of efficient market hypothesis. The first of them is the rationality of the people in the market. EMH assumes that people are reasonable with their decisions and on-point at valuing the new information. Secondly, even when the investors are not rational, their unreliable decision would cancel one out, therefore prices would be unaffected. Lastly, in the times of irrational decisions, rational arbitrageurs would keep the markets effective which in turn would remove the influence of the irrational decisions on the prices.

EMH asserts that investors are rational decision-makers who process information efficiently and make investment choices based on available data (Shleifer, 2000, pp. 2-5). Rationality in this context implies that investors weigh all available information, including past prices and relevant news, in an unbiased and objective manner. Investors are assumed to act in their best financial interest, aiming to maximize returns or minimize risks (Bodies et al. 2014, p. 348). This assumption plays a crucial role in EMH, as it forms the basis for the hypothesis that asset prices fully and accurately reflect all available information at any given time.

However, efficiency of the market does not only depend on the rationality of the investors. Even at the times of unreasonable decision, EMH assumes that any irrational behavior exhibited by individual investors tends to cancel out in the aggregate, contributing to market efficiency (Shleifer, 2000, pp. 2-5). The idea is rooted in the law of large numbers, asserting that as the number of market participants increases, the impact of individual irrational decisions diminishes. In a large and diverse market, the collective actions of rational investors responding to new information tend to offset the less systematic and more erratic choices made by irrational investors. This dynamic creates a self-correcting mechanism, where market prices, on average, converge towards their fair values.

Moreover, EMH does not only rely on the randomness of irrationality but also considers arbitrageurs as a correcting mechanism in the market. EMH posits that asset prices fully and accurately reflect all available information, leaving little room for profitable opportunities (Shleifer, 2000, pp. 2-5). Arbitrageurs, individuals or entities who exploit price discrepancies across different markets or securities, actively contribute to the adjustment process that aligns prices with their intrinsic values.

In an efficient market, any temporary mispricing or inefficiency created by new information is swiftly identified and exploited by arbitrageurs, who engage in buying or selling activities to capitalize on the price differentials. Their actions, driven by the pursuit of profit, help correct market prices and restore equilibrium. The presence of arbitrageurs is essential for ensuring that markets remain efficient over time, as their activities contribute to the rapid incorporation of new information into asset prices.

3.2 Forms of market efficiency

Fama (1970) classifies the efficiency of markets based on their responsiveness to new information, and it consists of three progressively inclusive categories: the weak form, semi-strong form, and strong form. This classification system serves as a fundamental framework for understanding how swiftly and comprehensively financial markets adjust to available information.

The weak form asserts that stock prices already encapsulate all information derived from market trading data, including historical prices, trading volume, and short interest (Bodie et al., 2014, p. 348). Its implications extend to challenging the effectiveness of trend analysis, suggesting that past stock price data, being publicly available and easily accessible, lose their predictive power (Bodie et al., 2014, p. 348). The logic follows that if historical data could reliably signal future performance, investors would have already exploited these signals, rendering them obsolete as they become widely known (Bodie et al., 2014, p. 348). The weak-form efficiency can also be shown in the following way:

$$P_t = P_{t-1} + E(r_t) + \alpha_t \quad \textbf{(1)}$$

where P_t is the return of a security at time t, and P_{t-1} is the return of a security at time t-1. $E(r_t)$ represents the expected return at time t and α_t represents the random variable.

The semi-strong form of the EMH, as described by Fama (1970), proposes that stock prices already incorporate all publicly available information, leaving investors unable to consistently achieve superior returns by analyzing widely accessible data. In this form, not only do past market trading data lose their predictive power, but also any information accessible to the public, such as financial statements, economic indicators, and relevant news, is swiftly and fully reflected in stock prices. Therefore, the semi-strong form challenges the feasibility of earning abnormal profits through in-depth analysis of public information, asserting that any attempt to exploit such data would be futile due to its rapid incorporation into market prices (Bodies et al. 2014, p.348). Investors operating under the semi-strong form of the EMH would face the daunting task of identifying mispriced securities before the broader market assimilates the relevant information, thereby complicating the prospect of consistently outperforming the market.

As the weak and semi-strong forms of the EMH primarily address the incorporation of publicly available information into stock prices, the strong form goes even further. According to the strong form, not only is it impossible for investors to profit from trading on information available to the public, but also abnormal profits from trading on insider information are unreachable. The strong form suggests that even with non-public, insider information, any potential advantage is short-lived, as such information rapidly spreads on the market and becomes incorporated into stock prices (Shleifer, 2000, pp. 5-10).

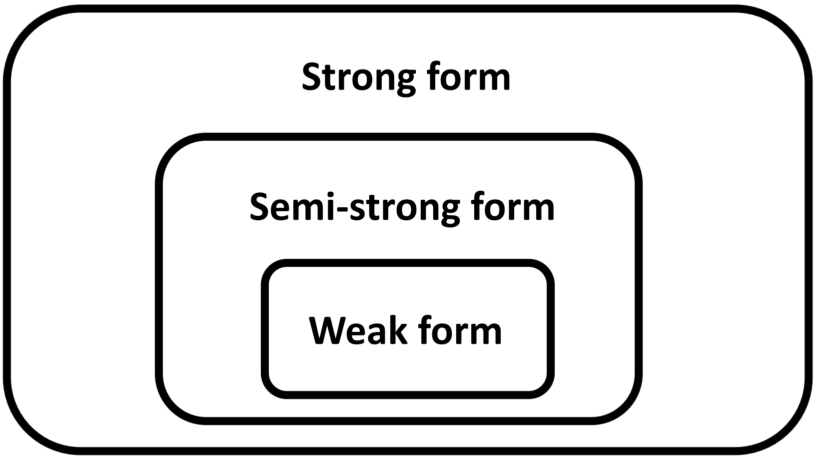

Figure 5. Forms of market efficiency

Figure 5 provides a visual representation of the three forms of market efficiency, namely strong form, weak form, and semi-strong form. However, it is crucial to recognize that these distinctions are not mutually exclusive. In practical terms, a market may concurrently exhibit characteristics of strong, weak, and semi-strong forms of efficiency.

For instance, a market that demonstrates strong form efficiency implies that all information, including both public and private, is fully reflected in current prices. Simultaneously, the market also showcase characteristics of weak form efficiency, where historical price and volume data are already incorporated into the existing prices. Furthermore, the market exhibits semi-strong form efficiency, indicating that public information is rapidly reflected in asset prices upon its announcement.

While much of the discourse surrounding the EMH has focused on the weak and semi-strong forms, the strong form's assertion of the impossibility of profitable insider trading has faced scrutiny. Instances of individuals facing legal consequences for illegal insider trading may challenge the principles of the strong form, suggesting that some informational advantages persist even within a legal framework. This nuanced perspective prompts ongoing debate about the limitations and applicability of the strong form of the EMH in understanding the intricate dynamics of financial markets.

3.3 Challenges

Since its emergence in the 1960s, the Efficient Market Hypothesis (EMH) swiftly gained popularity within the financial world, supported by a high number of empirical findings (Shleifer, 2000, p.1). However, this initial acclaim was rapidly met with serious criticism.

At the core of the EMH lies the foundational assumption that prices follow a random walk. This proposition was notably challenged by Lo and MacKinlay (2008), who, through a pivotal study, presents strong evidence of successive price movements in the same direction, thereby suggesting the potential for predicting future prices. Despite this, Malkiel (2003) asserts that the statistical dependencies identified are too weak to yield abnormal gains for investors, particularly when considering the impact of transaction costs on momentum strategies.

Another assumption of the EMH states that market participants are rational. However, this assumption encounters serious challenges from psychological evidence (Shleifer, 2000). While the EMH acknowledges the existence of irrationalities among investors, it contends that these irrationalities would collectively follow a random walk, thus neutralizing each other. Shleifer (2000) argues against this perspective by stating that these irrational decisions actually goes in the same direction, highlighting not only the irrational behavior of individual investors but also that of professionals such as fund managers who, in seeking financial advice, aim to avoid falling behind.

Moreover, EMH relies on the premise that, in the face of irrational price changes, arbitrageurs exploit the discrepancies, driving prices back to their equilibrium. However, this argument has its limitations. Firstly, for arbitrageurs to capitalize on market inefficiencies, there must be close substitutes available, and these are not always present (Shleifer, 2000). Additionally, the finite capacity of arbitrageurs poses a limit on their ability to correct mispricings. Assets exceeding this capacity thus remain inefficiently priced.

In response to these critiques, Malkiel (2003) maintains that markets, when viewed in a broader perspective, exhibit efficiency. While anomalies may arise, they are temporary and unpredictable, lacking the repeatability and profitability necessary to undermine the EMH. Malkiel (2003) emphasizes that, though markets may not achieve perfect efficiency, any deviations from random walks are short-lived and transient. Thus, for the EMH to hold, markets do not need to rigidly follow random walks.

4 Literature review

Given the limited research on earthquakes and their impact on the stock market, this section is divided into two parts. The first part covers event study research specifically focused on earthquakes. In this context, how seismic events influence financial markets is examined. The second part broadens the scope to encompass event study research in general studying various disasters, no matter if they are natural or political in nature.

4.1 Earthquake-related studies

In recent years, researchers have increasingly paid attention to studying the relationship between earthquakes and their impact on the stock market. Shelor et al. (1990) are pioneers in this field, conducting research on the effects of the 1989 San Francisco earthquakes on real estate stock prices, which is already discussed in the introduction part.

In a subsequent study on the same earthquake, Shelor et al. (1992) investigates the effects of the earthquake on insurance companies. They identified statistically significant positive abnormal returns on the day of the event. These returns were interpreted as the positive expectations of the investors following the sales of insurance. Furthermore, cumulative abnormal returns were calculated up to 15 days after the event, but no statistically significant results were found during this period. Concerning these findings, West (2003) argues that the study fails to incorporate the reduction in interest rates occurring two days after the earthquake. Hence, the observed behavior may not solely be caused by the earthquake but also by other macroeconomic influences, consequently lowering the reliability of the results.

Building on these studies, Yamori and Kobayashi (2002) investigates the effects of the 1995 Japan earthquakes on the shares of 13 Japanese insurance companies using a market model. In contrast to previous literature on earthquakes (see Shelor et al., 1990; Shelor et al., 1992), their findings resulted in statistically significant negative cumulative abnormal returns up to 4 days after the event. They underscore the effectiveness of

Japanese stock market at assessing the new information since the possibility of abnormal returns disappeared in a relatively short time period. However, regarding these differing results between US and Japan, the authors do not provide clear explanations. Also, having a sample of only 13 companies contributes to lower reliability in the results.

While the majority of prior literature on earthquakes focuses on Japanese and American stock markets, there are also other studies taking different directions. One of them is Worthington and Valadkhani (2004) which examines natural disasters, including earthquakes, bushfires, and floods, which occurred in Australia between 1983 and 2002. The researchers employ Autoregressive Moving Averages Model (ARMA) for their analysis. The study finds that these disasters had varying influences on the market, depending on the nature of the event. They assert that while these disasters created significant negative abnormal returns on the day of the event, the effects on the following days were inconsistent.

Similarly, Worthington and Valadkhani (2005) conducts an analysis of the impact of various natural, industrial disasters and terrorist attacks on ten distinct sectoral indices within the Australian stock market, utilizing the ARMA model. Their findings underscore the vulnerability of specific sectors, particularly within consumer discretionary, financial services, and materials. However, other sectors such as consumption stay generally unaffected by the abnormal impacts of these disasters.

In another study, Worthington (2008) expands upon the earlier research by broadening the sample from Worthington and Valadkhani (2004). Employing the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) approach, this research analyzes the effects of natural disasters, including storms, floods, bushfires, and earthquakes, on the Australian stock market. Contrary to prior literature, the study concludes that inclusion of variables for natural disasters does not account for the variation observed in daily market returns.

Brounen and Derwall (2010) examines the effects of major terrorist attacks spanning the period from 1990 to 2005. The study extends its analysis beyond terrorist attacks to include ARs and CARs for significant earthquakes. However, inconsistent with most of the prior literature, the study finds no significant abnormal returns, neither on the day of the event nor throughout the following days within the event window. They also state that the reactions of the stock markets are more severe domestically.

In their study, Kawashima and Takeda (2012) studies the effects of 2011 Fukushima nuclear accident, which happened as a result of East Japan earthquakes, on the stock prices of companies that owns the power station and other electric power utilities by employing classic event study approach. The findings of the study suggests that 2-day and 30-day CARs of all the companies shows statistically significant negative abnormal returns. While the companies that owned the nuclear station suffered higher negative ARs, 137-day CARs was not different than zero.

Scholtens and Voorhorst (2013) examines the effects of 353 earthquakes that happened between the years of 1973 and 2011 on domestic stock markets and found that the disasters had significant and negative effects in addition to the fact that the severity of the earthquake or the development level of the market does not change the reaction of the market against the earthquake. They also advocate the use of capital asset pricing model (CAPM) for calculating abnormal returns rather than the market model, mentioning CAPM's ability to make more sensitive estimations. However, this claim does not align with the literature. In addition to MacKinlay (1997) claiming that CAPM is more restrictive than simpler models, studies such as Bash and Alsaifi (2019) and Ahmed et al. (2022) show the capacity of the market model in making correct estimations.

