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ESG as a Double-Edged Sword in Crisis Management: Short-Term Market Reactions to Corporate Sustainability Initiatives After Disasters

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Abstract

This study examined the effect of the 2024 Hualien earthquake on the performance of tourism stocks in Taiwan, focusing on the interplay between disaster severity; government relief; and environmental, social, and governance (ESG) investment. An event study was conducted using a panel regression model for six listed hospitality firms with operations in Hualien or Taitung. The findings of the event study indicated that disaster-induced losses and employee casualties or dismissals had significantly positive effects on the short-term cumulative abnormal returns (CARs) of the six companies, reflecting investor expectations of prompt government aid. However, ESG investment had a significant negative effect on CARs, and it weakened the positive effects of disaster-induced losses and employee casualties or dismissals on CARs. These results suggest that although the market reacted rationally to disaster information, investor concerns regarding short-term ESG costs triggered emotional responses. This study contributes to the literature on the efficient market hypothesis, the resource-based view, and behavioral finance theory by highlighting the dual market effects of ESG investment following a disaster event. It recommends that governments implement transparent postdisaster economic support policies and that tourism firms strategically manage their ESG investments to balance sustainability with resilience.

Keywords: earthquake; tourism; disaster loss; employee casualties; dismissals; cumulative abnormal returns (CARs)

1. Introduction

On April 3, 2024, Taiwan experienced its second most powerful earthquake in the past 100 years, with Hualien County being the region most severely affected. In the immediate aftermath of the earthquake, the hospitality industry in Hualien faced an estimated loss of NT$84 million solely from the cancellation of accommodation bookings for the three consecutive holidays associated with the Qingming Festival [1]. The effects of the earthquake resulted in Chateau de Chine Hotel announcing its permanent closure, with all of its 86 employees laid off [2]. Moreover, the earthquake resulted in the death of an intern working at Silks Place Taroko [3]. Because of the severity of the earthquake-induced damage, the Hualien County Government submitted 52 reconstruction project proposals to the Public Construction Commission, Executive Yuan of Taiwan; the total estimated budget of these proposals was NT$1.59566 billion [4]. Following discussions with the Ministry of Agriculture of Taiwan, the Hualien County Government planned to implement ten infrastructure recovery projects, five disaster relief and restoration programs, eight business hardship assistance initiatives, and two consumer stimulus measures, allocating a budget of NT$1.4183 billion for these purposes [5]. On May 2, 2024, the Executive Yuan approved the "0403 Earthquake Recovery and Reconstruction Plan," integrating central and local government resources to allocate a total subsidy of NT$28.55 billion [6]. To support the hospitality industries of Hualien County and Taitung County in their disaster

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response, reconstruction, and operational recovery, the Tourism Administration, Hualien County Government, Taitung County Government, Ministry of Agriculture, Ministry of Culture, and other agencies in Taiwan introduced travel assistance programs. These programs included subsidies for group and individual travel as well as various accommodation and tourism incentives, all of which were valid up to December 31, 2024 [7].

Studies have indicated that the tourism industry is highly sensitive to major events such as natural disasters, which often lead to substantial volatility in tourism-related stocks [8,9]. Earthquakes represent short-term negative shocks and typically result in significantly negative abnormal returns in the stock markets of affected regions within the event window [10]. The effect of a disaster on stock price depends on the type and severity of the disaster. For example, large-scale disasters, such as major earthquakes, tend to cause sharp stock price declines, and stock prices take a long time to recover from these declines. Disaster severity, which is assessed in terms of casualties and economic loss, is generally positively correlated with the absolute value of abnormal stock returns; thus, a more severe disaster results in a larger decline in stock prices.

Sudden earthquakes trigger market reactions that are primarily concentrated in the immediate postdisaster period. However, their effect on stock prices is often temporary, with prices tending to revert to normal levels within a few days or weeks as recovery efforts progress and investor sentiment stabilizes, indicating a degree of market resilience. However, the recovery period can be long if secondary shocks, such as policy uncertainties or cascading crises, occur [10].

