Vaasan yliopisto
UNIVERSITY OF VAASA

Abu Sufiean

Stock Market Reaction to Extreme Climate Events: Evidence from Emerging Economies

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Author : Abu Sufiean (x4112422)

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ABSTRACT:

This thesis examines the short-term stock market reaction to extreme climate events in an emerging market context, with a specific focus on India. The study explores the question whether extreme climate events create abnormal stock market returns, as well as whether the response to these extreme climate events is more related to the nature of the event or to other market conditions. This research is driven by the growing economic and financial importance of climate-related risks and the scarcity of empirical studies on short-term market reactions to physical climate shocks in emerging economies. The empirical analysis is based on 25 extreme climate events that occurred in India during the period 2015–2025. Climate event data are taken from the EM-DAT international disaster database and financial market data are sourced from the NIFTY 50 index. This study utilizes the method of event study to quantify the cumulative abnormal returns (CARs) around the event dates. The constant mean return model is the main benchmark model, and an autoregressive AR (1) specification is used for the robustness analysis. Furthermore, a cross-sectional regression analysis is performed to test whether the abnormal returns are explained by event severity, event type and prevailing market conditions.

The results suggest that the abnormal stock returns in the immediate short-term event window (-1, +1) are statistically significantly related to extreme climate events. However, the significance disappears in longer event windows, suggesting that market reactions are temporary and short-lived. The regression results also indicate that event-specific variables, such as event type and abnormal return, do not systematically account for the differences in abnormal returns at aggregate market level. Instead, broader market conditions, including market volatility and pre-event market trends, appear to play a more important role in shaping investor reactions.

The results contribute to the climate finance literature by providing evidence from an emerging market setting and by highlighting the importance of market context in understanding financial market responses to climate-related shocks. The study indicates that the market reactions of the aggregates to extreme climate events depend not only on the intrinsic characteristics of the event but also on the market and financial conditions.

KEYWORDS: Climate finance; Extreme climate events; Stock market reaction; Event study; Abnormal returns; Emerging markets; India; NIFTY 50; Physical climate risk; Market conditions

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Abbreviations

AR	Abnormal Return
AR (1)	Autoregressive Model of Order 1
CAR	Cumulative Abnormal Return
CAPM	Capital Asset Pricing Model
EM-DAT	Emergency Events Database
EMH	Efficient Market Hypothesis
NIFTY 50	National Stock Exchange Fifty Index
OLS	Ordinary Least Squares
VIF	Variance Inflation Factor

1 Introduction

1.1 Background and Motivation

Climate change has risen to become a key point of focus in financial economics because it has become increasingly relevant to economic activity, the value of assets, and financial stability. One of its most obvious and immediate impacts is the increasing frequency and severity of extreme weather phenomena like floods, cyclones, heat waves and droughts. These happenings disrupt production, destroy infrastructure, disrupt supply chains and generate uncertainty around the future economic state. They consequently have a direct influence on the performance of firms and their anticipated cash flows and are therefore of great relevance to financial markets.

Climate risk has not only ceased to be considered a mere environmental issue but has also ceased to be considered as an issue of fundamental financial risk. Compared to more traditional risks, which may be firm-specific and diversifiable, climate risk impacts numerous sectors and regions at once, giving it a systematic aspect (Giglio et al., 2021). This implies that the risk of climate can affect aggregate market performance, anticipated returns and risk premia. This opinion is supported by empirical evidence. Bolton and Kacperczyk (2021) demonstrate that when the firm has greater exposure to carbon, the firm is more likely to earn higher expected returns, which implies that investors require compensation due to exposure to the risk of climate change. Likewise, Addoum et al. (2020) show that temperature shocks influence real economic activity, supporting the connection between climatic conditions and financial performance.

The literature differentiates between transition risk and physical risk. The transition risk is triggered by policy changes, technological changes and regulatory changes that accompany the transition towards low-carbon economy. In comparison, physical risk is the direct economic impact of extreme climate events (Venturini, 2022). Whereas transition risk has received relatively much interest in financial studies, physical climate risk, and especially its connection to short-term market behavior, has been relatively understudied. This gap matters as extreme weather events are sudden and mostly exogenous shocks that add new and often ambiguous information to financial markets.

Extreme climate events have a variety of impacts on the financial markets. They hamper anticipated corporate cash flows by interrupting operations and raising costs. They enhance uncertainty, which influences the perception of risk and the returns that are necessary. They also influence investor attention and sentiment especially when events attract much media attention. Moreover, these events can lead to portfolio and liquidity shifts as investors re-evaluate their risk exposure. These mechanisms imply that extreme climate events ought, in theory, to give rise to observable stock market responses, notably in the short run when new information is being incorporated into prices.

It is however an open question as to whether these reactions are in fact driven by the events themselves. Whether financial markets are efficient in processing information, then market responses should focus more on the characteristics of the event, e.g., severity or type. Simultaneously, when the market reactions are conditioned by some other factors like the previous trends or the feeling of the investors, then the effect of the event itself may be the secondary one. This generates an inherent contradiction to the comprehension of how shocks relationship to climate are priced in the monetary markets.

It is significant to understand the reaction of financial markets to such shocks due to several reasons. Investors should consider the impacts of climate related risks to portfolio performance and risk management policies. Policymakers should have knowledge on the mechanisms of spreading climate shocks using the financial system and the influence of the financial system on economic stability. There is growing interest among regulators in the implications of climate risk to systemic stability and market resilience. Nonetheless, empirical studies of short-term stock market reactions to extreme weather events are still scarce, especially in the emerging economies.