Wang and Kutan (2013) studies the impact of natural disasters, such as earthquakes, tsunamis and volcanic eruptions, on insurance sectors of Japan and USA following the methodology used by Worthington (2008). According to the results of the study, while there is no wealth effect on US and Japan composite stock markets, insurance sectors show different results as US insurance sector lose and those in Japan gain inconsistently with the prior literature (see Shelor et al., 1992; Yamori & Kobayashi, 2002). However, Wang and Kutan (2013) do not provide an explanation for these contradictory results between the two countries.

In their study, Carpenter and Suret (2015) analyze the effects of 161 environmental and non-environmental accidents between 1959 and 2010. Their study suggest that in general the market reacts to an announcement of an accident negatively and persistently. On the other hand, the calculated CARs does not show statistical significance one year after the accidents.

Ferreira and Karali (2015) show that financial markets are resilient to abnormal effects of the earthquakes. They find that earthquakes have no significant abnormal impact on macroeconomic variables such as GDP or GDP growth in all 35 countries except for Japan. These results are consistent with Fomby et al. (2013) and Wang and Kutan (2013). In relation to these findings, Valizadeh et al. (2017) argue that the examination of stock market indices may mask highly negative abnormal returns within specific sectors if these are offset by positive returns in other sectors.

In their study, Valizadeh et al. (2017) examines the effects of the 2011 Japan earthquakes on stock markets of Japan and its trading partners. The study employes a modified version of the market model for the short-term analysis and buy-and-hold abnormal return approach for the long-term analysis and concludes that the earthquake had significant negative abnormal effects on all the stock markets studied. On the other hand, in the sector specific analysis, it is found out that some sectors benefited from the earthquake having positive and significant abnormal returns. Their results show consistency with prior literature (Yamori & Kobayashi, 2002; Worthington & Valadkhani, 2005). However, the study utilizes only one index per sector, resulting in one observation per day. While this approach may lead to biased estimations, it still holds utility for examining the diverse reactions within sectors.

Summarizing the main findings of the authors in this chapter, while most of the studies suggest negative abnormal consequences of an earthquake, some of the studies challenge this narrative indicating that these negative effects may be temporary, limited to the day of the event. Furthermore, a distinct set of studies suggest that earthquakes may not exhibit statistically significant abnormal effects on stock markets. These differing findings underscore the complexity of the relationship between earthquakes and financial markets.

4.2 Other relevant studies

Earlier instances of event studies focused on examining market reactions to events such as stock splits and mergers. An illustrative example is the work of Keown and Pinkerton (1981), who investigates the effects of merger announcements on stock prices. In their study, they utilize a 100-day estimation period and a standard market model to estimate normal returns.

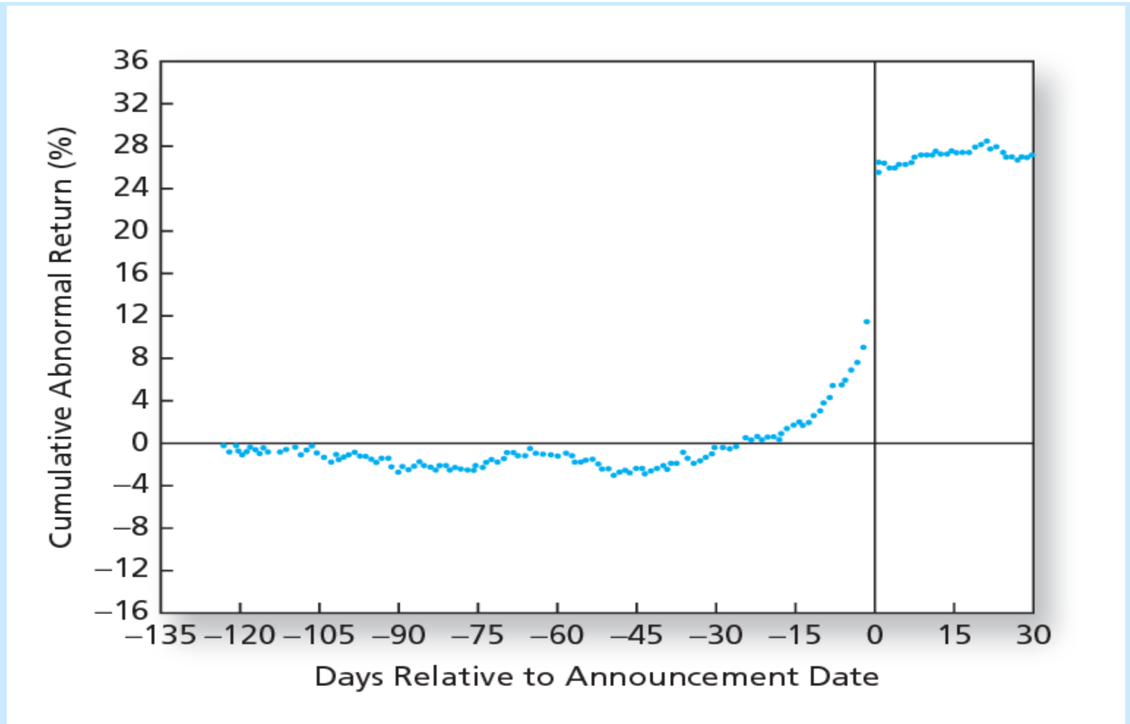

Figure 6. Market reaction to the new information around the announcement date (Keown and Pinkerton, 1981)

Figure 6 depicts the findings of their study, revealing a notable increase in abnormal returns approximately 15 days before the announcement date, suggesting the possibility of insider information leakage. However, following the announcement, the market immediately adjusted prices, aligning with the new information. The outcomes of this study show support to the semi-strong version of market efficiency, affirming that information is rapidly incorporated into stock prices after public disclosure, reinforcing the efficiency of the market in responding to significant events.

In the context of geopolitical events, the 1990 Iraqi invasion of Kuwait has been studied by Bradford and Robison (1997). The study employes the market model for estimating the CARs of 81 transportation firms and concludes that these firms suffered -2,09% CAR in the five-day event window. This result is consistent with prior literature.

Furthermore, Lamb (1998) focuses on the reaction of 34 publicly held property and casualty companies to Hurricane Andrew in 1992 and Hurricane Hugo in 1989 relative to their condition of exposure. The study draws inspirations from prior literature since it is seen that companies reacted to the 1989 California earthquake based on their geographic locations (see Shelor et al. 1990). With a 150-day estimation period and employing the standard event study methodology, the paper finds that the only statistically significant results are shown by firms exposed during Hurricane Andrew. However, this significance only lasts for two days after the event, implying a successful incorporation of new information into the stock prices. The study thus highlights the dynamic nature of market reactions to natural disasters and the efficiency with which information is absorbed and reflected in stock valuations. However, with respect to this methodology, Wang and Kutan (2013) emphasize the significance of assessing the stability of stock betas post-hurricanes, as volatility fluctuations during disasters could potentially alter stock betas.

Chen and Siems (2004) studies 14 different terrorist and military attacks that happened between the years of 1915 and 2001 including the Iraqi invasion of Kuwait as Bradford and Robison (1997) does. The study finds statistically significant negative abnormal returns in all the indices they included on the event day, while in event window CARs differed depending on the country. They also suggest that U.S. capital markets are less sensitive to terrorist attacks than in the past and faster to recover from such attacks than any other market.

Employing GARCH and classic event study model, Chesney et al. (2011) studies the effects of different terrorist attacks on stocks, bonds and commodity markets in 25 different countries. Their findings indicates that the general abnormal effect of the attacks were statistically significantly negative.

In their study, Bash and Alsaifi (2019) studies the effects of Jamal Khashoggi’s disappearance on stock market of Saudi Arabia by employing classic event study approach. For making a comparison between the estimators of normal returns, the study employs both mean-adjusted return and market model. The research finds statistically significant negative CARs up to 20 days after the event and both models produced similar results.

In their study, Ahmed et al. (2022) examine the impact of the Russia-Ukraine crisis on the European stock market using an event study methodology based on OLS estimations. The study utilizes the STOXX Europe 600 Index as the market benchmark and includes stocks belonging to this index in its sample. Employing an estimation window of 250 days and an event window of 50 days, the study reveals significant negative abnormal returns on the event day and surrounding days. A country-specific analysis indicates varying effects of the crisis across countries, with the Netherlands exhibiting the most negative abnormal results and the UK displaying the most positive. Additionally, the study conducts a sectoral analysis, demonstrating varied effects among different industries. Furthermore, it observes that small and medium-cap firms were more severely impacted by the crisis compared to large-cap firms.

Lastly, Malik et al. (2023) investigate how corporate social responsibility (CSR) and non-CSR companies from USA perform during 471 natural disasters that happened in USA between the years of 1995 and 2015. The paper employs a standard market model for estimating the normal returns and finds that CSR and non-CSR companies reacted to disasters differently. Companies with higher environmental engagements, as part of their CSR initiatives, demonstrate a more resilient market performance compared to their counterparts without environmental CSR commitments. This finding underscores the potential impact of CSR activities, specifically those focused on environmental considerations, on companies' ability to navigate and recover from the challenges posed by natural disasters.

5 Methodology and data

This chapter provides an overview of the data and methodology employed in the research. The presentation is organized into four subsections: the initial section describes the data included in the study. The subsequent sections outline the applied research methods and alternative methodologies. In addition to details of the data used in the paper, a description of a table containing descriptive statistics of the selected indices is presented to offer a thorough view of the dataset studied in this thesis. This structured approach aims to provide clarity and transparency regarding the foundational components of the research design.

5.1 Methodology

Event studies play an important role in capital market research, serving as a method to assess market efficiency. In this context, the presence of systematically nonzero abnormal security returns that persist after a specific type of event is seen inconsistent with market efficiency. These studies become a valuable tool for scrutinizing the efficiency of financial markets by examining the extent to which new information is rapidly and accurately reflected in security prices (Kothari & Warner, 2007, p.5). If abnormal returns persist beyond what is expected in an efficient market, it raises questions about the completeness and speed of information incorporation, providing insights into the efficiency or inefficiency of the market under consideration.

Given that this study aims to explore market efficiency in Türkiye using event study methodology, the calculation of abnormal returns holds considerable significance. To compute abnormal returns, the initial step involves calculating the normal return, a process for which various models are employed in the existing literature. The choice of the specific model for calculating normal returns becomes a critical aspect of the methodological approach, influencing the accuracy and reliability of the abnormal return calculations.

When it comes to selecting models for research, there are typically two main options to consider: economic models and statistical models (MacKinlay, 1997). Economic models, such as the Arbitrage Pricing Theory (APT) and Capital Asset Pricing Model (CAPM), rely on economic theories to support their assumptions and calculations. On the other hand, statistical models derive their expected returns from statistical assumptions about return behavior.

According to Campbell et al. (2011, p.156), CAPM were commonly employed in event studies in the 1970s. However, deviations detected from the model and the strong limitations imposed led to a decrease in the model's popularity. Furthermore, the flexibility of loosening these limitations by employing the market model at a minimal expense, which can still yield valuable estimations, contributed to the decline of CAPM (MacKinlay, 1997).

Another popular econometric model, Arbitrage Pricing Theory (APT), started to be involved in researches after the cease of CAPM, since it does not impose false limitations on the mean returns (Campbell et al. 2011, p.156). However, APT, while being a complex methodology, does not create a big difference practically compared to statistical models. Therefore, there appears to be no compelling reason to use econometric models over a statistical model (MacKinlay, 1997).

Statistical models tend to be more commonly used as they provide a straightforward way to estimate expected returns based on the behavior of past returns. Two popular statistical models in this area are the Constant Mean Return Model and the Market Model.

The Constant Mean Return Model, as described by MacKinlay (1997, p.17), operates under the assumption that the returns of a security follow a normal distribution, and that the average return remains consistent throughout the observation period. This model offers a straightforward approach and can prove valuable when analyzing securities expected to exhibit a steady return trend.

On the contrary, the market model, considering the behavior of the market as a whole, asserts that a security's return is influenced by both its systematic risk and the return of the overall market portfolio (MacKinlay, 1997). This model proves beneficial in scenarios where the market's behavior is anticipated to perform an important impact on the security under investigation. The Market Model can be perceived as an expanded version of the constant mean return model since it eliminates the part of the return relative to the market's return, enhancing the ability to detect event effects (MacKinlay, 1997, p.18). Due to these reasons and the potential advantages of the Market Model, it is employed in this paper for estimating abnormal returns.

5.1.1 Timing of the event

Accurate determination of the event day is highly important for the success of an event study (MacKinlay, 1997, p.15). In this study, the designated event day (t=0) corresponds to the day when the earthquakes occurred. Given that the earthquakes took place on the same day, one before the opening of the market and the other during the trading day, 6th February 2023 is chosen as the event date. This selection of date ensures that the event day aligns with the emergence of information to the market, providing a solid foundation for the following analysis of market reactions and abnormal returns associated with the earthquakes.

The pre-earthquake estimation window is designed to cover a period that is free of relevant impact factors on the target event, in this case, earthquakes. For this research, the daily returns of the sectoral indices and each stock in the BIST100 market index are calculated over this window. MacKinlay (1997) asserts that longer estimation periods reduces the variance since the additional variance caused by sampling error approaches zero. For reducing the variance without including potential confounding events, the length of this window is deliberately chosen to strike a balance.

Usually, event studies include a period of anticipation before the event to observe possible early market reactions, sometimes even taking into account insider information. In this study, however, given that the event in question is an earthquake and cannot be predicted in advance with today's technology, a forecasting period is not utilized. Therefore, the methodology chosen for this study does not use an anticipation period, in line with previous literature (e.g., Shelor et al. 1990; Shelor et al. 1992; Scholtens and Voorhorst, 2013; Valizadeh et al., 2017).