Postdisaster reconstruction efforts and tourism revitalization policies exert strong influences on consumer psychology in the tourism sector [11,12]. In addition, some studies have indicated that a firm's environmental, social, and governance (ESG) performance can influence its stock price. Strong ESG performance may attract investor attention, thereby mitigating abnormal price fluctuations [13,14]. Understanding the effectiveness of ESG strategies in controlling firms' stock price fluctuations after disaster events is crucial. Accordingly, the influences of these strategies on firms' postdisaster recovery and responses warrant further investigation.

This study examined the effect of the 2024 Hualien earthquake on the stock prices of publicly listed tourism companies in Taiwan with operations in Hualien or Taitung. Specifically, it focused on the interaction effects between disaster shocks, employee casualties and dismissals, government subsidy policies, and corporate ESG practices, as recommended by Antonaglia et al. [8], Pandey and Al-ahdal [9], Chen and Wu [14], Athar et al. [15] and Brueckner et al. [16]. By using a quantitative event study methodology, this research investigated the influences of the aforementioned factors on the cumulative abnormal returns (CARs) of various tourism-sector stocks following the 2024 Hualien earthquake, thereby indicating the market reaction patterns after a major disaster.

This study contributes to the literature by enhancing the understanding of the relationship between disaster events and stock market responses. Moreover, its findings offer practical insights to policymakers and corporate managers to enable them to respond more effectively to future disaster events. This study also provides strategic recommendations on the optimal allocation of ESG resources and implementation of postdisaster economic policies.

2. Literature Review and Hypotheses

The key themes explored in relevant research include the effects on stock prices of major events and crises, economic policies, market uncertainty, macroeconomic factors, government interventions and economic stimulus measures, investor sentiment, market psychology, market structure, and industry-specific characteristics.

The tourism and hospitality industry is highly sensitive to adverse events such as aviation accidents, terrorist attacks, armed conflicts, disease outbreaks, and natural disasters, all of which can lead to considerable volatility in the prices of tourism stocks. Blau et al. [17] found that the prices of US tourism and hospitality stocks declined substantially following major aviation incidents, with the 9/11 terrorist attacks having the most pronounced effect. Miguel Martins et al. [18] investigated the negative stock market responses in the European tourism and hospitality sector following the

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outbreak of the Russo-Ukrainian military conflict. Ji-Hong [19] and Bouoiyour and Selmi [20] highlighted that terrorist attacks and tourism-related crises (e.g., disease outbreaks), respectively, have significant negative effects on the stock prices of airlines, hotels, and telecommunication companies.

The COVID-19 pandemic severely disrupted the tourism industry. Carrillo-Hidalgo et al. [21] and Thorbecke [22] demonstrated that the pandemic caused a substantial decline in the stock prices of tourism firms, with a slow pace of recovery being observed. Ruhana et al. [23] confirmed that the COVID-19 pandemic and associated government responses had significantly negative effects on tourism stock performance. Brueckner et al. [16] argued that the impact of the COVID-19 pandemic on stock performance was closely related to the size of a firm's capital, with larger firms exhibiting greater resilience to shocks. Antonaglia et al. [8] and Pandey and Al-ahdal [24] emphasized that natural disasters such as earthquakes have profound influences on the tourism sector, often triggering excessive short-term stock price volatility.

Economic policy uncertainty (EPU), geopolitical risks, and financial market volatility exert significant and predominantly negative impacts on the performance of tourism stocks. Demir and Ersan [25] found that EPU in Europe and Turkey led to declines in the prices of Turkish tourism stocks. Similarly, Mohammadzadeh and Shahiki Tash [26] demonstrated that EPU negatively affects the number of inbound tourists, thereby adversely influencing tourism stock prices. Ji-Hong [19] determined that EPU has a strong negative effect on airline stock prices during bullish market periods. Kumar [27] employed a copula-based model and found that economic, geopolitical, and financial market uncertainties increase extreme downside risks in the tourism and leisure sector, thereby exerting downward pressure on tourism stock prices.