India presents a rather appropriate context in this analysis. The geographic and climatic conditions and the number of extreme weather events have risen over the past few years as the country is highly exposed to extreme weather events. Meanwhile, India is one of the few emerging economies that has one of the largest and most active stock markets in the region.

The combination of high exposure and active market makes it a good environment to study the way financial markets react to extreme climate events.

It is against this background that this thesis explores the short-term response of stock markets in an emerging economy to extreme climate events, and whether the response is more because of the intrinsic nature of the events or due to the prevailing market conditions. By putting the problem in this manner, the study essentially gets to the point of how climate related shocks are priced as event specific disruptions or whether broader market dynamics are dominating investor reactions.

1.2 Research Problem and Purpose

Even though the concept of climate risk has been widely appreciated as a significant factor in financial markets, empirical evidence on how markets react to extreme weather events remains incomplete and often inconsistent. A significant part of the literature deals with the exposure to long term climate risks and its impact on asset pricing (Giglio et al., 2021; Hong et al., 2020). Although this study presents significant information on the manner in which climate risk is slowly being integrated into the financial markets, it does not offer much information on how the financial markets respond to sudden and unexpected climate shocks.

Studies of natural disasters give some indication on the short-term market reactions, but the results are not in any way conclusive. Other studies indicate that there are negative abnormal returns and augmented volatility after the disaster events, which indicates that the market is responsive to new information. In other research, weak or statistically insignificant effects are found, especially at the aggregate market level. Such inconsistent findings lead to one of the fundamental questions on whether observed market responses are influenced by the economic impact of the event or as a result of broader market dynamics.

One of the reasons why these inconsistencies may occur is the variation between the firm level and the market level analysis. Although the impact of the losses experienced by individual firms may be compensated at the aggregate level, owing to the diversification of the sectors. The other explanation is connected to the differences in methodology which decrease the comparability of the studies and makes it hard to isolate the effect of climate events.

In theoretical terms, stock market reactions to extreme climate events can be viewed in the context of the Efficient Market Hypothesis (Fama, 1991) which argues that the price of stocks can be explained by publicly available information. According to this model, extreme climate events are expected to result in speedy price changes and unusual returns in a brief period. This forecast is, however, based on the assumption that the information is transparent, quantifiable and readily interpreted by the investors.

As a matter of fact, information pertaining to climate is usually doubtful, difficult and dynamic. The economic impacts of extreme climatic events cannot be immediately seen and may vary as more information becomes accessible. This gives disparities in investor expectations and may cause delayed or incomplete price changes. The studies in behavioral finance also indicate that investor attention, sentiment, and perception are significant factors in determining market responses in uncertainty (De Bondt and Thaler, 1985; Tetlock, 2007). This can lead to market reactions that are both rational adjustments and behavioral processes instead of being an example of efficient pricing.

The main weakness of the current body of literature is that it pays excessive attention to the developed markets. Such markets have financial systems that are more transparent and efficient in nature with more access to information. On the contrary, the emerging markets tend to be more characterized by information asymmetry and various institutional frameworks. These differences pose significant questions whether results in developed markets can be applied to emerging markets.

Against this background, the purpose of this study is to examine how stock markets respond to extreme climate events in the short term within an emerging market context. It analyses the Indian stock market and examines the question as to whether such events produce abnormal returns. It also looks into whether the intensity and nature of these reactions is different depending on the magnitude and type of the event. Moreover, the research determines to what degree the overall market environments influence investor behavior. By focusing on these questions, the study goes beyond descriptive analysis and directly deals with the relative significance of event specific factors and market wide dynamics.

1.3 Research Gap and Positioning

Although there is a fast-growing body of research on climate finance, there are still several key gaps. Many of the literature available is on the exposure to long term climate risks, and there is limited literature on how markets are responsive to sudden and extreme climate events in the short term. This brings about doubt on the effectiveness with which financial markets absorb new information in the environment of increased uncertainty.

Another apparent difference between firm level and market level results is also visible. Strong negative effects of climate events on performance and valuation have often been reported in firm-level studies, whereas weaker or mixed effects have been reported in market-level studies. This implies that aggregation and diversification are crucial factors in determining the overall market performance, but these processes are not well understood.

The geographical focus of existing research presents another limitation. The majority of empirical research focuses on developed markets and rather little has been given to emerging economies. This is a notable gap in the literature since emerging markets are also more vulnerable to climate risks in most instances and may have different structural and behavioral characteristics.

Furthermore, the impact of event characteristics is also not adequately studied. Although it is commonly believed that stronger events should produce greater market responses, there have been few and scattered empirical studies to support this belief. Likewise, variations in the type of event can also result in different economic effects, but this dimension has not been systematically studied within a consistent empirical framework.The other crucial gap relates to the contribution of the broader market conditions. Market responses are not dictated by the events themselves, but they are influenced by the existing market trends, volatility and the mood of the investors. Not taking into consideration those factors can result in incomplete or imprecise conclusions about market behavior.

This research stands to fill these gaps through a systematic event study paradigm that will be used to study short-term stock market responses to extreme climate events in India. What is more significant is that it directly measures whether market responses are informed by the inherent nature of climate events or rather by the more general market conditions. By doing so, it breaks the implicit assumption in much of the literature that it is the event characteristics that are the main drivers of the market responses and instead tests whether it is the market context that is the dominant factor in market responses.

1.4 Contribution of the Study

The present study would be added to the climate finance literature in a number of significant ways. First, it offers empirical evidence concerning short-term stock market responses to extreme climatic events, which fills a gap in the literature that has mostly concentrated on long-term climate risk exposure.