Following methodologies used in previous literature (e.g. Shelor et al., 1990; MacKinlay, 1997), an estimation window of 120 days (t=-120 to t=-120) prior to the event day is chosen, as this choice allows for a deeper analysis, capturing a range of market behavior while minimizing the risk of being influenced by unrelated events during the estimation process.

The event window is the time period during which abnormal returns are calculated to assess the effects of the earthquake. In this study, it covers the day of the event and 10 business days after the earthquake (from t=0 to t=10). This length has been used in previous literature with robust results (Yamori & Kobayashi, 2002; Brounen & Derwall, 2010). Since this thesis aims to assess the immediate reaction of sectoral indices and the constituents of the market index, using a short event window proves suitable. Also, Ferreira and Karali (2015) indicates that shorter even windows can prevent contamination of

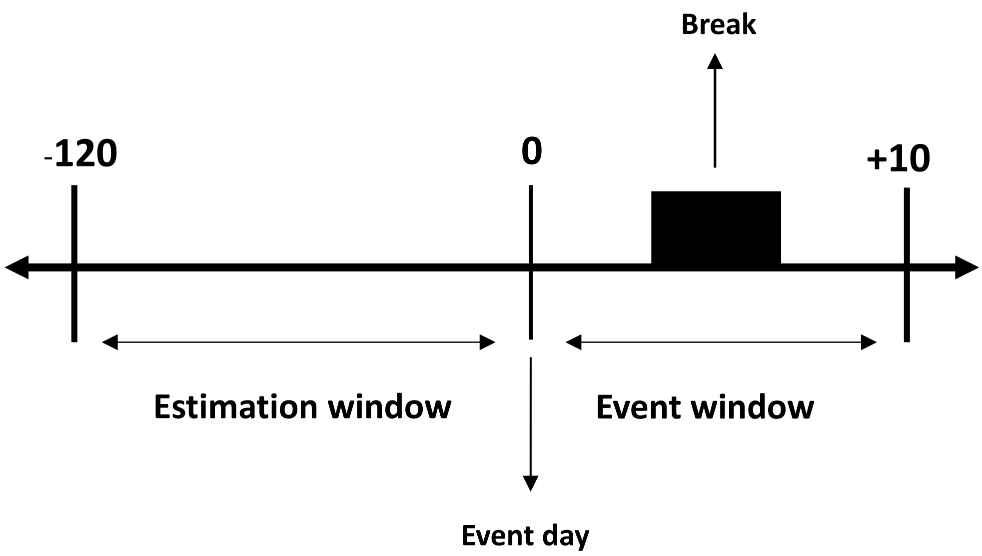

Figure 7. Time line of the study

estimations by external factors that affect the returns of market index. Moreover, Brown and Warner (1980) indicate that the reliability of tests tend to decrease in large event window and advocate for the employment of short event windows. Figure 7 depicts the timeframe of the research, spanning from 120 before and 10 days after the event, covering the estimation period, event day and event window.

5.1.2 Calculating normal returns

Computing abnormal returns correctly carries significance to conduct an event study effectively. Abnormal returns can be calculated by subtracting expected returns, i.e., normal returns, from actual returns. For estimating the normal returns, as mentioned earlier, this research uses the market model proposed by Fama et al. (1969).

The market model correlates the return of a specific stock market index by conducting a regression analysis of historical prices against the value of market portfolio index. In this model, disturbance term calculated on out of sample basis is utilized as abnormal returns, following the approach outlined by Brown and Warner (1985) and MacKinlay (1997). The utilization of abnormal returns when analyzing market indices is particularly valuable, providing insights into the financial markets' responses to specific events, as highlighted by Chen and Siems (2004). Moreover, the market model has been previously employed in prior literature with a wide range of studies (e.g., Keown & Pinkerton, 1981; Shelor et al., 1990; Shelor et al., 1992; MacKinlay, 1997; Yamori & Kobayashi, 2002; Ahmed et al., 2022). The market model is defined as follows:

$$R_{i,t} = \hat{\alpha}_i + \hat{\beta}_i R_{m,t} + \varepsilon_{i,t} \qquad \textbf{(2)}$$

where, $R_{i,t}$ is the logarithmic daily returns of security or index *i* on day *t*, α_i is the idiosyncratic return, β_i is the beta coefficient, $R_{m,t}$ is the return of the market portfolio at time *t*, $\varepsilon_{i,t}$ is the disturbance term at time period t. The coefficients α_i and β_i are obtained through the Ordinary Least Squares (OLS) method. The analysis is computed under the assumption that the variance of the disturbance term is constant. The normal returns are then defined as following:

$$NR_{i,t} = \hat{\alpha}_i + \hat{\beta}_i R_{m,t} \tag{3}$$

5.1.3 Calculating abnormal returns

Next step in the methodology for this study involves finding abnormal returns to investigate the impact on stock prices. Abnormal returns are in essence the disturbance term calculated on a sample basis (MacKinlay, 1997, p.20). Abnormal returns are calculated by subtracting the normal return from the actual return, where the expected return is estimated using the market model. The abnormal returns (AR) are defined as the actual returns minus the computed normal returns:

$$AR_{i,t} = R_{i,t} - NR_{i,t} \tag{4}$$

where, $AR_{i,t}$ is the abnormal return of security or index i at time t, $R_{i,t}$ is the actual return of security or index i at time t, $NR_{i,t}$ is the normal return of security or index i at time t.

Next, the abnormal return observations needs to be summed up for drawing overall conclusions (MacKinlay, 1997, p.21). That can be done in two dimensions, one being through securities and the other being through time. In this study, both approaches are employed for finding out the effects on the sectoral indices and the market in general.

For sectoral indices, the abnormal return observations need to be aggregated through time. This concept called cumulative abnormal return is necessary to investigate multiple days in the event window. Following MacKinlay (1997), CAR for sectoral indices are as follows:

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{i,t} \tag{5}$$

For the investigation regarding the market, observations from individual stocks need to be first aggregated through securities. Therefore, the average abnormal return (AAR) is calculated across stocks constituting the market index at time t within the event window. Since aggregating abnormal returns allows conclusions to be drawn about the overall impact of earthquakes, providing a thorough understanding of the overall effects, this approach is more informative than analyzing each event separately. This combined approach improves the capability to identify broader patterns and tendencies in market behavior during seismic events. Following MacKinlay (1997) the AAR are defined as follows:

$$AAR_t = \frac{1}{N}\sum_{i=1}^{N} AR_{i,t} \tag{6}$$

Besides offering useful information about the immediate response of the market, average abnormal returns are also potentially relevant in evaluating the market's behavior in the days that follow. This reassessment is where cumulative average abnormal returns (CAAR) serve as a valuable benchmark, as an indicator of the resilience of the market and its potential ability to recover from a natural catastrophe. By enabling an aggregated metric of abnormal returns over a certain horizon, CAAR highlights the persistent effects of the market beyond the initial event window and its recovery path. Contributing to a more complete picture of overall market dynamics and the capability to recover from serious setbacks, such as natural disasters.

The cumulative average abnormal returns (CAARs) are obtained by aggregating the abnormal returns over the event window. CAARs are then tested for significance using t-tests and the results are analyzed and interpreted to draw inferences about the impact of the event on stock prices. Given that this methodology has been extensively employed in prior studies, CAARs are considered to be a robust and reliable approach to analyze the impact of events on stock prices in a cumulative manner.

Following MacKinlay (1997) CAAR is defined as follows:

$$CAAR(t_1, t_2) = \sum_{t_1}^{t_2} AAR_t \tag{7}$$

5.1.4 Testing for statistical significance

The final step in this methodology, following the calculation of abnormal returns, comprises the consideration of the statistical significance of these abnormal returns. When conducting event studies, researchers typically face two main concerns when selecting the testing methodology.

One of the main concerns is the issue of non-normality. Utilizing daily returns in the study poses the risk of non-normal distribution, thus suggesting the use of a testing method that does not rely on normal distribution. However, MacKinlay (1997) suggests that as the size of the estimation window increases, the sample approximates normal distribution, making a standard t-test sufficient. Additionally, Brown and Warner (1985) demonstrate that even when the sample deviates from normal distribution, t-tests can still effectively determine statistical significance.

Another concern pertains to the assumption in event study methodology that abnormal returns are uncorrelated cross-sectionally. Ahmet et al. (2022) highlight the significance of this issue in their study, where the event date is same across all stocks in the sample. Similarly, in this thesis, the event date is same across all stocks studied. Despite this concern, Brown and Warner (1985) suggest that adjustment for cross-sectional dependence is only necessary in specific cases. Additionally, their findings reveal that these tests are only half as powerful as tests assuming independence. In alignment with this, upon examining the results of Ahmet et al. (2022), it is evident that standard tests effectively determine statistical significance. Consequently, in this thesis, a standard t-test is employed.

For a two-tailed test, the statistical significance of the results is determined by deriving t-values, which are then compared to critical values at the 10%, 5% and 1% significance levels. Identifying statistical significance relies on if the calculated t-value surpasses the critical values corresponding to the chosen significance levels. When the "t" value is larger than these critical values, the findings are regarded as statistically significant, verifying that the observed abnormal returns are statistically significant or simply the result of random fluctuations. With this particular statistical evaluation, a solid layer is applied to the explanation of the findings of the event study.

The first two hypotheses to be tested are the ARs and CARs for sectoral indices. This test shows if the results obtained in the event window deviates from zero statistically significantly. Therefore, these two hypotheses are as follows:

$$H_0 = AR_{it} = 0$$
$$H_0 = CAR_{it} = 0$$

For testing these hypotheses, the approach outlined by MacKinlay (1997) is followed. The result of the test demonstrates the robustness of the findings. Therefore, test statistics for AR of the sectoral indices are as follows:

$$TS_{AR_i} = \frac{AR_{i,t}}{\sqrt{\sigma^2_{ARi}}} \quad \textbf{(8)}$$

$$\sigma^2_{AR_i} = \frac{1}{L_1 - 2} \sum_{t=T_0+1}^{T_1} AR^2_{i,t} \quad \textbf{(9)}$$

where, σ^2_{ARi} is the variance of index or security i and L_1 is the length of estimation period. Test statistic of CAR for sectoral indices is as follows:

$$TS_{CAR_i(t_1,t_2)} = \frac{CAR_i(t_1, t_2)}{\sqrt{\sigma^2 CAR_i(t_1, t_2)}} \quad \textbf{(10)}$$

$$\sigma^2 CAR_i(t_1, t_2) = (t_2 - t_1 + 1)\sigma^2_{AR_i} \quad \textbf{(11)}$$

where; $\sigma^2 CAR_i$ is the variance of index or security i between t_1 and t_2. After stating the hypotheses for sectoral indices, AARs and CAARs of the market constituents in the event window days is also checked. Therefore, the other two hypotheses are as follows:

$$H_0 = AAR_{it} = 0$$

$$H_0 = CAAR_{it} = 0$$

The null hypothesis states that the average and cumulative abnormal returns are equal to zero in the event window. To test these hypotheses, the approach proposed by MacKinlay (1997) is followed in order to the test statistic for the AAR and the CAAR for day ”t”. It is as follows:

$$TS_{AAR_t} = \frac{AAR_t}{\sqrt{\sigma^2 AAR_t}} \quad \textbf{(12)}$$

$$\sigma^2 AAR_t = \frac{1}{N^2} \sum_{i=1}^{N} \sigma_{AR_i}^2 \quad \textbf{(13)}$$

$$TS_{CAAR(t_1,t_2)} = \frac{CAAR(t_1, t_2)}{\sqrt{\sigma^2 CAAR(t_1, t_2)}} \quad \textbf{(14)}$$

$$\sigma^2 CAAR(t_1, t_2) = \sum_{t=t_1}^{t_2} \sigma^2 AAR_t \quad \textbf{(15)}$$

5.2 Data

The data employed in this paper consists of the daily closing prices of the constituents of Borsa Istanbul 100 Index (BIST100). BIST100 consists of the 100 biggest companies in the Turkish stock market by their market capitalization. Also, 27 other sectoral indices provided by Borsa İstanbul is included in the research for sectoral analysis.

BIST stands as the exclusive exchange entity in Türkiye, situated in Istanbul and listing 605 companies. It plays a pivotal role in the Turkish economy, serving as a platform for companies to raise capital by issuing stocks, bonds, and various securities. Beyond facilitating capital for businesses, BIST also presents investment opportunities for both local and international investors, making it a key player in fostering the growth and development of Türkiye's financial markets.

Being the sole exchange entity in Türkiye, BIST is of importance for running the nation's financial markets. Additionally, BIST manages the Istanbul Stock Exchange National 100 (BIST100) index, the primary stock market index in Türkiye, further underscoring its significance in the financial landscape.