The performance of tourism-related stocks is also strongly affected by macroeconomic factors, including exchange rates, inflation, oil prices, consumer confidence, the number of international tourists, and general economic conditions. Zhang et al. [28] assessed the combined effect of exchange rates, oil prices, and the Korea Composite Stock Price Index on international tourist arrivals. Katircioglu and Salih [29] highlighted that Turkish tourism stocks are highly sensitive to macroeconomic variables, particularly exchange rates and inflation. Moreover, Demir et al. [30] and Mohammadzadeh and Shahiki Tash [26] found that consumer confidence indices, exchange rate volatility, and inbound tourist volumes significantly affect tourism stock returns. Qin et al. [31] reported that the effect of oil price fluctuations on Chinese tourism stocks varies over time and is influenced by market inertia. Hadood and Irani [32] and Dlawar [33] identified correlations between oil price shocks, commercial and financial activity, and tourism stock performance. Furthermore, Grechi et al. [34] found that overall market conditions and the Chicago Board Options Exchange Volatility Index effectively explain the returns of European tourism stocks.

Governmental economic stimulus packages and relief programs significantly enhance the stock performance of tourism enterprises. Elrazaz et al. [35] identified significant positive associations between COVID-19-related stimulus measures and the stock prices of tourism firms, particularly over a short-term period. Ishak et al. [36] noted that green policy announcements have both positive and negative effects on stock performance in the tourism and leisure sector, highlighting the uncertainty inherent in policy effects. Similarly, Ghosh [37] found that US government support programs significantly improved the returns of US tourism and leisure-related stocks.

Investors' psychological expectations and emotions significantly affect the short-term performance of tourism stocks. Shi et al. [38] found that during the COVID-19 pandemic, heightened public attention to information had a significant influence on investor sentiment, leading to a notable short-term undervaluation of tourism stocks in China. Similarly, Rudež [39] observed that the varying pace of investor confidence recovery during the COVID-19 pandemic resulted in divergent recovery trajectories for tourism-related stocks.

Researchers have found that various firm-specific economic factors influence stock performance. In particular, studies have shown that financial indicators such as return on assets (ROA), debt-to-equity ratio, earnings per share, dividends per share, price-to-earnings ratio, book value per share,

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and firm size affect the stock prices of listed companies, with ROA exerting the strongest effect [40–43]. Furthermore, the reactions of stock prices to earnings announcements are often delayed, with the price drift persisting for several weeks or even months, especially when financial disclosures are incomplete or market liquidity is low [44]. Studies on listed firms have indicated that ESG-related positive or negative news events can immediately affect stock prices. Strong ESG performance tends to attract greater investor attention and subsequently reduce abnormal stock price volatility [13,14].

Earthquake disasters tend to cause negative abnormal returns for tourism stocks in the short term. According to the efficient market hypothesis (EMH), major disasters are a type of unexpected negative information, which results in stock price volatility. Therefore, the returns of stocks fall significantly below normal levels on the day of a disaster and in the subsequent days [9]. This effect is particularly pronounced for companies engaged in tourism services because disasters often lead to sharp declines in tourist numbers and revenue expectations over a short-term period. Some studies have observed that swift government intervention or postdisaster reconstruction can cause stock prices to rebound rapidly following a disaster, rendering the long-term CARs of stocks statistically insignificant [45]. On the basis of the aforementioned discussion, this study formulated the following hypothesis:

H1: Across different periods, disaster-induced losses, employee casualties, and employee dismissals have significant negative effects on the CARs of the stocks of tourism companies with operations in disaster-affected areas.

Studies have suggested that strong ESG performance can mitigate the stock price decline experienced by firms during and following disaster events. For instance, during the COVID-19 pandemic, negative abnormal returns were less severe for firms actively engaging in corporate social responsibility initiatives. This effect was particularly pronounced for global hotel chains, for which ESG performance exhibited a significant association with CARs, indicating the moderating effect of ESG on stock price declines during crises [46,47]. Wang [48] confirmed that prolonged business closures and employee casualties caused by disasters directly affect a firm's operations and contribute to negative stock price fluctuations. Research has highlighted the close relationship between ESG performance and carbon reduction efforts. Firms with high ESG ratings are more likely to actively implement carbon reduction strategies. To reduce their overall emissions, environmentally conscious companies often establish clear carbon reduction goals and measures, such as improving energy efficiency, adopting renewable energy, and implementing carbon management mechanisms. These actions not only align with the sustainability expectations of investors and stakeholders but also enhance corporate governance and reputation [49]. Bae [50] proposed an ESG evaluation framework that includes employee safety and social responsibility factors for the hospitality industry, suggesting a linkage between ESG and variables such as employee casualties and dismissals. On the basis of the aforementioned discussion, this study formulated the following hypothesis:

H2: ESG performance effectively moderates the negative effects of disaster shocks, employee casualties, and employee dismissals on the stock prices of tourism companies.

3. Research Design

3.1. Research Sample

This study focused on tourism stocks listed on the Taiwan Stock Exchange (TWSE) and Taipei Exchange in 2025. The research sample comprised 29 publicly listed companies operating in tourism-related industries, such as the hotel industry (e.g., Regent Hotels, stock number 2707); the travel industry (e.g., Lion Travel, stock number 2731); and the leisure, recreation, and food and beverage industries (e.g., Wowprime Corporation, stock number 2727). Of these companies, six had branches in Hualien or Taitung: Regent (stock number 2707), Farglory (stock number 2712), YungShin (stock number 2748), Forte (stock number 2736), The Lalu (stock number 5704), and Nanhwa (stock number 5905).

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3.2. Research Period and Event Selection

The research period was the entire year of 2024 to ensure inclusion of the target event and a sufficient postevent sample window. The selected event was the Hualien earthquake, which occurred on April 3, 2024. This major and unexpected disaster mainly affected the Hualien–Taitung area, resulting in an immediate impact on the stock market in Taiwan. The present study employed the event study methodology to examine the effects of the earthquake on tourism stocks in Taiwan.

3.3. Data Sources and Data Frequency

Stock price data, namely daily closing prices, for each company in the research sample were obtained from the *Taiwan Economic Journal* or from the public information platform of the TWSE. In addition, the TWSE Capitalization Weighted Stock Index was used as a market benchmark index. In accordance with the event methodology approach, daily, weekly, and monthly data were employed to capture short-, medium-, and long-term abnormal returns, respectively, under the influence of the earthquake [10]. In this approach, if the event date falls on a nontrading day or a day involving market closure (e.g., because of a typhoon), the calculation is started from the first trading day after the event. Moreover, if necessary, secondary data, such as news announcement dates or government-issued warning dates, are incorporated to determine the event timing more accurately.

3.4. Panel Regression Models

This study employed panel regression models [51–54] to investigate the postearthquake relationships between CARs and several key variables for the stocks of six tourism and hospitality firms with operational bases in Hualien or Taitung. The key variables were the duration of business suspension caused by the disaster, employee casualties and layoffs, ESG engagement, and the government subsidies provided to disaster-affected areas in three periods (April 3–30, May 1–3, and May 4–December 31, 2024). A panel data model, which incorporates time-series and cross-sectional dimensions, offers several advantages. By stacking time-series data for each cross-sectional unit, such a model increases the degrees of freedom and combines information from two dimensions. This approach mitigates multicollinearity and reduces the risk of estimation bias, thereby yielding more efficient parameter estimates. Consequently, this study adopted a panel data regression model. The basic expression of a panel data model is given as follows:

$$R_{it} = \alpha_i + \beta_i' X_{it} + \mu_{it} \quad i = 1, \ldots, N \; ; \; t = 1, \ldots, T \qquad (1)$$

$$E(\varepsilon_{it}) = 0 \; ; \; Var(\varepsilon_{it}) = \sigma 2 < \infty$$

where N denotes the number of cross-sectional units in the panel data, t represents the time, μ_{it} is the error term, X_{it} is a $k \times 1$ vector of explanatory variables, β_i' is a $k \times 1$ vector of coefficients, k refers to the number of explanatory variables, and αi and βi are time-invariant parameters that are influenced solely by cross-sectional heterogeneity.