Second, it adds to the current discussions between firm-level and aggregate market reactions. Although previous studies tend to record high firm level effects, results of this study suggest that the effects are not necessarily high at the aggregate index level. This underscores how diversification and counterbalancing sectoral effects can contribute to overall market performance.

Third, the research incorporates both event-based and overall market-based factors into one empirical research. This will enable a more detailed evaluation of the forces causing market responses. Its findings indicate that market responses are affected more by present market conditions rather than depending on the special features of the climate-event itself. This observation gives a critical insight into the assumption that severity or type of events is the most important factor in dictating how markets respond.

Lastly, the study expands the empirical literature to an emerging market setting by focusing on India. This is critical since market structure, availability of information, and investor behavior might vary considerably compared to developed economies. The study, therefore, brings in context-specific evidence on the manner in which climate-related shocks are processed in the financial markets and offers an insight that may not be reflected in the studies that are based on developed markets.

1.5 Structure of the Thesis

This thesis is divided into six chapters, each of which covers a certain aspect of the study. The first chapter is an introduction to the study by presenting the background and motivation, defining the research problem, outlining the research gap, and highlighting the contribution of the study. The second chapter will present a literature review of the existing literature, theoretical framework, and research hypotheses. The third chapter outlines the data utilized in the analysis, and provides descriptive statistics, such as data sources, variable construction, and important summary measures. The fourth chapter elaborates the methodology, such as event study framework and the econometric models used to study stock market responses to extreme climate events. The fifth chapter will give the empirical findings and explain the findings in terms of the research question and the available literature. The last chapter concludes the study with a summary of the key findings, an interpretation of key findings, and a recommendation of future research directions.

2 Literature Review

2.1 Climate Risk and Financial Markets

This paper focuses on the response of financial markets to extreme climate events by analyzing their ability to support the observed market behavior through existing financial theories. The Efficient Market Hypothesis (EMH) offers a general framework of information integration in price, but its generalizability to climate-related shocks remains unclear. Instead of viewing EMH as an overarching explanation, this paper uses it as a reference point with which actual market reactions can be measured in the face of uncertainty and non-homogeneous investor behavior.

According to the EMH, stock prices reflect all publicly available information (Fama, 1991). The semi-strong form of this should be that new information should prompt rapid and impartial price adjustments through changes in expectations about future cash flows and risk. According to this framework abnormal returns must occur only when new information enters the market and must be immediate and short lived. This makes a clear theoretical prediction: in case extreme climate events provide relevant information, their effect should be reflected fast in stock prices within a narrow event window.

Such information shocks as extreme climate events can be interpreted. Floods, cyclones, and heatwaves are such events that disrupt production, destroy assets, and raise operating costs, thus affecting expectations regarding firm performance (Addoum et al., 2020). Theoretically, these effects are expected to be reflected in the stock prices by the quick change of the price. This gives the reason of using event study methodology, which is developed to isolate the effects of new information on the asset prices (MacKinlay, 1997).
However, the nature of climate-related information challenges the assumptions underlying the EMH. The economic impact of climate events cannot be predicted, changes and are hard to measure at the time they happen. Empirical evidence indicates that such information does not necessarily get incorporated in an efficient manner, especially when its implications are unclear or long-term (Hong et al., 2020; Pankratz et al., 2023; Giglio et al., 2021). This puts a distance between the theoretical forecasts and the market action.

The event study framework is a systematic approach to investigating this gap. It compares actual returns to the expected returns to isolate abnormal performance, within a specified event window (MacKinlay, 1997; Brown and Warner, 1985). When markets are efficient, abnormal returns must be centered on the date of the event as well as not lasting. But weak, delayed or short-run abnormal returns can be a sign that markets are struggling to process complex information or that other factors are affecting the observed results.

Notably, the scientific evidence on the market responses to climate factors is not consistent. Some reports indicate that the expected returns and risk premia of asset prices reflect climate risk (Bolton and Kacperczyk, 2021; Ilhan et al., 2021), whereas others report delayed responses, forecast errors, and incomplete adaptation (Hong et al., 2020; Pankratz et al., 2023). This lack of consistency is intended to indicate that the market reaction to climate events cannot be entirely accounted for using a single theoretical framework.

The major weakness of the available literature is that it tends to assume that market responses can be predicted solely by the characteristics of events. Nevertheless, financial markets exist in the broader economic and financial contexts which can potentially affect the interpretation of new information. Existing literature has already shown that in many cases, aggregate market responses to climate events are both weak and short-lived, despite firm-level effects being substantial. This casts doubt on the fact that there are broader market conditions which are vital in influencing the observed outcomes.

Following this, this paper will take a step further than assuming market responses are solely influenced by the nature of the event. Rather, it takes into consideration that short-term stock market reactions to extreme climate events are a product of interaction between event-related information, and overall market. This view offers a basis to developing a more integrated theoretical framework as well as empirically testing whether market reactions are event-specific or market-specific.

2.2 Theoretical Framework

Based on the shortcomings highlighted in the preceding section, this study creates a combined theory to explain the responsiveness of financial markets to extreme climatic events. The framework does not make use of one theoretical approach but rather a combination of three complementary perspectives: the Efficient Market Hypothesis, behavioral finance, and the impact of market conditions. This integration is needed to clarify the reasons empirical evidence on the market response to climate changes is usually inconsistent and why observed effects are often short-lived.

Efficient Market Hypothesis gives the framework of how the market is supposed to process new information (Fama, 1991). If extreme climate events present relevant information about economic disruption and firm performance, stock prices will respond quickly, leading to abnormal returns comprised within a short event window. However, as discussed in Section 2.1, this prediction depends on the assumption that information is clear and easily interpretable, which is often not the case for climate-related shocks.