In the scope of this research, the data collection focuses on the daily closing prices of BIST100 constituents and 27 sectoral indices from 18th August 2022 to 27th February, 2023. These indices serve as quantitative measures of the overall market performance within a country, encapsulating the collective sentiments and expectations of investors regarding future cash flows and discount rates. Also, for computing the abnormal returns, a benchmark is needed and BIST100 is employed as the market benchmark. The approach of using a market benchmark index, such as BIST100, along with its constituent stocks has been employed in previous literature (e.g., Ahmet et al., 2022). This method aims to provide a more complete understanding of how seismic events influence the

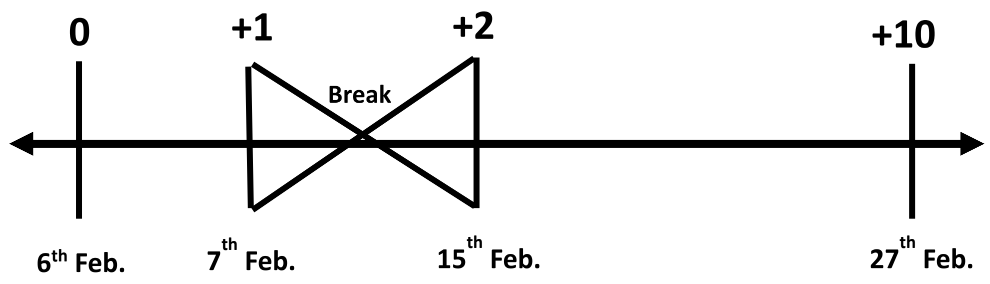

Figure 8. Time line of the event days

broader financial landscape, offering insights into investor perceptions and reactions in the aftermath of earthquakes.

To carry out this analysis, the daily stock prices of carefully selected indices have been extracted from Thompson Reuters database using University of Vaasa's access. After collecting the data, 14 firms have been taken out of the sample since the daily stock price or market value data were not available for the entire estimation period. Additionally, two days after the event date, on 8th February 2023, the authorities decided to close the market and void all trades made on that day. Consequently, the data for 8th February and the subsequent days when the market was closed were removed from the sample, as the prices did not differ from those observed on 7th February 2023. The day the markets reopened, 15th February, is designated as day +2 in this thesis as can be seen from Figure 8. Now that the data is described, logarithmic daily percentage index returns are calculated using the following formula for 27 sectoral indices and 86 firms comprising the market index:

$$R_{it} = \ln\left(\frac{P_{it}}{P_{it-1}}\right) \tag{16}$$

where R_{it} is the return of the index i for a period t, P_{it} is the price of the index i at the end of period t and P_{it-1} is the price of index i at the end of period t-1. Table 1 presents the descriptive statistics of logarithmic daily returns of selected indices.

Table 1. Descriptive statistics of logarithmic daily returns of selected indices

	Mean	Med.	Max.	Min.	Std. D.	Skew.	Kurt.	Obs
BIST100	0,41%	0,49%	9,42%	-9,01%	0,026	-0,430	2,708	131
BANKING	0,32%	0,01%	9,49%	-10,39%	0,042	-0,079	0,357	131
BASIC MATERIALS	0,37%	0,30%	9,08%	-8,01%	0,031	0,189	1,033	131
CHEMICALS	0,48%	0,83%	9,44%	-10,01%	0,029	-0,312	1,170	131
CORPORATE GOVERNANCE	0,38%	0,42%	9,29%	-9,00%	0,025	-0,368	2,694	131
ELECTRICITY	0,42%	0,46%	8,32%	-8,65%	0,027	-0,395	1,538	131

	Mean	Med.	Max.	Min.	Std. D.	Skew.	Kurt.	Obs
FOOD & BEVE-RAGE	0,25%	0,56%	8,99%	-8,42%	0,024	-0,561	2,674	131
HOLDING & IN-VESTMENTS	0,38%	0,56%	9,26%	-9,07%	0,026	-0,389	2,305	131
INFO TECHNO-LOGY	0,23%	0,30%	8,19%	-8,97%	0,024	-0,670	2,720	131
INSURANCE	0,38%	0,21%	6,98%	-9,14%	0,025	-0,488	1,912	131
INV. TRUSTS	0,24%	0,49%	8,53%	-8,95%	0,024	-0,388	1,790	131
LEASING & FAC-TORING	0,04%	0,14%	9,25%	-10,34%	0,032	-0,290	0,537	131
METAL GOODS, MACHINERY	0,43%	0,63%	9,28%	-9,35%	0,024	-0,624	3,764	131
MINING	0,70%	0,44%	9,52%	-10,17%	0,038	-0,002	0,304	131
FINANCIALS	0,35%	0,28%	9,03%	-8,81%	0,028	-0,343	1,566	131
INDUSTRIALS	0,44%	0,68%	9,23%	-8,23%	0,024	-0,441	2,633	131
SERVICES	0,44%	0,55%	8,98%	-9,28%	0,024	-0,563	3,616	131
TECHNOLOGY	0,43%	0,44%	8,88%	-9,87%	0,029	-0,612	2,085	131
REAL ESTATE	0,30%	0,47%	8,08%	-8,55%	0,026	-0,635	1,676	131
SPORTS	0,02%	0,30%	6,57%	-10,38%	0,029	-0,615	1,517	131
SUSTAINABILITY	0,39%	0,46%	9,39%	-8,95%	0,026	-0,283	2,498	131
TELE COMMS	0,44%	0,38%	9,52%	-10,53%	0,038	-0,155	0,315	131
TEXTILE & LEAT-HER	0,40%	0,54%	8,24%	-8,40%	0,025	-0,625	2,361	131
TOURISM	0,21%	0,49%	6,89%	-8,64%	0,024	-0,572	1,480	131
TRANSPORATION	0,56%	0,27%	9,45%	-9,72%	0,031	0,089	0,967	131
WHOLESALE & RETAIL	0,30%	0,43%	9,38%	-8,49%	0,024	-0,119	2,534	131
WOOD, PAPER & PRINT	0,35%	0,63%	9,01%	-9,62%	0,026	-0,722	2,132	131
NON METAL PRO-DUCTS	0,68%	0,67%	8,87%	-7,94%	0,028	0,092	1,391	131

6 Empirical results

The empirical results obtained through the methodology outlined in the preceding chapter are presented and discussed in this chapter. Firstly, the findings from the market index constituents are presented and discussed to examine the overall market reaction to the earthquake. Subsequently, the results for sectoral indices are presented and discussed to explore how different sectors responded to the earthquake. This structured approach allows for an in-depth analysis of the impact of the earthquake on both the broader market and specific sectors within it.

6.1 Reactions of market index constituents

Table 2 and Table 3 present the average abnormal returns and cumulative average abnormal returns observations from the event day to 10 days later. Additionally, t-test values are displayed in the right column to indicate statistical significance. Also, the actual returns of market index are shown in Appendix C for comparison since abnormal returns correspond to the difference between actual returns and normal returns estimated using Equation 3. Moreover, Figure 9 is added to convey the actual daily returns of the market

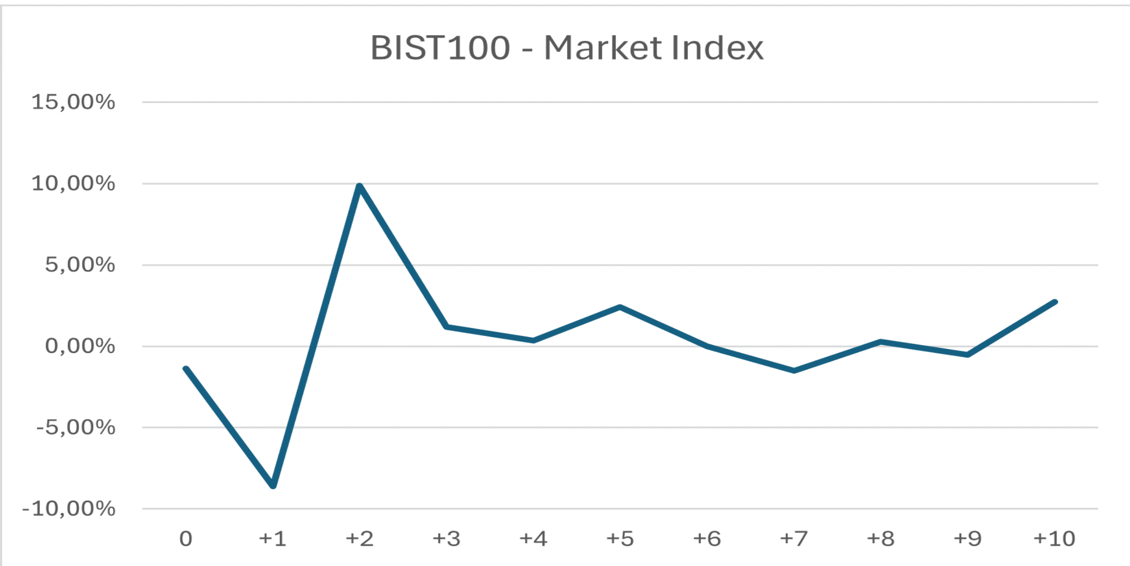

Figure 9. Actual daily returns of the market index in the event days

index visually. These separate analyses offer insights into how the market reacted to the earthquake on each day of the event window and cumulatively over different periods.

The findings from Table 2 suggest that the constituents of the market responded to the earthquake slightly less negatively than the estimated normal return on the event day, indicating a slight anticipation of less unfavorable conditions than expected. However, this result does not exhibit statistical significance. Similarly, on the second day following the earthquakes, there is a 0.24% negative average abnormal return, but again this result lacks statistical significance. These results are consistent with previous literature as Brounen and Derwall (2010) in the earthquake part of their study and Lamb (1998) for Hurricane Hugo finds similar results on the event day and the following days.

Furthermore, after the second day of the earthquakes, a 5-day market break was observed. Following this break, prices adjustments to new information revealed a statistically significant 0.75% positive abnormal return inconsistently with prior literature. Also, day +2 is when high actual returns for the market index were observed as can be seen from Figure 9. Therefore, it can be said that the constituents of the market index reacted more positively than expected on this day of the event window. Other days within the event window showing statistically significant abnormal returns include day +3, +5, +6, +9, and +10, with the highest abnormal return observed 6 days after the event at 1.46%, and the lowest being -2.04% 3 days after the earthquakes.

Indeed, the observed results do not exhibit consistency, with negative abnormal returns following positive abnormal returns, pointing at potential undervaluations and overvaluations occurring after each other. This pattern underscores the dynamic and complex nature of market responses to seismic events, where market sentiment and valuation assessments can fluctuate rapidly in response to evolving conditions. Moreover, it is essential to acknowledge that the event window corresponds to a period marked by search and rescue efforts, during which new information may emerge and influence market sentiment. The emergence of such information could contribute to the observed fluctuations in abnormal returns during this timeframe.

Table 2. Average abnormal returns for the constituents of the market index

The table demonstrates average abnormal returns (AAR) calculated for each day of the event window. Statistical significance levels are shown at 10% by *, 5% by ** and 1% by ***.

t	AAR	t-value
0	0,52%	1,45
+1	-0,24%	-0,68
+2	0,75%	2,10**
+3	-2,04%	-5,71***
+4	-0,09%	-0,26
+5	1,12%	3,13***
+6	1,46%	4,10***
+7	-0,28%	-0,77
+8	0,32%	0,90
+9	0,75%	2,11**
+10	-0,73%	-2,04**

Additionally, the differing reactions among stocks comprising the market index further contribute to the fluctuating market response following the earthquake. Previous literature has demonstrated that while investors may perceive disaster times as unfavorable for some stocks, they may also view them as favorable for others in terms of abnormal returns (e.g., Shelor et al., 1992; Valizadeh et al., 2017). These differing reactions among individual stocks can amplify the overall volatility and unpredictability of the market in the aftermath of the event. Consequently, the fluctuating market response observed in the aftermath of the earthquake can be attributed to a combination of factors, including varying perceptions of valuation, the emergence of new information during the event window, and the differing reactions among stocks within the market index.

These results, when perceived completely, do not show consistency with most of the prior literature. Nevertheless, there are some studies showing partial consistency. For instance, Yamori and Kobayashi (2002) finds inconsistent abnormal returns after the earthquake for the low exposure portfolio in their analysis. However, it is important to note that their study specifically focuses on insurance firms, which may not be directly comparable to broader market reactions. Insurance firms may exhibit unique characteristics and responses to natural disasters due to their exposure to risk and liability management strategies, which could differ from the broader market dynamics.

For assessing the overall effect within the event window, cumulative average abnormal returns (CAAR) are computed. Upon examining the results from Table 3, a different picture emerges. Initially, the 2-day CAAR displays a positive abnormal return of 0.28%, however lacking statistical significance. This suggests a slightly less downward movement in the market following the earthquake than expected using Equation 3, however it does not reach levels of statistical significance.

Conversely, the 3-day CAAR reveals a positive abnormal return of 1.03%, not so significantly at the 10% level meaning that the abnormal part of the reaction on the event day and following 2 days were positive when combined. This observation underscores the volatility and uncertainty surrounding market dynamics in the immediate aftermath of seismic events. Subsequently, when AAR of the 4th day following the earthquakes, which is the lowest AAR observed at -2.04% is aggregated into the cumulative average, the resulting CAAR stands at -1.10%, yet it fails to achieve statistical significance. This trend persists throughout the event window, with fluctuations in abnormal returns reflecting the market's reaction to evolving conditions.

Notably, the 10-day CAAR depicts a positive abnormal return of 2.27%, which is statistically significant at the 5% level. This result indicates that combined abnormal return for market constituents on the event day and following nine days deviated positively from estimated normal return. Finally, there are only two CAAR in the event windows showing statistical significance. One being the 3-day and the other being the 10-day CAAR. All the other observations fail to demonstrate statistical significance. The lowest cumulative average abnormal return observed in the event window is negative 1.10% from 5-day CAAR. On the other hand, the highest cumulative average abnormal return is observed from 10-day CAAR.