3.4.1. Mixed-Effects Model

If no significant differences exist in cross-sectional units, either over time or across entities, such that $\alpha i = \alpha j$ and $\beta i = \beta j$, the panel data can be estimated using an ordinary least squares regression model. Under this condition, the regression model is simplified to a pooled model as follows:

$$R_{it} = \alpha + \beta' X_{it} + \mu_{it} \qquad i = 1, \ldots, N \; ; \; t = 1, \ldots, T \qquad (2)$$

where N represents the number of cross-sectional units in the panel dataset, t denotes the time, μ_{it} is the error term, X_{it} is a $k \times 1$ vector of explanatory variables, β' is a $k \times 1$ vector of coefficients, and k indicates the number of explanatory variables in the model.

3.4.2. Fixed-Effects Model

A fixed-effects model accounts for cross-sectional and time-series data in the estimation process. Such a model assumes the existence of unobserved effects that are correlated with the explanatory

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variables; thus, it allows for heterogeneity across individual-specific and time-invariant (i.e., time-fixed) effects. In this study, a fixed-effects model was employed to capture individual-specific heterogeneity. The adopted model is expressed as follows:

$$R_{it} = \alpha_1 + \alpha_2 D_2 + \cdots + \alpha_n D_n + \beta' X_{it} + \mu_{it}$$

$$i = 1, \ldots, N;\ t = 1, \ldots, T;\ \varepsilon_{it} \sim i.i.d.(0, \sigma^2)$$

$$D_i \begin{cases} 1 & i = 2, \ldots, N \\ 0, & \text{others} \end{cases} \quad (3)$$

where N denotes the number of cross-sectional units in the panel dataset; t represents the time; α_i varies across individual units, capturing unobserved heterogeneity; D_i is a dummy variable indicating structural differences between units; μ_{it} is the error term; X_{it} is a $k \times 1$ vector of explanatory variables; β' is a k × 1 vector of coefficients; and k refers to the number of explanatory variables in the model.

3.4.3. Random-Effects Model

The difference between a random-effects model and a fixed-effects model is that a random-effects model assumes that the variation arising from individual-specific structural differences or temporal changes is random. Thus, a random-effects model considers unobserved effects to be uncorrelated with the explanatory variables. A random-effects model is expressed as follows:

$$R_{it} = \alpha + \mu_i + \beta' X_{it} + \mu_{it}$$
$$= \alpha + \beta' Y_{it} + \varepsilon_{it} \qquad i = 1, \ldots, N;\ t = 1, \ldots, T \quad (4)$$

where N denotes the number of cross-sectional units in the panel dataset, t represents the time, A is the average intercept value for the underlying population, μ_i denotes the individual-specific random error component, and μ_{it} represents the idiosyncratic error. Moreover, X_{it} is a $k \times 1$ vector of explanatory variables, β' is a $k \times 1$ vector of coefficients, and k indicates the number of explanatory variables in the model.

3.4.4. Evaluation of the Consistency of Fixed- and Random-Effects Models

The Hausman test was employed to examine the consistency of the estimations obtained using fixed- and random-effects models. This test evaluates whether individual effects are correlated with the explanatory variables. The corresponding test statistic is expressed as follows:

$$H = (\hat{\beta}_{\text{fixed}} - \hat{\beta}_{\text{random}})'[Var(\hat{\beta}_{\text{fixed}}) - Var(\hat{\beta}_{\text{random}})]^{-1}(\hat{\beta}_{\text{fixed}} - \hat{\beta}_{\text{random}}) \sim x^2(w) \quad (5)$$

where $\hat{\beta}_{\text{fixed}}$ represents the coefficient estimated using the fixed-effects model, $\hat{\beta}_{\text{random}}$ denotes the coefficient estimated using the random-effects model, and w indicates the number of explanatory variables. The null hypothesis and alternative hypothesis of the Hausman test are defined as follows:

H_0: The individual effects are uncorrelated with the explanatory variables (i.e., the random-effects model is appropriate).

H_1: The individual effects are correlated with the explanatory variables (i.e., the fixed-effects model is appropriate).