Behavioral finance builds on this model by taking into consideration the process by which investors process complex and uncertain information. In the conditions of uncertainty, investors also do not just rely on fundamentals, but on attention, sentiment, and cognitive biases (De Bondt and Thaler, 1985; Tetlock, 2007). The extreme weather events tend to be widely covered by media, which raises their visibility and affects the perception of investors. Consequently, market responses can be short-term overreaction with subsequent partial correction instead of immediate and impartial adjustment as suggested by EMH. This is a behavioral explanation to why abnormal returns might be transient or irregular.

But rational explanations of market responses and behavioral explanations of market responses cannot account fully in explaining the variation in market responses. One of the most critical factors that have not been fully explored in the literature is the contribution of the already existing market conditions. Financial markets exist in a wider economic context that has an impact on the interpretation of new information. During a time of high market performance, high valuations can result in greater sensitivity to any negative shock, and the subsequent price changes will be more abrupt. Conversely, in weaker market conditions, the marginal effect of new information can be small due to the already existing risk as reflected in prices.

The implication of such an interaction between the information given by the events and the market conditions is that the abnormal returns are not decided only by the intrinsic nature of the events. Rather, market reactions are indicative of a blend of information processing, investor behavior, and the overall financial situation. This view is useful in explaining why the aggregate market responses are usually weak or inconsistent, even when the effects of firms are large, and the reasons why the results of studies differ.

The event study research methodology can be the empirical connection between these theoretical points of view. It is a direct means to measure market reactions to new information by measuring abnormal returns in relation to expected performance (MacKinlay, 1997; Brown and Warner, 1985; Kothari and Warner, 2007). The abnormal returns timing and persistence can provide an insight into the underlying mechanisms of market behavior. Short-term and immediate reactions can indicate that there was rapid incorporation of information or that it was caused by a temporary overreaction, whereas weak or insignificant reactions can suggest that the broader market conditions or diversification override aggregate results.
This combined system results into a more in-depth concept of market behavior. Instead of taking markets as fully efficient and strictly driven by behavioral biases, it recognizes that both mechanisms are at work and are influenced by the prevailing market environment. Consequently, it is predicted that the short-term stock market responses to extreme events in climatic conditions are indicative of the interplay between the nature of the event and the overall market conditions.
Significantly, this framework offers the theoretical basis of the empirical analysis undertaken in this study. It indicates that even though extreme weather events can produce observable market responses, they are not likely to rely on the characteristics of events to determine the nature and extent of their market responses. Rather, the overall market conditions are likely to be instrumental in dictating the investor reactions. This is directly tested in the empirical analysis, especially in testing whether the abnormal returns are due to event-related factors or rather due to market trends that exist before the events.

2.3 Natural Disasters and Stock Market Reactions

The empirical evidence on the relationship between natural disasters and the performance of the stock market has been widely studied in financial economics, but the empirical evidence is still in fragments and internally inconsistent. Early research typically finds that there are negative short-term market responses, although more recent studies focus on heterogeneity among firms, sectors, and market structures. This difference does not only constitute a difference in empirical findings but also a difference in the measurement and level of analysis of disaster impacts. Consequently, the literature fails to agree on a single explanatory mechanism, which begs the question whether stock market responses are mainly influenced by the nature of events, or the overall market environment.

Theoretically, these reactions are mostly regarded in the Efficient Market Hypothesis (EMH), which postulates that stock prices adapt to new information (Fama, 1991). The occurrence of natural disasters may be considered as the unexpected information shock that has influenced expectations about the future cash flows and risk. In this model, the prices are to change quickly and effectively. But this forecast is based upon the belief that information is instantly intelligible and readable. Information related to disasters is uncertain, incomplete and changes over time, which undermines the applicability of EMH and creates a tension between theoretical expectations and observed market behavior.

This tension is reflected in the empirical findings. Statistically significant abnormal returns and higher volatility in the wake of disasters have been documented in early studies like Worthington and Valadkhani (2004) confirming the existence of rapid market adjustment. These studies, however, are based on aggregate market indices, and make implicit assumptions about the uniformity of market reactions. A broader macroeconomic literature reveals that country and institutional specifics of disaster effects are extremely heterogeneous and challenging to the assumption of homogeneous market responses (Noy, 2009; Cavallo et al., 2013).

Later studies change the emphasis to heterogeneity at the firm level, which squarely attacks the conclusion based on aggregates. As demonstrated in Bourdeau-Brien and Kryzanowski

(2017), market responses vary depending on the geographic proximity and firm-specific exposure, with stronger negative abnormal returns of firms located nearer to the affected areas. Correspondingly, Zhao et al. (2024) establishes that natural disasters raise the probability of crashing stocks, which implies that the impact of disasters is not limited to the increase in the average returns but rather to the spread of the risks. These results imply that the effects of disasters are very localized and uneven, which contributes to explaining why they are usually diluted in aggregate indices.

This difference between firm-level and aggregate results is one of the main inconsistencies of the literature. Although the effects are always reported to be significant when studies are performed at the firm level, weak or statistically insignificant results are often reported when studies are conducted at the aggregate level. In line with this distinction, Song (2025) demonstrates that the effects of climate risk are captured by firm-level returns but are hidden in aggregate indices because of diversification and counterbalancing sectoral effects. This means that even weak aggregate responses cannot be read as indications of low impact, but instead it is the consequence of aggregation of heterogeneous firms.