Table 3. Cumulative average abnormal returns for the constituents of the market index

The table demonstrates cumulative average abnormal returns (CAAR) calculated for each day of the event window. Statistical significance levels are shown at 10% by *, 5% by ** and 1% by ***.

t_1,t_2	CAAR	t-value
(0,1)	0,28%	0,55
(0,2)	1,03%	1,66*
(0,3)	-1,01%	-1,42
(0,4)	-1,10%	-1,38
(0,5)	0,01%	0,01
(0,6)	1,48%	1,56
(0,7)	1,20%	1,19
(0,8)	1,52%	1,42
(0,9)	2,27%	2,02**
(0,10)	1,55%	1,31

A possible explanation for the observed behavior of the market lies in the calculation of the cumulative average abnormal returns. These metrics are essentially the sum of abnormal returns over a specified period. Upon closer examination of Table 2, it becomes evident that negative AARs are followed by positive AARs, and vice versa, during the event window.

These alternating patterns of positive and negative AARs effectively cancel each other out when aggregated into the CAAR, thereby mitigating the overall impact on the cumulative average abnormal return. Consequently, despite fluctuations in individual daily returns, the net effect on the cumulative average abnormal return may appear less pronounced due to the offsetting nature of positive and negative abnormal returns.

These results are consistent with prior literature (e.g., Shelor et al., 1990; Worthington, 2008; Brounen & Derwall, 2010). For instance, Brounen and Derwall (2010) finds no statistically significant CAR in the event window for earthquakes. Also, they underscore that even if earthquakes are similar to terrorist attacks in sense that they both occur unannounced, cause high number of casualties and receive considerable media attention, the abnormal effects of earthquakes on the stock markets are marginal.

In conclusion, this chapter of the study finds that the AAR after the market break does show statistical significance, therefore hypothesis one is to be rejected. However, the CAAR of the stocks investigated does not demonstrate statistically significant positive or negative abnormal returns. Therefore, hypothesis two is not to be rejected.

6.2 Reactions of sectoral indices

Even though the constituents of the market index show differing results, it is still necessary to investigate the sector specific effects of the earthquake to further analyze the reaction to this disaster. Therefore, Appendix A and Appendix B showing the abnormal returns and cumulative abnormal return calculated for different indices of Turkish stock market are presented. Also, a table showing the actual daily returns of these indices are presented in Appendix C.

Initially, the banking sector shows an insignificant negative abnormal reaction to the earthquake on the event day. It can be seen that the only statistically significant result is shown on the day after the earthquake at 10% level. Also, CAR results support these findings as there are no significant abnormal reactions in the event window. Therefore, the banking sector seems to be resilient against the abnormal effects of the earthquake meaning that it does not deviate from normal return estimations statistically significantly. These results do not show consistency with Valizadeh et al. (2017) and Worthington and

Valadkhani (2005) as they find statistically significant negative abnormal results up to 16-day CAR and that financial services show sensitivity to the natural disasters, respectively. However, these results could be due to differences in banking regulation and preparedness.

The basic materials sector show a positive and statistically significant abnormal response to the earthquake on the event day. This trend continues until the last day in the event window. Also, CAR of the basic materials show that these results persist when aggregated as 11-day CAR show statistically significant 11,67% positive abnormal return. Regarding the actual returns, it can be seen from Figure 10 that this index showed actual positive daily returns in most of the days in the event window including the event day. Therefore, these results, inconsistently with Valizadeh et al. (2017), show that the market found the conditions favorable for the basic resources sector.

Another sector that seems to be actively following the normal return estimations after the earthquake is chemicals as it shows only one statistically significant abnormal return on 3 days after the event at 4,17%. However, when looking at the CAR, it can be seen that the cumulative abnormal response following the earthquake is significantly negative. Nevertheless, that is only valid for a 2-day CAR since the market adjusts to the information after that and shows no other statistically significant CAR. This result also does not show consistency with Valizadeh et al. (2017) since they show that Japanese chemicals sector reacts to the earthquake significantly and negative in terms of abnormal returns.

Furthermore, corporate index, which is composed of companies with high levels of corporate governance compliance, reacts indifferently than estimated to the earthquake as it demonstrates mostly statistically insignificant abnormal returns in the event window. The only exception is 3 days after the earthquake with 0,89% positive abnormal return significant at 10% level. This trend also follows when the abnormal returns are aggregated.

The electricity sector on the other hand shows a negative but insignificant abnormal reaction to the earthquake on the event day. Similarly to other sectors, the first significant response is on the 4th day of the earthquake as it shows -5,12% abnormal return. Even though this response also shows persistency in CAR, the sector index stops demonstrating statistically significant abnormal returns in the second half of the event window.

The food and beverages sector shows an insignificant but positive abnormal response to the earthquake on the event day, however this trend reverses in 3 days showing statistically significant -6,46% abnormal return. The same trend is also present in the results of CAR, however similarly to the electricity sector, these abnormal returns becomes insignificant in the second half of the event window.

The holdings and investments index seems also to be resilient to the abnormal effects of the earthquake as it shows its only statistically significant reaction 3 days after the earthquake. Also, CAR of the holdings and investment index shows no statistically significant abnormal return on none of the CAR computed for the event window.

The information technology sector responds to the earthquake with a -0,71% insignificant abnormal return indicating a negative but insignificant deviation from estimated normal return. However, on the following day, the index shows a statistically significant -3,10% abnormal return. The same characteristic emerges on 3 days after the event as it shows -6,42% abnormal return. Furthermore, CAR results of this index shows that the information technology sector is negatively affected by the earthquake in terms of abnormal returns, however these findings does not last in the second half of the event window. Unlike others, these results show consistency with Valizadeh et al. (2017).

The insurance sector is affected negatively by the earthquake on the event day as it shows -3,15% abnormal return significantly at 10% level, meaning that the actual response was more negative than normal return expectations. Even though these negative abnormal reactions continue every day in the event window, they do not cause statistical significance until the last day in the event window where -3,36% AR is seen significantly at 10%. However, when the results are aggregated, a different picture emerges as the insurance sector shows negative and significant CAR on all the days in the event window. For instance, 11-day CAR shows -13,61% abnormal return significantly at 5% level. These results show consistency with Yamori and Kobayashi (2002) and Valizadeh et al. (2017) as both papers find that the insurance sector is negatively affected by the earthquakes. However, these findings do not align with Shelor et al. (1992) as they find that the insurance stock prices rose after 1989 San Francisco earthquake. Regarding these varying results, Yamori and Kobayashi (2002) underscore the importance of the differences between the perception of investors, markets and regulations.

Another efficiently priced index seems to be investments and trusts as it shows only two statistically significant and negative abnormal responses to the earthquake on the days following the earthquake. However, when the results are aggregated, negativity of this response deepens as the 2-day CAR shows -6,20% significant at 1% level. These results only last until 5-day CARs and then loses statistical significance.

Leasing and factoring sectors reacts to the earthquake negatively on the event day in terms of both actual returns and abnormal returns. However, this result does not show statistical significance for abnormal results. Furthermore, similar to the other sectors, the first statistically significant abnormal return comes after 3 days with -6,43%. No other day in the event window shows significant results. Looking at cumulative results, 2-day, 4-day and 5-day CARs shows significant results. The direction of the trend is negative at -5,84 significant at 10% level initially, however when the abnormal returns after the market break are added, 4-day and 5-day CARs show -10,38 and -11,24% respectively at 5% level, indicating that this sector is more negatively affected by the earthquake than estimated.

When it comes to the metal goods sector, the results show that the abnormal effect of the earthquake is short-living and limited. This sector shows abnormal responses to the disaster the day after the earthquake and the market break. These results show -2,47% AR significant at 5% level, however after the market break the trend takes a different turn and demonstrates a positive 1,86% abnormal return at 10% level. When the results are aggregated, there seems to be no significant finding. While CAR decreases to -2,78 insignificantly at 5-day results, 11-day CAR shows 0,18% abnormal return insignificantly. Therefore, it can be said that the metal goods index is affected by the earthquake minorly and insignificantly in terms of abnormal returns.

Similarly to the metal goods sector, mining also seems to be resilient against the abnormal effects of the earthquake. The index responded to the earthquake on the event day negatively with -1,24% abnormal return, however this result does not demonstrate statistical significance. In line with most of the sectors analyzed, the sharpest decline in abnormal returns happens 3 days after the earthquake with -5,00% significant at 10% level. Furthermore, the sector does not show any other significant result until the last day of the event window when -6,41% abnormal return significantly at 5% level is observed. When the results are aggregated through time, the same trend follows as there are no significant CAR in the event window. However, 11-day CAR shows -12,28% cumulative abnormal return insignificantly. It is infrequent to see this high abnormal return to be insignificant, however this can be explained by the volatility of the mining index. Higher volatilities causes higher standard deviations, therefore the indices that fluctuate more often and more sharply need to show bolder effects to be taken statistically significant. Furthermore, 11-day CAR is divided by 11-day standard deviation, therefore it is possible to see high but insignificant results.

The financials index shows a slightly more negative response than estimated normal return to the earthquake on the event day with -0,25% abnormal return that is statistically insignificant. The one and only significant daily abnormal return is observed 3 days later with -1,54% at 10% level. In the following days, a positive trend follows, however, none of these returns demonstrate statistical significance. When considered cumulatively, there are no statistically significant CAR computed for any of the days in the event window as for the lowest point is seen as -2,57 in 5-day CAR insignificantly. Furthermore, 11-day CAR shows a positive abnormal result with 0,54% which is also insignificant. These results do not show consistency with Valizadeh et al. (2017) and Worthington and Valadkhani (2005) as they find that financials show sensitivity to the earthquake. This can be explained by the macroprudential differences and financial health of the countries. Due to differences in regulations and ownership structures, these institutions may be affected by disastrous events in different manners.

The industrials sector reacts to the earthquake indifferently than estimated normal return with a minor negative abnormal return on the event day. While this trend follows on the second day of the event, it takes a different turn after the market break and becomes positive. Similarly to other sectors, industrials also show its first statistically significant abnormal response 3 days after the event with a positive 1,75% abnormal return significant at 5% level. This positive abnormal response continues with 1,85% abnormal return at 1% level, however reverses after -2,21% abnormal return significantly at 1% level. After this last negative abnormal response, no other statistically significant trend can be seen. When considered aggregated, the first statistically significant abnormal response is seen at 5-day CAR with 3,25% cumulative abnormal return. The last significant abnormal response is observed with 10-day CAR at 4,45% at 5% level. These results show that the response of the industrials index positively deviates from estimated normal returns and do not show consistency with Valizadeh et al. (2017).

The services sector responds to the earthquakes with -0,18% abnormal return but insignificantly on the event day. However, on the following day, -1,79% AR is observed significant at 5% level. Even though the sector does not show statistical significance on the market reopening day, -3,42% AR significantly at 1% level is seen on the following day. When considered cumulatively, the results show that the sector demonstrated significant abnormal returns for nearly all the days in the event window. While 7-day CAR, which is the lowest CAR observed in the event window, shows -7,40% abnormal return significant at 1% level, 11-day CAR show -5,59% result at 5% level. These results show consistency with Valizadeh et al. (2017) since they also observe a 16-day negative and significant CAR in the utilities sector.

When it comes to the technology sector, it can be seen that the index reacted to the event in a fluctuating nature in terms of abnormal returns, however the first statistically significant AR is observed 3 days later than the earthquake with -4,85% abnormal return at 1% significance level. Other days in the event windows do not show statistical significance for ARs. When aggregated, the abnormal reaction follows a downward trend, showing statistical significance at 5-day CAR with -6,46% return. The negativity peaks at 6-day CAR with -8,65% significantly at 5% level and continues until the last day of the event window insignificantly. These results align with prior literature (e.g., Valizadeh et al., 2017) as it is common to observe that the technology sector is affected more negatively than estimated by earthquakes.

The real estate sector on the other hand, responds to the earthquakes more negatively than estimated normal return but insignificantly on the event day. Similarly to other sectors, real estate also shows its first significant result 3 days after the event day with -3,68% abnormal return at 1% level. However, these results fluctuate in the second half of the event window showing statistically significant positive abnormal returns from time to time. When aggregated, there seems to be only two statistically significant results from 4-day and 5-day CARs with -5,03% and -5,57% respectively, not so significantly at 10% level. These results indicate that the index reacted to the event more negatively than expected initially, however this abnormal response does not last for long. These findings partially align with Shelor et al. (1990) and Valizadeh et al. (2017). When assessing the impacts of earthquakes, risk factors regarding the location of the real estate firms carries significance, for instance Shelor et al. (1990) show that while firms in the earthquake area is affected more by the 1989 California earthquake, those unexposed are minorly affected in terms of abnormal returns.

The sports sector shows a more negative reaction than expected to the earthquake on the event day with -1,25% AR but insignificantly. This reaction follows the same trend one day and 3 days later showing statistically significant -7,32% and -5,21% abnormal returns, respectively. These negative results also persist when the results are cumulated as 2-day, 4-day, 5-day and 6-day CARs shows statistical significance. The most negative results are found 4-day CAR with -12,64% significant at 5% level. These results can be explained by unclarity about the future of the football league as it was postponed to an unknown date after the earthquake.

Another index that seems to be efficiently priced after the earthquake is sustainability as it shows minor abnormal response to the earthquake both on the day of the event and also on the other days in the event window. The same trend also follows when the abnormal returns are accumulated over time. The index responds to the earthquake with a positive abnormal reaction initially with 0,81% CAR, however this response reverses as 11-day CAR shows -0,77% return. Furthermore, none of these results show statistical significance. These results show consistency with Malik et al. (2023) as they also show that companies with higher CSR compliance demonstrate higher resiliency compared to non-CSR companies during natural disasters. Malik et al. (2023) underscore the importance of how being environmentally responsible could contribute to financial stability.