3.4.5. CARs

To ensure the accuracy and reliability of the research findings, this study employed appropriate estimation methods and a series of statistical diagnostic tests, including normality, heteroskedasticity, and autocorrelation tests. Expected returns were first calculated by carefully selecting the target event, target firms, estimation window, and event window. Subsequently, abnormal returns were calculated as the difference between actual and expected returns during the event window. This study used the ordinary least squares method to construct a regression model

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for each firm in the sample to estimate the effect of the earthquake event on the firm's stock prices. Each constructed regression model was expressed as follows:

$$R_{i,t} = a_i + \beta_i R_m + \varepsilon_{it} \quad (6)$$

where $R_{i,t}$ denotes the expected return of firm i at time t, R_m represents the return of the market portfolio at time t, a_i is the intercept value in the market model, β_i reflects the systematic risk (market beta), and ε_i is the error term. Once the expected returns had been estimated, the abnormal returns were calculated as follows:

$$AR_i = R_i - E(R_i) \quad (7)$$

where AR_i denotes the abnormal return of firm i, R_i represents the actual return of firm i, and $E(R_i)$ indicates the expected return of firm i. The average abnormal return is defined as follows:

$$\overline{AR}_t = \frac{1}{N}\sum_{i=1}^{N} AR_i \quad (8)$$

where $\overline{AR}_t$ denotes the average abnormal return of all firms in the sample at time t and N represents the total number of observations. CARs were calculated by summing the abnormal returns of all firms in the sample over a specified event window as follows:

$$CAR_{[\tau_1,\tau_2]} = \frac{1}{N}\sum_{i=1}^{N}\sum_{t=\tau_1}^{\tau_2} AR_{i,t} \quad (9)$$

where $CAR_{[\tau_1,\tau_2]}$ denotes the CARs over the event window from τ_1 to τ_2, which were obtained by summing the average abnormal returns of all firms from τ_1 to τ_2.

3.5. Regression Model

On the basis of the formulated hypotheses, a panel regression model was constructed to analyze the effects of various factors on the postearthquake CARs of the stocks of the six companies operating in Hualien or Taitung. This model comprised three independent variables: disaster-induced losses [8,9] (DL), employee casualties and dismissals [8,9] (ECD), and implementation of ESG initiatives (ESGI) [49]. In addition, a stacked variable was constructed to explore the moderating effects of government relief measures implemented during three postearthquake periods (April 3–April 30, May 1–May 3, and May 4–December 31, 2024) [37] on the influences of the aforementioned three factors on CARs.

Two panel data regression models were developed in this study, namely a fixed-effects model and a random-effects model. These models are expressed as follows:

$$CAR_{[\tau_1,\tau_2]} = \beta_0 + \beta_1 X_{1,i,t} + \beta_2 X_{2,i,t} + \beta_3 X_{3,i,t} + \beta_4 X_{1,i,t} X_{3,i,t} + \beta_5 X_{2,i,t} X_{3,i,t}$$

where X_1 indicates whether the company experienced losses because of earthquake-related damage, X_2 represents the number of employee casualties and dismissals resulting from the earthquake, and X_3 denotes whether ESGI-related carbon reduction initiatives were implemented by the company.

4. Results

Table 1 presents the results obtained with the fixed- and random-effects models. The two models produced nearly identical outcomes in the estimation of the effects of the three considered independent variables on the dependent variable, namely CARs. Therefore, the Hausman test was conducted to determine the more appropriate model for the analysis [55]. The fixed-effects model had a higher goodness-of-fit value (chi-square = 510, p = 0.000) than did the random-effects model; therefore, the fixed-effects model was identified as the more appropriate model for analysis. The results obtained with the fixed-effects model indicated that DL and ECD had significant positive effects on CARs; thus, H1 was not supported. However, ESGI, DL × ESGI, and ECD × ESGI had significant negative effects on CARs. Thus, ESGI-related carbon reduction efforts negatively affected CAR. Moreover, the positive effects of DL and ECD on CARs were weaker for companies that did

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not implement ESGI-related carbon reduction efforts than for companies that did. The aforementioned findings are inconsistent with H2.