The behavior of investors is another reason why these mixed results have occurred. The fact that a disaster is accompanied by increased uncertainty and significant media attention may initiate a strong short-term response and price fall. These movements can in part revert, as more information about the real economic impact becomes available, and as such is evaluated. This over-reaction and subsequent correction pattern are not consistent with strict predictions of EMH and is more in line with behavioral finance predictions (De Bondt and Thaler, 1985; Tetlock, 2007). This mechanism is further supported by evidence on investor attention, which suggests that market responses to economic fundamentals, rather than just to visibility and salience, are driven by investor attention (Barber and Odean, 2008; Da et al., 2011).

The importance of wider market circumstances in the influences of these reactions is also stressed in the literature. Schuster and Lueg (2026) discover that physical climate events are correlated with negative short term abnormal returns which are partly caused by investor attention. Nevertheless, the degree of such reactions depends on the financial environment and the interaction between the new information and the financial environment as opposed to the event itself.

This is an even more complicated relationship due to sectoral and institutional factors. The industries that are more directly exposed to climate-related shocks include insurance, agriculture, and infrastructure industries, whereas the other sectors may be less affected or even indirectly benefited. Simultaneously, economic harm can be minimized by government reaction, reconstruction activity, and fiscal aid, which will help to stabilize the expectations of investors. There is evidence that institutional quality is critical in determining the economic and financial effects of disasters (Noy, 2009; Felbermayr and Gröschl, 2014).

In general, the literature suggests several channels through which natural disasters impact stock markets, such as the declines in expected cash flows, higher uncertainty, shifts in investor sentiment, and sectoral reallocation. However, these mechanisms do not operate independently. Instead, they engage with one another and the general conditions in the market, they generate highly contingent outcomes, not consistent across events.

However, the body of literature is still disjointed and has not come up with a cohesive empirical model. It is not an unambiguous agreement on the duration or the magnitude of the market effects and the differences in methodology decrease the comparability between studies. Moreover, a significant part of the evidence is in developed markets, which restricts its applicability to emerging economies. Although there are studies like Song (2025), which indicate that the climate risk is priced in emerging markets, they are predominantly focused on the exposure of the firm at the cost of the short-term response to discrete phenomena.

Taken together, the literature provides evidence that responses of the stock market to natural disasters cannot be attributed to the characteristics of the event. They are rather influenced by the interplay between the exposure at the firm level, investor behavior, and overall market conditions. This means that short run market responses can be weak or inconsistent on an aggregate level, although underlying firm level effects are potentially strong.

In this context, there is a clear need for a systematic analysis of short-term stock market responses to extreme climate events in an emerging market setting. This study will attempt to present more robust and comparable evidence as to how financial markets respond to such shocks and to clarify whether observed reactions are motivated by the events themselves or by the overall financial environment.

2.4 Physical Climate Risk and Firm-Level Effects

Literature in the recent past has given a lot of emphasis to the effects of the risks associated with climate on the performance of firms and the mechanisms through which the effects are transferred to the financial markets. This strand gives a more detailed picture of the impact of climate shocks on firms at the micro level, and how investors use this information to value their investments. But though there is consistent, firm level evidence that climate shocks are economically important, it does not fully explain how these effects can be translated into broader market outcomes, especially at the aggregate index level.

In terms of pricing assets, climate risk at a firm level impacts the perceived risk and the expected returns. Investors revise future cash flow expectations and add more risk to the valuation models when the performance of firms is influenced by climate events (Fama, 1991). This model justifies why climate shocks ought to be captured in the financial markets. It however assumes that investors could accurately assess the magnitude and timing of these effects, which is often an unrealistic assumption given the uncertainty, incomplete information, and delayed realization of the impact of climatic effects.

One notable contribution of this literature is the difference between the direct economic impacts and indirect valuation impacts. Physical climate risks e.g. extreme temperatures, floods, cyclones etc. can cause disruption of operations, a reduction in productivity, an increase in costs, and uncertainty in future performance. These effects not only have a direct impact on the fundamentals of firm, but also affect the expectations of investors, prior to the realization of their full economic impact. Consequently, actual economic losses and stock prices responses are not always moving in the same direction, which demonstrates a lack of correlation between actual firm performance and market performance. This difference can be supported by the broader evidence of the fact that climate conditions have a major impact on the economic output and productivity on the firm and macro level (Dell et al., 2012; Burke et al., 2015).

Empirical evidence has been able to support these mechanisms but also indicate significant inconsistencies. Addoum et al. (2020) demonstrate that temperature shocks not only influence establishment-level sales and actual economic activity but also have a negative impact on revenues and operating income, with investors initially underestimating the extent of these impacts. These results imply that climate risk is both a short-term operational shock and a valuation issue but also point to the fact that markets do not necessarily immediately incorporate this information. This questions the assumption of complete efficiency of prices and suggests that market short run reactions might be incomplete or delayed.

Besides performance implications, climate risk affects how downside risk is perceived by investors. According to Ilhan et al. (2021), the uncertainty in climate policy is reflected in the option markets, whereas Bolton and Kacperczyk (2021) find it to be priced in the equity markets. These findings suggest that climate risk is at least partially reflected in financial markets, but in many ways, including expected returns, risk premia, and downside protection, and not through a single consistent mechanism. This multi-channel pricing makes it difficult to interpret the stock price responses, especially in the short run.

An additional weakness is caused by disparities in the measurement of climate risk in various studies. There are those that are interested in operating performance, others on valuation effects and others on the downside (or crash) risk. These different methods are related to each other, but they capture various aspects of risk and are not directly related to whether firm-level shocks translate into short-term market responses. Consequently, literature tends to present parallel information but not a coherent explanation, which adds to the discrepancy of empirical evidence.