The telecommunication sector responds to the earthquake insignificantly but positively on the day of the event in terms of abnormal returns. Similar to other sectors, the first significant abnormal response is shown on 3 days after the event, as it demonstrates -4,96% AR at 5% level. The same trend follows for two more days statistically significantly. When aggregated, the negativity in the abnormal response becomes more observable. Starting from 5-day CAR, the sector shows increasingly negative and statistically significant abnormal responses until the last day of the event window as 11-day CAR shows -20,88% significant at 5% level. This behavior of the market can be explained by the loss of trust to GSM operators in the country during the earthquake. One of the biggest newspapers in Türkiye, Habertürk (2023) describes the situation as a big failure as 2.451 cell towers deactivated, and communication was disrupted when it was most needed.

The textile sector demonstrates negative but insignificant abnormal reactions to the earthquakes in the initial days of the event. However, the results start to gain statistical significance after the market break as -3,14% and 3,75% abnormal returns seen at 5% level. When aggregated, the only significant abnormal response is seen at 5-day CAR with -6,03%. However, this result show low levels of significance at 10% level. Therefore, it can be said that the textile sector is minorly affected by the earthquake in terms of abnormal returns. This could be explained by the geographical location of textile companies in Türkiye. Most of these companies are located around Bursa which is a city in the west and far from the affected area, therefore geographical exposure is low. Lamb (1998) indicates that the geographical risk determined by the location of the firms could decrease their exposure to disasters and lighten the impacts of the new information.

The tourism sector shows generally negative abnormal returns; however, the only statistically significant one comes 3 days after the event with -5,16% significant at 1% level. When the results are aggregated, the trend becomes less prominent as only 3-day and 4-day CAR show statistical significance at 10 % level. This result does not show consistency with Valizadeh et al. (2017); however, this also can be explained by the geographical location of the tourism center of the country which is located far from the earthquake area.

The transportation sector reacts more negatively than estimated normal return with -1,07% abnormal return to the earthquakes on the event day. This negative trend follows on most of the days in the event window while none of them demonstrate statistical significance. When the results are aggregated, the findings still persist. While 7-day CAR reaches as low as -9,31% at 10% level, this stands out as the only statistically significant findings in the event window. Therefore, it can be said that the transportation sector reacts to the earthquake indifferently than estimated both on the day of the event and the following days in terms of abnormal returns.

Similarly to the transportation sector, wholesale and retail seems to be resilient against the abnormal effects of the earthquakes as it demonstrates only one statistically significant abnormal return in the event window. This result is seen on the market reopening day with 2,50% AR significant at 10% level. This trend can also be observed when the results are aggregated as there are no statistically cumulative abnormal return found for this sector. Therefore, it can be said that investors did not find the conditions more unfavorable than estimated for the wholesale and retail sectors. These results may be explained by the expansive size of the sector in Türkiye as Ahmed et al. (2022) show that large firms are less negatively affected by geopolitical crises.

The wood and paper sector on the other hand, react more negatively than expected but insignificantly with -1,93% abnormal return on the event day. This is followed by a statistically significant -3,42% abnormal return at 5% level. Furthermore, the lowest return is observed 3 days after the event with -5,43% significantly at 1% level. A similar trend follows when the results are cumulated as 2-day, 4-day, 5-day and 6-day CARs are showing statistical significance. The lowest CAR is seen in the 5-day CAR with -8,44% significant at 5% level. Therefore, it can be said that the wood and paper sector is more negatively and significantly affected than estimated by the earthquake on the event day and following days.

Finally, the non-metal products sector responds to the earthquake highly positively on the event day and in the following days both in terms of abnormal returns and actual returns. The index demonstrates 8,30% abnormal return on the event day significant at 1% level and this trend follows for nearly all the days in the event window. When the results are aggregated, these findings persist as all the CARs computed for the days of event window show high statistical significance. For instance, 11-day CAR demonstrates

39,75% abnormal return significant at 1% level. Therefore, it can be said that the market considers the conditions highly favorable for the non-metal products sector.

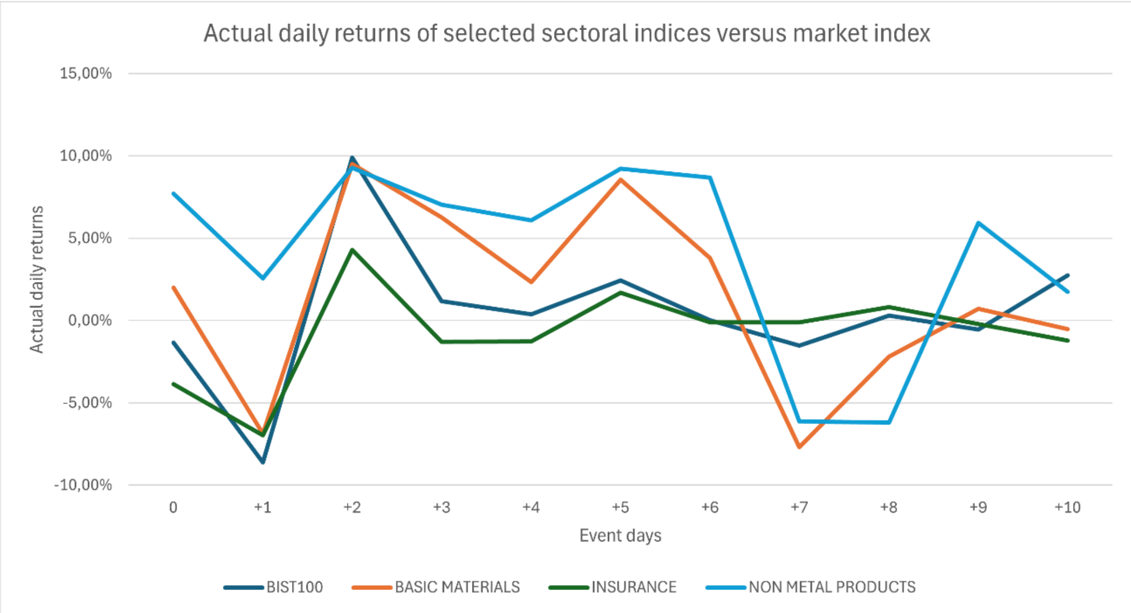

Figure 10. Actual daily returns of selected sectoral indices versus market index

In conclusion, while most of the market responds to the earthquake more negatively than expected by the normal return estimations, there are still some sectors that are affected positively such as basic materials and non-material products. This behavior can also be seen by analyzing the actual returns presented in Figure 10. Therefore hypothesis 3 and 4 is not to be rejected. Furthermore, especially non-material products sector responds to the earthquake highly positively. This behavior can be attributed to the investors' interpretation of the conditions as it can be seen from the media that especially cement, iron and steel shares rose dramatically after the earthquake (DailySabah, 2023). The fact that the shares of firms producing the materials used for building new houses further supports the idea that investors expected a rise in the construction of new houses and bought the opportunity.

7 Conclusion

The threat of earthquakes worldwide has heightened concerns about their impact on our daily lives. With the growth of urban centers and population density, the potential damage from such disasters have become increasingly severe. Consequently, starting from the 1989 California earthquake, research studying the effects of earthquakes on economies and stock markets have gained attention. Therefore, this thesis aims to investigate the effects of the 2023 earthquakes in Türkiye on the Turkish stock market both at a general level and within specific sectors.

Existing literature presents differing perspectives on the impact of earthquakes. While some argue for negative abnormal effects, others suggest that earthquakes have no significant abnormal impact on capital markets. Additionally, there are studies proposing potential positive abnormal impacts on various sectors (e.g., Shelor et al., 1992).

The methodology in this thesis involves estimating normal returns through an expected return model and then calculating the difference between actual returns and normal returns. The market model is employed as the expected return model, with an estimation window of 120 days and an event window of 10 trading days chosen for analysis. Significance testing is conducted using a standard t-test. While there are concerns regarding the use of a standard test with non-normally distributed or cross-sectionally dependent samples, previous literature supports the adequacy of a standard t-test even when these issues are present.

Building on this research landscape, this thesis analyzes the abnormal impact of the earthquake on stocks comprising the market index on the event day and throughout the event period. On a daily basis, the earthquake's effect fluctuated, exhibiting both negative and positive abnormal trends. However, when examined collectively, this effect diminished, revealing a relatively minor abnormal impact. Several factors account for this difference, including the emergence of new information in the days following the earthquake, instances of overvaluation and undervaluation, and the disproportionate influence of positively affected stocks on average.

On the other hand, the analysis of sectoral indices paints a different picture. While many sectors experienced negative abnormal effects from the earthquake, some, notably those in basic materials and non-metal products, saw significant positive abnormal impacts. These sectors exhibited statistically significant and highly positive reactions to the earthquake for nearly all the days in the event window.

While several sectors initially more negatively impacted than estimated by the earthquake, such as chemicals, electricity, food and beverage, information technologies, investments and trusts, leasing and factoring, services, technology, sports, textiles, and wood & paper, they also appeared to mitigate this impact in the second half of the event window. However, sectors like insurance were unable to offset the negative effects and showed consistent negative and statistically significant abnormal returns throughout the event window.

A different finding was the lagged abnormal reaction on the day of the earthquake, which transformed into a statistically significant negative abnormal impact on nearly all stocks on the day after the market reopened. This delayed investor reaction suggests a response to new information that emerged during the market closure.

Interpreting the efficiency of the market based on these results proves challenging due to the variability in outcomes. According to the assumptions of efficient markets, sectoral indices and stocks should not exhibit statistically significant abnormal return opportunities. While this holds true when considering cumulative effects, daily reactions paint a different picture. Consequently, it can be argued that the constituents of the market index do not offer a clear indication of market efficiency.

Furthermore, upon analyzing sectoral indices, it becomes evident that certain sectors, such as electricity and services, align with market efficiency as they only present abnormal return opportunities for a brief period within the event window. However, other sectors, such as basic materials and non-metal products, demonstrate that abnormal gains were achievable both cumulatively and individually throughout the event window.

If this behavior of sectoral indices is interpreted as investor irrationality, it could serve as evidence supporting the arguments put by Shleifer (2000). As stated earlier, Shleifer (2000) suggests that despite EMH assuming that investor irrationality would cancel each other in the aggregate, investors might be irrational in the same direction, thereby creating these opportunities. This interpretation could also challenge the effectiveness of arbitrageurs as corrective mechanisms, given that prices failed to adjust to new information within the 11-day event window, potentially indicating market inefficiency.

In conclusion, while daily fluctuations in stock prices following the earthquakes displayed a mixed pattern of positive and negative trends, the cumulative abnormal impact over the event window appeared to be relatively small. This nuanced response underscores the complexity of market reactions to external shocks and highlights the importance of considering both short-term fluctuations and long-term trends in assessing market resilience. Furthermore, the sectoral analysis showed varying impacts across different sectors, with some sectors experiencing significant positive effects while others struggled to mitigate the negative impact. These findings emphasize the need for sector-specific analyses to capture the heterogeneous nature of market responses to seismic events. Overall, this study contributes to a deeper understanding of the interplay between the earthquakes and financial markets, providing valuable insights for investors, policymakers, and researchers alike.

The implications of this study extend beyond literature to policymakers and authorities tasked with disaster preparedness and risk mitigation. The findings offer valuable insights that can inform new policy responses to natural disasters, particularly earthquakes, which pose a significant threat to Türkiye. While predicting the exact timing of earthquakes remains impossible, earthquake risk data provides important indicators of potential seismic activity and approximate magnitudes. Employing these insights, policymakers can identify the sectors most vulnerable to earthquakes, enabling targeted measures to reduce risk exposure.

One potential strategy involves motivating production facilities in high-risk sectors to relocate to less vulnerable areas within the country. This relocation could mitigate the economic impact of earthquakes on key industries and contribute to overall resilience. Additionally, regulatory measures within the stock market can be extended based on the research findings. Understanding the market's reaction during and after seismic events can inform policy decisions aimed at stabilizing financial markets and safeguarding investor interests.

Moreover, there is a need for initiatives to enhance financial literacy and educate investors, particularly newcomers to the market. By growing a better understanding of market dynamics and risk management strategies, authorities can encourage investors to make informed decisions and navigate volatile market conditions more effectively. Also, the insights derived from this thesis hold relevance for investors seeking to manage risk exposure within their portfolios. Reaching a deeper understanding of how the market reacts to seismic events, investors can make more informed decisions during times of disasters. By employing these findings, investors can better anticipate market movements and adjust their investment strategies, thus reducing the potential of both under and overvaluations.

Furthermore, increased investor awareness and understanding of market dynamics during periods of crisis can contribute to market efficiency by minimizing the impact of panic-driven selling or irrational decision-making. When investors are equipped with sufficient knowledge about the potential reactions of the market to disasters, they are better positioned to make rational investment decisions that align with their long-term financial goals.

Ultimately, by incorporating the findings of this thesis into their investment and policy strategies, investors and authorities can enhance their ability to navigate turbulent market conditions and mitigate the impact of unforeseen events. This underscores the importance of ongoing research and analysis in providing valuable insights that empower investors and authorities to make informed decisions and manage risk effectively in dynamic market environments.