Table 1. Panel regression results.

Independent Variable	Dependent Variable: CAR	
	Fixed-effects model	Random-effects model
C	-13.9440***	-10.0492
Disaster Loss (DL)	33.1918***	18.7465**
Employee Casualties or Dismissals (ECD)	0.3417***	0.3163***
ESGI	-3.4360***	-2.3621
DL x ESGI	-0.0024***	-0.0010*
ECD x ESGI	-0.0015***	-0.0107***
Chi-square	510	
p	0.00000	

Source: Estimation results obtained through panel regression with Model 1. Notes: ***, significant at the 1% level; **, significant at the 5% level; *, significant at the 10% level.

5. Discussion and Conclusion

5.1. Discussion

The following findings were obtained from the results acquired with the panel regression model. First, DL and ECD exert significant positive effects on the CARs of Taiwan's tourism stocks following a disaster. This finding indicates that the Taiwanese market anticipates affected tourism firms, many of which are well-established and reputable, to demonstrate responsible attitudes and actions. It also expects that the government will promptly intervene through large-scale economic stimulus measures and postdisaster reconstruction subsidies. Such expectations enhance investors' outlook regarding the future performance of tourism firms. Consequently, although disasters cause short-term fluctuations in tourism stock prices, they also lead to investor expectations regarding potential recovery benefits arising from subsequent government policies.

Second, the results suggest that ESG-related carbon reduction measures have a significant negative effect on the CARs of tourism stocks in Taiwan after a major disaster event. This finding indicates that although such ESG efforts are typically viewed favorably by investors, they are perceived as increasing short-term operational costs, which is unfavorable under the financial pressures of postdisaster recovery. Consequently, ESG-related expenditures may be interpreted by the market as a negative signal, causing ESG to exert additional downward pressure on stock prices.

Third, the results indicate that ESG initiatives weaken the positive effects of DL and ECD on the CARs of tourism stocks in Taiwan. This finding suggests that although disaster-induced losses and employee casualties or dismissals tend to increase the CARs of tourism companies, these effects are weakened by firms' engagement in ESG. Investors may believe that firms would face challenges related to financial and managerial resources when managing ESG commitments and postdisaster reconstruction simultaneously; thus, ESG initiatives can negatively influence investor sentiment after a disaster event.

Overall, the aforementioned findings differ from those reported in the existing literature and highlight the potential negative effects of ESG initiatives on tourism stocks following a disaster-related shock. Engagement in ESG initiatives, which is expected to have positive market effects during normal periods, may have negative effects on tourism stock prices following a disaster. The gap between investor expectations regarding ESG investment costs and government-provided recovery support may be a key factor contributing to these outcomes.

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5.2. Theoretical Implications

The theoretical implications of the research findings are as follows. First, the findings validate and extend the EMH. The rapid reflection of disaster-related losses and employee death or dismissal events in stock prices supports the theoretical perspective that markets are capable of promptly absorbing and responding to major information shocks [9]. However, the market's expectations regarding government policy interventions and the complex effects of ESG initiatives suggest that market reactions are not entirely rational, with investor sentiment and cognitive biases playing a role in these reactions [38,39].

Second, the results of this study indicate the effectiveness and limitations of ESG initiatives in exceptional incentive conditions. Strong ESG performance is generally believed to enhance corporate resilience and mitigate risk [46,47]. However, the findings of the present study reveal that over a short-term period, investment costs associated with ESG initiatives may increase market perceptions of corporate risk. This finding provides new insights into the relationship between ESG initiatives and financial performance, enriching the literature on this topic [13,14].

Third, the findings of this study support the resource-based view (RBV) of firms. Under disaster shocks, various resource allocation strategies, such as investments in ESG, significantly influence a firm's short-term market performance. As a strategic resource, ESG initiatives and the timing and management of related investments can critically shape a firm's stock market response during disruptive events [49,50].

Fourth, this study provides additional empirical support for behavioral finance theory. The contradictory effects of ESG investments on market reactions suggest that market participants might not behave in a completely rational manner. They may be constrained by a limited capacity to process short-term information, leading to emotional responses and overreactions. This finding validates the relevance of investor sentiment theory and market psychological factors in determining stock prices [38].