This is further complicated by information frictions that complicate this relationship further. Investors may not respond instantly when the economic implications of climate events are uncertain or not easily observed in the short-term, yet they may strongly respond when perceived extreme risks are high in the face of high uncertainty. This translates to unstable pricing dynamics especially in the short-term. Hong et al. (2020) and Giglio et al. (2021) provide some evidence that the climate risk is economically significant, but it is not always reflected in the prices of assets in a straightforward and timely manner, which contributes to the idea that short-term market responses may not always follow theoretical expectations.

There are behavioral reasons that can further explain such deviations. Investors can show disaster myopia, which is the underestimation of the probability of rare but severe events, which may result into underpricing of risk in normal situations and abrupt adjustments to shocks (Schuster and Lueg, 2026). Furthermore, these reactions can be enhanced by media coverage and information salience, which suggests that the market responses do not just depend on the fundamentals but also on the perceived and interpreted media coverage. This supports the perception that investor focus and behavioral reaction influence a lot on determining the short-term market results.

The literature is still scarce in understanding how the effects of the firm level climate is converted into the immediate aggregate market effects. Most studies are considering long-term exposure or firm-specific results with rather few studies examining short-term price changes around discrete weather events. This restricts the possibilities to directly relate micro-level evidence to aggregate market behavior, especially in emerging markets where the frictions in information as well as structural differences are more pronounced.

Significantly, firm-level effects are not always carried over to equally effective aggregate market effects. Industrial diversification can counter-act adverse effects in one firm with neutral or positive effects in another that have weak or statistically non-significant index-level responses. Aggregate indices can thus produce a lower estimate of the real effect of climate events due to cross-sectional variation. This observation is directly relevant to the findings of this research, where specific characteristics of events, such as severity and type, are not found to be statistically significant at the aggregate level, but more broad market conditions are a more significant contributor to the explanation of short-term market reactions.

In this respect, the literature draws a basic lack of connection between the evidence at the firm level and the aggregate market results, especially in the short term. Although consistent results of firm-level studies always show significant effects, market-level results are usually inconsistent and weak. This gap will probably be even larger in the emerging markets because of the high levels of information frictions and structural variations. This paper will discuss this problem by considering stock market reactions to extreme climate events on the aggregate level, through a systematic event study model, and explicitly recognizing the role of the broader market conditions. In so doing, it directly tests whether market reaction is primarily a result of event characteristics or a result of financial environment in which events occur.

2.5 Conceptual Framework

This paper formulates a conceptual framework to describe the impact of extreme climatic events on the stock market and to help clarify how these effects come about. Instead of considering market responses as an immediate and direct result, the framework acknowledges that market responses to stock prices are driven by a series of interconnected processes that may involve economic turmoil, investor interpretation, and macro market dynamics. This is critical since the results of this study in the market indicate that reactions are short lived and not driven by the severity and type of the event, thus indicating a context dependent reaction instead of a simple event driven reaction.

Extreme climate events are considered as external shocks that take place without the influence of the financial markets; however, they do interact with the environment where they occur. These events cause a series of events that affect the performance of firms and the behavior of investors, which eventually results in a change in prices of stocks. But this is not a smooth process, with uncertainty, information frictions, and market sentiment prevailing in each stage. Consequently, the same events can produce different market responses based on the situations and market conditions, which is consistent with evidence that climate-related risks are processed differently across the time horizons and market conditions (Giglio et al., 2021).

Initially, the economic effect on firms is involved. Floods, cyclones, and heatwaves can damage assets, disrupt production, interrupt supply chain, and increase costs, reducing anticipated future cash flows and firm value. The real economic activity and firm performance are proven to be affected by climate shocks using empirical evidence (Addoum et al., 2020; Pankratz et al., 2023; Dell et al., 2012). These impacts, however, differ across firms and sectors based on exposure and resilience, i.e. aggregate market responses may not have fully reflected underlying firm-level impacts.

The second stage is the increase in uncertainty. Investors are uncertain after an event in the climate in terms of the extent of damage, length of the disruption, and chances of recovery. This makes expectations regarding cash flow and risk in the future more complex, affecting stock prices. The literature on climate finance implies that such risk is a part of a broader valuation environment, rather than a short-term shock (Giglio et al., 2021; Hong et al., 2020; Pástor et al., 2021). But the investors do not react in a similar manner, and this leads to unequal market reactions.

The third step is investor reaction, in which the revisions of the expectations occur in response to the economic impact as well as uncertainty. Investors change the portfolios, reevaluate risk, and instill new information into the prices. At this level, perception and attention are of importance. When the visibility of events is higher, they might provoke more responses, although the economic consequences of such events might remain unclear. This is in line with the evidence that investor attention and sentiment affect price dynamics in situations of uncertainty (Barber and Odean, 2008; Da et al., 2011; Tetlock, 2007). These trends indicate that market adjustments are more of a rational valuation process than a fully efficient adjustment process.

Such processes are captured by the stock price in the form of abnormal returns during the period of the event. Nevertheless, the size and orientation of these returns cannot be solely influenced by the nature of the events. Though severity and type can have a disruption effect, it may not be fully visible at the aggregate level because of diversification and counterbalancing sectoral responses.

Concurrently, the conditions prevailing in the market are important factors that influence the reactions of investors. High valuation in strong markets could cause more intense responses to negative shocks, whereas in weaker markets, the extra effect might be less pronounced. This is consistent with the evidence of asset pricing that time-varying risk premia and macro-financial conditions are more relevant in explaining the short-term market reactions (This is consistent with the evidence of asset pricing that time-varying risk premia and macro-financial conditions are more relevant in explaining the short-term market reactions (Pástor et al., 2021).

In this research, the response in the stock market is quantified with the help of abnormal returns calculated in the framework of event study. These returns are considered in context of event characteristics and market conditions such as volatility and pre-event trends. In this way, a more detailed evaluation of the joint impact of event-specific and market-wide factors on the behavior of the stock market is possible.