Expanding the scope of research on the effects of disasters, particularly earthquakes, on financial markets is needed for making reliable decisions and drawing robust conclusions. While this study provides valuable insights, further investigation is required to enhance the understanding of this complex relationship.

One avenue for future research could involve modifying the dataset and methodology to explore alternative scenarios and test the robustness of the findings. This could include employing a longer estimation period or extending the event window to conduct a more comprehensive long-term analysis. Additionally, classifying stock data based on factors such as geographical location or market capitalization could shed light on how different variables influence the impact of earthquakes on financial markets.

In the context of Türkiye, further analysis could focus on different earthquakes and their varying impacts on investor behavior and market dynamics. Moreover, expanding the research to include other natural disasters and analyzing their effects on neighboring countries could provide insights into the international impacts of such events. Comparing the responses of developing markets to similar disasters could also offer valuable insights into the role of market development in shaping these impacts.

Also, while analyzing the sectoral impacts, since there is only one observation per day due to direct employment of the sectoral indices, there could be a potential of unreliability in the results even though this approach is employed in the previous literature which was described as a short-coming of this study. Therefore, the sample can be expanded and the stocks constituting the indices can be employed for better analysis of the sectoral impacts.

Methodologically, future studies could explore the use of alternative models such as CAPM, APT, market-adjusted return, or mean-return models to compare results and assess the robustness of findings. Additionally, incorporating non-parametric tests and cross-sectional dependence adjusted tests alongside parametric tests could enhance the reliability and validity of the results.

Lastly, conducting further regression analysis using additional variables such as casualty and injury figures, earthquake magnitude, population density in affected areas, and total damage assessments could provide deeper insights into the factors influencing abnormal returns in the aftermath of earthquakes. By incorporating these variables into the analysis, researchers can better understand the underlying mechanisms driving abnormal reactions to seismic events.

In conclusion, advancing research on the effects of earthquakes and other disasters on financial markets is crucial for informing decision-making and enhancing risk management strategies. By addressing these avenues for further investigation, future studies can contribute to a deeper understanding of the effects of natural disasters and specifically earthquakes on financial markets, ultimately facilitating more informed decision-making in times of crisis.

References

Ahmed, S., Hasan, M. M., & Kamal, M. R. (2022). Russia–Ukraine crisis: The effects on the European stock market. *European Financial Management*, 29(4), 1078–1118. https://doi.org/10.1111/eufm.12386

Bachelier, L. (1900). Théorie de la spéculation. *Annales Scientifiques de l'École Normale Supérieure*, 17, 21–86. https://doi.org/10.24033/asens.476

Bash, A., & Alsaifi, K. (2019). Fear from uncertainty: An event study of khashoggi and stock market returns. *Journal of Behavioral and Experimental Finance*, 23, 54–58. https://doi.org/10.1016/j.jbef.2019.05.004

Bodie, Z., Kane, A., & Marcus, A. J. (2009). *Investments* (8th ed.). McGraw Hill.

Bradford, B. M., & Robison, H. D. (1997). Abnormal returns, risk, and financial statement data: The case of the iraqi invasion of Kuwait. *Journal of Economics and Business*, 49(2), 193–204. https://doi.org/10.1016/s0148-6195(97)81515-9

Brounen, D., & Derwall, J. (2010). The impact of terrorist attacks on International Stock Markets. *European Financial Management*, 16(4), 585–598. https://doi.org/10.1111/j.1468-036x.2009.00502.x

Brown, S. J., & Warner, J. B. (1985). Using daily stock returns. *Journal of Financial Economics*, 14(1), 3–31. https://doi.org/10.1016/0304-405x(85)90042-x

Campbell, J. Y., Lo, A. W., & MacKinlay, A. C. (2011). *The econometrics of Financial Markets*. Princeton University Press.

Carpentier, C., & Suret, J.-M. (2015). Stock market and deterrence effect: A mid-run analysis of major environmental and non-environmental accidents. *Journal of*

Environmental Economics and Management, 71, 1–18. https://doi.org/10.1016/j.jeem.2015.01.001

Chen, A. H., & Siems, T. F. (2004). The effects of terrorism on global capital markets. *European Journal of Political Economy*, 20(2), 349–366. https://doi.org/10.1016/j.ejpoleco.2003.12.005

Chesney, M., Reshetar, G., & Karaman, M. (2011). The impact of terrorism on Financial Markets: An empirical study. *Journal of Banking & Finance*, 35(2), 253–267. https://doi.org/10.1016/j.jbankfin.2010.07.026

Cowles, A. (1933). Can stock market forecasters forecast? *Econometrica*, 1(3), 309. https://doi.org/10.2307/1907042

Cowles, A. (1944). Stock market forecasting. *Econometrica*, 12(3/4), 206. https://doi.org/10.2307/1905433

Daily Sabah. (2023, February 20). Turkish cement, steel maker stocks jump on reconstruction hopes. https://www.dailysabah.com/business/economy/turkish-cement-steel-maker-stocks-jump-on-reconstruction-hopes

Fama, E. F. (1965). The behavior of stock-market prices. *The Journal of Business*, 38(1), 34. https://doi.org/10.1086/294743

Fama, E. F., Fisher, L., Jensen, M. C., & Roll, R. (1969). The adjustment of stock prices to new information. *International Economic Review*, 10(1), 1. https://doi.org/10.2307/2525569

Fama, E. F. (1970). Efficient Capital Markets: A review of theory and empirical work. *The Journal of Finance*, 25(2), 383. https://doi.org/10.2307/2325486

Ferreira, S., & Karali, B. (2015). Do earthquakes shake stock markets? *PLOS ONE*, 10(7). https://doi.org/10.1371/journal.pone.0133319

Fomby, T., Ikeda, Y., & Loayza, N. V. (2011). The growth aftermath of natural disasters. *Journal of Applied Econometrics*, 28(3), 412–434. https://doi.org/10.1002/jae.1273

Habertürk. (2023). Operatörler yine sınıfta kaldı. https://www.haberturk.com/operatorler-yine-sinifta-kaldi-3564007-teknoloji

Hogg, R. (2023). Earthquake-hit Turkey's stock exchange halts trading until February 15 as a deepening selloff knocks $35 billion off its key index. *Business Insider*. https://markets.businessinsider.com/news/stocks/earthquake-turkey-stock-exchange-halts-trading-after-35-billion-selloff-2023-2

Kawashima, S., & Takeda, F. (2012). The effect of the Fukushima nuclear accident on stock prices of electric power utilities in Japan. *Energy Economics*, 34(6), 2029–2038. https://doi.org/10.1016/j.eneco.2012.08.005

Kendall, M. G., & Hill, A. B. (1953). The analysis of economic time-series-part I: Prices. *Journal of the Royal Statistical Society.* Series A (General), 116(1), 11. https://doi.org/10.2307/2980947

Keown, A. J., & Pinkerton, J. M. (1981). Merger announcements and insider trading activity: An empirical investigation. *The Journal of Finance*, 36(4), 855. https://doi.org/10.2307/2327551

Kothari, S. P., & Warner, J. B. (2007). Econometrics of event studies. *Handbook of Empirical Corporate Finance*, 3–36. https://doi.org/10.1016/b978-0-444-53265-7.50015-9

Laleoğlu, B. (2023). Uluslararası Veriler Işığında 6 Şubat Depremleri. *Kriter*, 7(77). https://kriterdergi.com/dosya-deprem-ve-afet-yonetimi/uluslararasi-veriler-isiginda-6-subat-depremleri

Lamb, R. P. (1998). An examination of market efficiency around hurricanes. *Financial Review*, 33(1), 163–172. https://doi.org/10.1111/j.1540-6288.1998.tb01614.x

Lo, A. W., & MacKinlay, A. C. (2008). *A non-random walk down wall street*. Princeton University Press.

MacKinlay, A. C. (1997). Event Studies in Economics and Finance. *Journal of economic literature*, 35(1), 13-39.

Malik, I. A., Chowdhury, H., & Alam, M. S. (2023). Equity market response to natural disasters: Does firm's Corporate Social Responsibility Make Difference*? Global Finance Journal*, 55, 100801. https://doi.org/10.1016/j.gfj.2022.100801

Malkiel, B. (1999). *A Random Walk down Wall Street: Including a life-cycle guide to personal investing*. New York: W.W. Norton & Company, Inc.

Malkiel, B. G. (2003). The efficient market hypothesis and its critics. *Journal of Economic Perspectives*, 17(1), 59–82. https://doi.org/10.1257/089533003321164958

Nikkinen, J., & Vähämaa, S. (2010). Terrorism and stock market sentiment. *Financial Review*, 45(2), 263–275. https://doi.org/10.1111/j.1540-6288.2010.00246.x

Özmen, B., Güler, H., & Nurlu, M. (1997). *Coğrafi Bilgi Sistemi Ile Deprem Bölgelerinin incelenmesi*. Bayındırlık ve İskan Bakanlığı Afet İşleri Genel Müdürlüğü.

Regnault, J. (1863). Calcul des chances, et philosophie de la bourse. Mallet-Bachelier. https://ia802604.us.archive.org/12/items/calculdeschances00regn/calculdeschances00regn.pdf

SBB (Strateji ve Bütçe Başkanlığı). (2023). Post-earthquake assessment. *2023 Kahramanmaraş and Hatay Earthquakes Report*. https://www.sbb.gov.tr/wp-content/uploads/2023/03/2023-Kahramanmaras-and-Hatay-Earthquakes-Report.pdf

Scholtens, B., & Voorhorst, Y. (2013). The impact of earthquakes on the domestic stock market. *Earthquake Spectra*, 29(1), 325–337. https://doi.org/10.1193/1.4000103

Shelor, R. M., Anderson, D. C., & Cross, M. L. (1992). Gaining from loss: Property-liability insurer stock values in the aftermath of the 1989 California earthquake. *The Journal of Risk and Insurance*, 59(3), 476. https://doi.org/10.2307/253059

Shelor, R., Anderson, D., & Cross, M. (1990). The impact of the California earthquake on real estate firms' stock value. *Journal of Real Estate Research*, 5(3), 335–340. https://doi.org/10.1080/10835547.1990.12090623

Shleifer, A. (2000). *Inefficient markets: An introduction to behavioral finance*. Oxford University Press.

Silva, V., Calderon, A., Caruso, M., Costa, C., Dabbeek, J., Hoyos, M. C., Karimzadeh, Z., Martins, L., Paul, N., Rao, A., Simionato, M., Yepes-Estrada, C., Crowley, H., & Jaiswal, K. (2023). Global seismic risk map. *Zenodo*. https://doi.org/10.5281/zenodo.8409623

Smirnov, Y. (2020). Efficient Market Hypothesis (EMH). *FinancialManagementPro*. https://web.archive.org/web/20210919212506/https://financialmanagementpro.com/efficient-market-hypothesis/

Valizadeh, P., Karali, B., & Ferreira, S. (2017). Ripple effects of the 2011 Japan earthquake on International Stock Markets. *Research in International Business and Finance*, 41, 556–576. https://doi.org/10.1016/j.ribaf.2017.05.002

Wang, L., & Kutan, A. M. (2013). The impact of natural disasters on stock markets: Evidence from Japan and the US. *Comparative Economic Studies*, 55(4), 672–686. https://doi.org/10.1057/ces.2013.16

West, J. (2003) *Impact of catastrophic loss in insurance security returns*. Paper presented to the Business and Economic Society International (BESI) Conference, San Francisco, 24-28 July.

Worthington, A. C. (2008). The impact of natural events and disasters on the Australian Stock Market: A GARCH-M analysis of storms, floods, cyclones, earthquakes and bushfires. *Global Business and Economics Review*, 10(1), 1. https://doi.org/10.1504/gber.2008.016824

Worthington, A., & Valadkhani, A. (2004). Measuring the impact of natural disasters on Capital Markets: An empirical application using intervention analysis. *Applied Economics*, 36(19), 2177–2186. https://doi.org/10.1080/0003684042000282489

Worthington, A., & Valadkhani, A. (2005). Catastrophic shocks and Capital Markets: A comparative analysis by disaster and sector. *Global Economic Review*, 34(3), 331–344. https://doi.org/10.1080/12265080500292641

Yamori, N., & Kobayashi, T. (2002). Do Japanese insurers benefit from a catastrophic event? *Journal of the Japanese and International Economies*, 16(1), 92–108. https://doi.org/10.1006/jjie.2001.0477

Appendices

Appendix A. Abnormal returns for sectoral indices

The table demonstrates abnormal returns (AR) calculated for each day of the event window for sectoral indices. Statistical significance levels are shown at 10% by *, 5% by ** and 1% by ***.