Finally, this study highlights the applicability of signaling theory [47] in the context of stock pricing following major disasters, thus expanding the scope of this theory. By rapidly implementing relief and reconstruction policies, governments can send positive signals to the market, thereby fostering optimistic expectations in investors. Similarly, firms can convey their long-term resilience and sense of social responsibility through well-designed ESG strategies, thus influencing investor perceptions and firm valuations.

In summary, the findings of this study validate the EMH and RBV and expand the scope of application of signaling theory to the context of stock pricing after a disaster event. The results reveal the contextual effects of ESG initiatives and highlight the critical influences of behavioral biases and signaling mechanisms on the responses of financial markets to unexpected shocks.

5.3. Practical Implications

The results of this study have implications for policymakers and corporate managers facing major crises in financial markets. First, the results indicate that rapid and transparent government relief measures are essential for stabilizing markets after a disaster event. Prompt implementation of reconstruction plans and open communication of government support improve market confidence and sentiment, thereby reducing market uncertainty and postdisaster stock volatility. Thus, governments should ensure the timeliness of their policy implementation.

Second, the research findings highlight the dual market effects of ESG investments following a disaster event. Companies must carefully manage the scale and timing of ESG resource allocation during postdisaster recovery periods. They should evaluate the short-term financial impact of ongoing or planned ESG initiatives and adjust priorities or implement initiatives in phases to avoid an excessive financial burden during periods when liquidity is critical. Immediately investing substantial resources in ESG activities after a disaster may undermine investors' confidence in the firm's financial stability. Therefore, firms should adopt a flexible ESG strategy to retain the benefits of ESG measures without negatively affecting investor confidence.

Finally, companies should enhance their crisis management and resilience planning by establishing dynamic risk management mechanisms. By simulating the effects of various levels of

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ESG or other investments on different aspects, including corporate finances and investor perceptions, management personnel can effectively maintain an appropriate balance between the potential and negative effects of such investments. Moreover, firms should actively collaborate with the government in postdisaster relief and reconstruction. This approach not only allows firms to leverage governmental support, thereby reducing their financial and operational burdens, but also strengthens their brand image and goodwill among stakeholders.

In conclusion, the results of this study suggest that following a disaster event, governments must swiftly announce and implement relief measures, and companies must strategically deploy resources, particularly ESG resources. These strategies can synergistically enhance market stability and improve corporate resilience during future disasters.

5.4. Limitations and Future Research

This study has certain limitations. First, this study focused on six tourism and hospitality firms with operations in Hualien or Taitung. The limited size and industry-specific nature of the sample may constrain the generalizability of the findings. Future research is encouraged to expand the sample to include different industries for comparative analysis.

Second, this study investigated short-term stock market reactions following the 2024 Hualien earthquake, with data collected up to December 31, 2024. This relatively short observation window may not have adequately captured the long-term effects of ESG initiatives or recovery policies. Future studies should extend the observation window for CARs to examine whether the initial patterns identified in this study persist or reverse over time (e.g., whether ESG-oriented firms that initially underperform exhibit higher long-term performance).

Third, in this study, corporate carbon reduction efforts were considered a proxy indicator for engagement in ESG initiatives, with the primary focus being on the environmental dimension. Future research may consider alternative or more comprehensive ESG metrics, such as aggregate ESG scores or specific social initiatives, for assessing the separate influences of various ESG dimensions on stock prices following a natural disaster.

Finally, the results of this study were possibly affected by unobserved confounding factors. For instance, firms with strong ESG commitments may differ in other characteristics, such as their size, financial reserves, and insurance coverage. Such differences can influence firms' postdisaster recovery capacity and may have introduced bias in the evaluation of the effects of ESG initiatives on stock prices. Moreover, the strong government intervention in the examined scenario might have overshadowed other market forces. Future studies should control for or investigate these factors; they may conduct cross-country comparative analyses to clarify how policy environment affects the market outcomes of ESG strategies and market efficiency.

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