The conceptual relationship can be summarized as follows:

Extreme climate event → Economic disruption → Increased uncertainty → Investor reaction → Abnormal stock returns

However, this process is affected by the context of the market, because each stage is exposed to the existing conditions. The framework thus does not assume that events alone cause an investor to act in a certain manner but focuses on the interaction between the event, interpretation by the investor, and the wider financial environment.

In conclusion, extreme climate events lead to economic disruption, increased uncertainty, and revised investor expectations, resulting in abnormal stock returns. Notably, the magnitude and the course of this response are not only defined by the characteristics of the event but also by the initially developed market conditions. This framework offers a systematic basis to analyze whether market responses are either small or situation specific.

2.6 Research Gap and Hypothesis Development

Even though the literature on climate finance and market responses to disasters has grown substantially, it is still fragmented and does not offer a coherent explanation of how extreme climate events are processed by financial markets in the short run. Current literature can provide valuable information on aspects of climate risk but has rarely attempted to incorporate these views in a single framework, which would explain short-term market dynamics, especially in new market environments. Consequently, the literature does not adequately answer whether stock market responses are mostly motivated by the inherent nature of climate events or the overall financial context in which such events are taking place.

The first weakness is that it heavily focuses on long-term pricing of climate risks, as opposed to short-term market dynamics. References like Giglio et al. (2021) and Hong et al. (2020) show that the asset price of longer horizons and across classes incorporates climate risk. Although these results indicate that climate risk is an economically viable variable, they do not give much information regarding the response of markets to sudden and discrete climate shocks. This generates a fundamental disconnect between the pricing of long-term risks and the short-processing of information, leaving unanswered the question of whether markets are efficient in their responses to the arrival of new information on climate-related risks.

A second limitation relates to the issue of methodological inconsistency. Early literature is generally based on aggregate market indices and simple before and after comparisons, whereas more recent literature refers to firm level heterogeneity (or risk-based measures) such as crash risk. Nevertheless, not many studies utilize a uniform event study design to analyze short-term abnormal returns. This lack of methodological congruence makes it hard to tell whether variations in results are due to real economic effects or due to differences in empirical design (MacKinlay, 1997; Brown and Warner, 1985; Kothari and Warner, 2007). As a result, literature fails to give a clear reference point on which short-term market efficiency is to be assessed in the context of climate shocks.

Third, there is still inconsistent empirical evidence on the processing of climate-related information. It has been suggested in some studies that the price incorporates climate risk, especially in the form of risk premia and downside protection (Ilhan et al., 2021; Bolton and Kacperczyk, 2021). Conversely, other studies have reported lagging responses, forecasting errors, and underestimating the effects of climate change (Pankratz et al., 2023; Hong et al., 2020). This divergence shows that the processing of information regarding climate issues is not uniform and market reactions to information and their clarity, timeliness, and interpretability. Therefore, it is possible that the assumption of fully efficient markets does not hold in the context of complex and uncertain climate events.

Fourth, there is apparent geographical bias in the literature. Most of the empirical research is devoted to developed markets, where information is more easily accessible, and the institutional frameworks are comparatively robust. Since emerging markets are more susceptible to physical risks, they are under-explored. Although studies like Song (2025) offer evidence that climate risk is priced in emerging markets, they primarily address firm-level exposure and not short-term market responses to discrete events. This restricts the generalizability of the current findings and opens the question of whether the market dynamics vary systematically across the market environments.

Fifth, there is a gap between risk-driven strategies and event-driven analysis. Recent reports are gradually focusing on downside risk and crash risk (e.g., Zhao et al., 2024), but do not explicitly study abnormal returns on events dates. This prevents the possibility of attributing any changes in perceived risk to short-term price changes, leaving a partial explanation of how risk perceptions can be converted to short-term price adjustments.

Finally, the available literature tends to believe that event characteristics, including severity and type, are the key determinants of market reactions. The contribution of the prevailing market conditions, such as the level of valuation, volatility, and market trends, has received comparatively little attention. This omission is essential as the asset pricing theory implies that the sensitivity of the market to new information is not equal across economic conditions (This is consistent with the evidence of asset pricing that time-varying risk premia and macro-financial conditions are more relevant in explaining the short-term market reactions (Pástor et al., 2021). Failing to consider these conditions is prone to conclude that market responses are driven by the nature of events when larger-scale financial forces are at play.

All these constraints suggest that the literature lacks a unified or integrated description of short-term market reactions to extreme climate events. Specifically, it is not clear whether the observed abnormal returns are largely due to the nature of the events themselves or to the market context within which they occur. This is a basic literature gap.

This paper fills this gap by determining an integrated empirical model that jointly assesses event specific attributes and existing market conditions using a consistent event study design. The study directly tests competing explanations of market behavior by focusing on the short-term abnormal returns in an emerging market setting. In doing so, it goes beyond the implicit belief that event characteristics are the sole determinants of market outcomes and instead measures the relative significance of event-driven and context-driven mechanisms.

Hypothesis Development

The hypotheses are based on the combination of the three theoretical perspectives: the Efficient Market Hypothesis, behavioral responses in the face of uncertainty, and the impact of market conditions. These views lead to conflicting forecasts on how stock markets would react to extreme climate events, and empirical testing the market behavior can be conducted directly.