	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
BANKING	-0,01%	4,24%*	-3,40%	0,47%	-0,54%	-2,83%	-1,15%	3,52%	0,29%	-0,70%	3,47%
BASIC MATERI-	3,40%**	1,66%	0,13%	5,06%***	2,07%	6,00%***	3,83%**	-6,43%***	-2,38%	1,33%	-3,00%*
CHEMICALS	-2,69%	-2,05%	0,88%	4,19%**	0,73%	0,65%	-0,76%	-2,13%	0,05%	0,01%	-0,16%
CORPORATE	0,12%	-0,19%	0,12%	0,48%	-0,89%*	0,21%	0,26%	-0,03%	0,12%	0,31%	-0,72%
ELECTRICITY	-1,75%	-2,21%	1,26%	-5,12%***	-0,26%	0,79%	0,32%	0,12%	4,80%***	-0,75%	-2,08%
FOOD & BEV.	0,42%	-1,85%	2,18%*	-6,36%***	-1,06%	-0,29%	1,76%	-0,25%	1,50%	1,10%	-0,08%
HOLDING & INV.	-0,06%	-0,57%	0,37%	-1,73%**	-0,84%	1,17%	-0,01%	0,54%	0,35%	-0,11%	0,45%
INFO TECH.	-0,71%	-3,10%**	2,06%	-6,42%***	-0,12%	1,62%	1,99%	0,37%	2,01%	0,66%	-1,85%
INSURANCE	-3,15%*	-0,93%	-2,77%	-2,34%	-1,73%	-0,23%	-0,30%	0,81%	0,42%	-0,02%	-3,36%*
INV. TRUSTS	-2,53%	-3,68%**	3,00%*	-2,46%	-1,94%	2,45%	1,60%	-0,33%	1,63%	1,78%	-0,78%
LEASING &	-3,03%	-2,81%	1,89%	-6,43%***	-0,86%	3,44%	0,75%	-0,86%	1,38%	1,54%	0,29%
METAL GOODS	0,02%	-2,47%**	1,86%*	-1,30%	-0,89%	0,16%	-0,16%	0,96%	1,03%	0,47%	0,13%
MINING	-1,24%	0,62%	0,29%	-5,00%*	3,63%	-4,17%	-1,89%	1,58%	0,85%	-0,52%	-6,41%**
FINANCIALS	-0,25%	0,88%	-0,90%	-1,54%*	-0,77%	0,31%	0,43%	0,90%	0,50%	0,26%	0,71%
INDUSTRIALS	-0,01%	-0,57%	1,09%	1,75%**	0,99%	1,85%***	1,23%*	-2,21%***	-0,56%	0,89%	-0,99%
SERVICES	-0,18%	-1,79%**	0,88%	-3,42%***	-0,92%	-1,33%*	-0,64%	1,38%*	1,15%	-0,80%	0,07%
TECHNOLOGY	1,59%	-1,84%	0,27%	-4,85%***	-1,63%	-2,20%	0,45%	1,79%	0,06%	-0,54%	-0,36%
REAL ESTATE	-0,65%	-1,02%	0,32%	-3,68%***	-0,54%	3,43%**	5,15%***	-2,63%*	1,47%	3,08%**	-2,84%**
SPORTS	-1,25%	-7,32%***	1,14%	-5,21%**	1,02%	-0,53%	2,08%	2,74%	2,86%	-0,64%	-2,49%
SUSTAINABILITY	0,52%	0,29%	-0,22%	-0,16%	-0,58%	-0,64%	-0,20%	0,40%	-0,32%	0,00%	0,13%
TELECOMMS	1,82%	-0,24%	-1,48%	-4,96%**	-5,36%**	-4,74%*	-2,70%	4,10%	-3,65%	-2,10%	-1,58%
TEXTILE & LE-	-0,74%	-2,13%	1,50%	-3,14%**	-1,51%	3,75%**	2,63%*	1,17%	0,72%	0,40%	-0,69%
TOURISM	-2,18%	-1,21%	1,15%	-5,16%***	-0,39%	1,74%	-0,32%	-2,25%	0,45%	-0,01%	1,13%
TRANSPORTA-	-1,07%	-1,30%	0,21%	-2,31%	-0,14%	-1,87%	-2,83%	0,70%	-0,34%	-0,37%	2,68%
WHLSALE& RET.	1,68%	-1,90%	2,50%*	-2,26%	0,18%	-1,27%	0,78%	0,46%	0,82%	-0,30%	-0,17%
WOOD & PAPER	-1,93%	-3,42%**	2,36%	-5,43%***	-0,01%	0,88%	1,01%	1,81%	1,73%	-0,03%	0,66%
NON-METAL PR.	8,30%***	8,86%***	2,10%	5,89%***	5,57%***	7,03%***	8,25%***	-5,31%***	-6,70%***	6,07%***	-0,29%

Appendix B. Cumulative abnormal returns for sectoral indices

The table demonstrates cumulative abnormal returns (CAR) calculated for each day of the event window for sectoral indices. Statistical significance levels are shown at 10% by *, 5% by ** and 1% by ***.

	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	0,10
BANKING	4,23%	0,83%	1,30%	0,75%	-2,08%	-3,22%	0,30%	0,59%	-0,12%	3,35%
BASIC MATERI-	5,05%**	5,18%*	10,25%***	12,32%***	18,32%***	22,14%***	15,72%***	13,34%***	14,67%***	11,67%**
CHEMICALS	-4,74%**	-3,86%	0,33%	1,06%	1,72%	0,96%	-1,17%	-1,11%	-1,11%	-1,27%
CORPORATE	-0,07%	0,05%	0,52%	-0,36%	-0,15%	0,11%	0,07%	0,19%	0,50%	-0,22%
ELECTRICITY	-3,95%	-2,69%	-7,81%**	-8,08%**	-7,29%***	-6,96%	-6,85%	-2,05%	-2,80%	-4,87%
FOOD & BEVE-	-1,43%	0,75%	-5,61%**	-6,67%**	-6,96%**	-5,20%	-5,45%	-3,95%	-2,85%	-2,93%
HOLDING & IN-	-0,63%	-0,25%	-1,99%	-2,83%	-1,66%	-1,67%	-1,14%	-0,79%	-0,90%	-0,45%
INFO TECH.	-3,81%*	-1,74%	-8,16%***	-8,29%**	-6,66%*	-4,67%	-4,30%	-2,29%	-1,63%	-3,48%
INSURANCE	-4,08%*	-6,86%**	-9,19%***	-10,93%***	-11,16%***	-11,46%**	-10,66%**	-10,24%*	-10,25%*	-13,61%**
INV. TRUSTS	-6,20%***	-3,20%	-5,67%*	-7,61%**	-5,16%	-3,56%	-3,89%	-2,26%	-0,48%	-1,26%
LEASING &	-5,84%*	-3,95%	-10,38%**	-11,24%**	-7,80%	-7,05%	-7,91%	-6,53%	-4,99%	-4,71%
METAL GOODS,	-2,44%	-0,58%	-1,89%	-2,78%	-2,62%	-2,77%	-1,81%	-0,77%	-0,31%	-0,18%
MINING	-0,62%	-0,33%	-5,34%	-1,71%	-5,88%	-7,78%	-6,20%	-5,35%	-5,87%	-12,28%
FINANCIALS	0,64%	-0,27%	-1,80%	-2,57%	-2,26%	-1,83%	-0,92%	-0,43%	-0,17%	0,54%
INDUSTRIALS	-0,58%	0,51%	2,26%	3,25%**	5,10%***	6,33%***	4,12%**	3,56%*	4,45%**	3,46%
SERVICES	-1,96%*	-1,08%	-4,51%***	-5,43%***	-6,76%***	-7,40%***	-6,02%***	-4,87%**	-5,66%**	-5,59%**
TECHNOLOGY	-0,25%	0,02%	-4,83%	-6,46%*	-8,65%**	-8,20%*	-6,41%	-6,35%	-6,90%	-7,25%
REAL ESTATE	-1,67%	-1,35%	-5,03%*	-5,57%*	-2,14%	3,01%	0,38%	1,85%	4,93%	2,09%
SPORTS	-8,56%**	-7,43%	-12,64%**	-11,62%**	-12,15%*	-10,07%	-7,33%	-4,47%	-5,11%	-7,60%
SUSTAINABI-	0,81%	0,59%	0,43%	-0,15%	-0,79%	-0,99%	-0,58%	-0,91%	-0,90%	-0,77%
TELE COMMS	1,58%	0,11%	-4,85%	-10,21%*	-14,95%**	-17,65%***	-13,56%*	-17,21%**	-19,31%**	-20,88%**
TEXTILE & LEAT-	-2,88%	-1,38%	-4,52%	-6,03%*	-2,28%	0,35%	1,52%	2,25%	2,65%	1,96%
TOURISM	-3,39%	-2,24%	-7,40%*	-7,79%*	-6,05%	-6,37%	-8,62%	-8,18%	-8,19%	-7,05%
TRANSPORA-	-2,37%	-2,16%	-4,47%	-4,61%	-6,48%	-9,31%*	-8,62%	-8,96%	-9,33%	-6,65%
WHOLESALE &	-0,21%	2,29%	0,03%	0,21%	-1,07%	-0,28%	0,18%	0,99%	0,70%	0,53%
WOOD, PAPER	-5,35%**	-2,99%	-8,42%**	-8,44%**	-7,55%*	-6,55%	-4,74%	-3,01%	-3,04%	-2,38%
NON METAL	17,15%***	19,25%***	25,14%***	30,71%***	37,74%***	45,98%***	40,67%***	33,98%***	40,04%***	39,75%***

Appendix C. Actual daily returns of the market index and sectoral indices

The table demonstrates actual daily returns calculated for each day of the event window for market index and sectoral indices.

	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
BIST100	-1,35%	-8,62%	9,88%	1,17%	0,36%	2,43%	0,01%	-1,51%	0,29%	-0,54%	2,74%
BANKING	-2,18%	-8,29%	9,96%	1,83%	-0,32%	0,24%	-1,41%	1,10%	0,41%	-1,73%	7,21%
BASIC MATE-	1,99%	-6,88%	9,51%	6,26%	2,33%	8,54%	3,79%	-7,70%	-2,19%	0,70%	-0,51%
CHEMICALS	-3,72%	-9,52%	9,90%	5,49%	1,18%	2,96%	-0,63%	-3,32%	0,43%	-0,36%	2,40%
CORPORATE	-1,22%	-8,61%	9,73%	1,61%	-0,55%	2,56%	0,25%	-1,53%	0,38%	-0,25%	1,92%
ELECTRICITY	-2,55%	-8,29%	8,68%	-4,03%	0,16%	2,74%	0,49%	-0,84%	5,31%	-0,99%	0,06%
FOOD & BEV.	-0,60%	-8,07%	9,40%	-5,39%	-0,82%	1,43%	1,75%	-1,38%	1,69%	0,68%	1,87%
HOLDING	-1,34%	-8,67%	9,70%	-0,64%	-0,50%	3,49%	-0,01%	-0,90%	0,62%	-0,63%	3,04%
INFO TECH.	-1,59%	-8,58%	8,53%	-5,51%	0,11%	3,23%	2,01%	-0,63%	2,21%	0,30%	-0,10%
INSURANCE	-3,86%	-6,96%	4,27%	-1,30%	-1,27%	1,69%	-0,11%	-0,10%	0,82%	-0,22%	-1,22%
INV. TRUSTS	-3,27%	-8,56%	8,90%	-1,76%	-1,71%	3,94%	1,62%	-1,21%	1,82%	1,47%	0,81%
LEASING	-4,29%	-9,82%	9,69%	-5,58%	-0,82%	5,26%	0,50%	-2,32%	1,37%	0,85%	2,24%
METAL GO-	-0,91%	-8,92%	9,72%	-0,29%	-0,50%	2,16%	-0,04%	-0,11%	1,38%	0,16%	2,37%
MINING	-2,09%	-7,15%	9,99%	-3,44%	4,47%	-1,51%	-1,47%	0,55%	1,54%	-0,62%	-3,42%
FINANCIALS	-1,78%	-8,43%	9,45%	-0,39%	-0,48%	2,81%	0,35%	-0,82%	0,71%	-0,41%	3,55%
INDUSTRIALS	-1,11%	-7,90%	9,67%	2,85%	1,38%	4,05%	1,31%	-3,39%	-0,25%	0,49%	1,40%
SERVICES	-1,19%	-8,87%	9,40%	-2,28%	-0,48%	0,83%	-0,50%	0,21%	1,54%	-1,12%	2,52%
TECHNO-	0,48%	-9,40%	9,28%	-3,62%	-1,18%	0,07%	0,57%	0,52%	0,43%	-0,92%	2,22%
REAL ESTATE	-1,81%	-8,20%	8,42%	-2,73%	-0,30%	5,51%	5,23%	-3,87%	1,67%	2,61%	-0,65%
SPORTS	-1,75%	-9,86%	4,30%	-4,77%	1,08%	0,20%	2,04%	2,19%	2,93%	-0,88%	-1,64%
SUSTAINABI-	-0,89%	-8,56%	9,85%	1,01%	-0,23%	1,81%	-0,21%	-1,17%	-0,05%	-0,57%	2,92%
TELECOMMS	0,38%	-9,98%	9,99%	-3,42%	-4,70%	-1,83%	-2,54%	2,49%	-3,13%	-2,57%	1,68%
TEXTILE & LE-	-1,60%	-8,05%	8,58%	-2,20%	-1,15%	5,69%	2,76%	0,19%	1,03%	0,11%	1,32%
TOURISM	-2,75%	-5,45%	6,05%	-4,42%	-0,15%	3,03%	-0,26%	-2,90%	0,65%	-0,22%	2,56%
TRANSPOR-	-2,13%	-9,26%	9,91%	-0,97%	0,42%	0,64%	-2,58%	-0,55%	0,15%	-0,68%	5,64%
WHLSALE&	0,68%	-8,14%	9,83%	-1,40%	0,44%	0,47%	0,78%	-0,67%	1,03%	-0,70%	1,82%
WOOD & PA-	-2,76%	-9,18%	9,43%	-4,44%	0,32%	2,67%	1,10%	0,83%	2,04%	-0,32%	2,67%
NON-METAL	7,69%	2,57%	9,27%	7,04%	6,08%	9,21%	8,69%	-6,12%	-6,21%	5,93%	1,73%