According to the Efficient Market Hypothesis, the prices of stock are responsive and correct to new information (Fama, 1991). If extreme climate events provide relevant information on economic disruption and the performance of firms, the market ought to respond immediately to generate abnormal returns within a short event window. Nonetheless, when information is complicated, unpredictable or hard to comprehend as it is suggested by both behavioral theory and empirical data (Hong et al., 2020; Pankratz et al., 2023), price adjustments might be slow, dull or irregular. It gives rise to the initial hypothesis:

H1: Extreme climate events lead to statistically significant abnormal stock returns in the short term.

This is a hypothesis that extreme climate events are perceived as information shock in the form of relevant information. Although theory would predict a clear response, previous evidence indicates that such responses can be weak or short lived at the aggregate level by diversification and information friction.

The second hypothesis is based on the severity of the events. In theory, more extreme events ought to produce more economic disturbance, more uncertainty, and more corrections in perceived cash flows, resulting in greater market responses. Firm level evidence, however, indicates that they may not be directly transduced into aggregate market responses due to diversification and counteracting sectoral impacts (Bourdeau-Brien and Kryzanowski, 2017; Song, 2025). This poses an empirical question which is not trivial:

H2: The severity of extreme climate events influences the magnitude of abnormal stock market reactions.

This hypothesis is about whether severity continues to be a significant determinant of market responses at the aggregate level or whether the effect of severity is subdued by the broader market dynamics.

The third hypothesis tests the variations within the types of events. Economic activity is impacted by different types of climate events, such as floods, cyclones, and heatwaves, but in varying ways, including infrastructure damage, supply chain disruption, and productivity loss. But it is not yet clear whether any of these variations can be translated into observable variation in aggregate market returns:

H3: Different types of extreme climate events are associated with different stock market reactions.

This hypothesis tests to determine whether event type has any significant explanatory power that is not simply the overall market reaction but rather a distinct market response to the specific event.

The fourth research question is answered using the robustness analysis instead of the formal hypothesis testing, which investigates whether the results obtained are consistent across alternative model specification and event windows.

The hypotheses are effectively tested through an event study framework to test the abnormal stock returns related to extreme climate events. More to the point, they also enable one to directly determine the causes of short-term reactions of the markets to the events in question as well as the overall market conditions. The difference is essential to the interpretation of empirical findings, and it adds to a more in-depth interpretation of the way financial markets process climate-related information.

3 Data and Variable Construction

3.1 Overview

The chapter describes the construction of the data set on which the empirical analysis will be conducted and the construction of the main variables. The importance of a well-defined data chapter is since the credibility of an event study is dependent on the quality of the event identification, the timing of the observations, and the manner of return measurements. With the structured format of the high-quality reference thesis, the chapter does not refer to the results but only describes the data used to obtain the results.

This thesis has an empirical design centered around 25 extreme climate events in India, the NIFTY 50 index, and a set of event-level explanatory variables that subsequently appear in the regression analysis. The dependent variable in that chapter is cumulative abnormal return and the regressors include log severity, flood, storm, market volatility and pre-event trend. Here the same structure is made so that the process of data estimation is clean and transparent.

3.2 Data Sources and Study Period

3.2.1 Financial market data

The financial market data are sourced out of the NIFTY 50 index which is the major benchmark index of the Indian stock market. The NIFTY 50 is a handy proxy of the overall market behavior since it reflects large, liquid and widely traded firms. The use of an index as opposed to individual stocks is in line with the objective of the thesis which is to analyze the aggregate market responses to climate related shocks as opposed to the firm specific responses.

Returns are calculated by use of daily index values. Daily information is required as the event study framework quantifies the market response within a short period around every event. Data on a monthly basis would be too gross to serve this purpose and would make it difficult to notice immediate price adjustments. Daily market data are used, therefore, to enable the study to capture more accurately the timing of the reaction.

3.2.2 Climate event data

Climate event data are obtained through EM DAT which is the international disaster database maintained by the Centre of Research on the Epidemiology of Disasters. EM DAT is a popular tool in academic research since it offers standardized data on disaster type, timing and reported impact. This renders it appropriate to determine major climate occurrences in a uniform manner.

The sample period will be between 2015 and 2025. This is not too recent to capture several extreme climate events but at the same time is not too old to indicate the present structure of the Indian market. It also addresses a period of time where climate-related disturbances have become increasingly apparent in economic and financial discourses.

The last sample consists of 25 events. Each of the occurrences is considered a single observation in the empirical study. This level of structure is critical since the regression analysis does not analyze market returns at the day-to-day level. Rather, it employs a single cumulative measure of the market response to various climate shocks.

Table 3.1: Main data sources

Data component	Source	Use in the study
Market data	NIFTY 50	Measures aggregate stock market performance
Climate event data	EM DAT	Identifies event type, timing, and impact
Study period	2015–2025	Defines the sample frame
Unit of observation	Event level	One climate event corresponds to one observation

3.3 Event Selection and Sample Construction

The quality of an event study strongly depends on the selection of the events. This thesis incorporates an event that meets three conditions. First, it should take place in India. Second, it should be defined in EM DAT as an extreme climate-related event. Third, it should be marked by a date that can be easily identified to allow the event window to be matched with trading days.

This is concerned with the events that are most likely to be germane within financial markets since they produce a visible shock to economic activity and investor expectations. The most applicable categories in the Indian context are floods, storms, cyclones, and heatwaves since this is one of the most prevalent types of climate disruption and can impact production, infrastructure, transport, and short-run market sentiment. The thesis subsequently sub-categorizes some of these types of shocks into dummy variables so that the analysis can test whether the market is responsive to different types of shocks.

Another important issue is timing. The occurrence of climate events is not necessarily during trading days. When an event occurs on a weekend or a market holiday, a subsequent trading day is taken as the date of the event. This is normal practice in even study research since the market is unable to react until trading is reinstated. The nearest trading day will provide the measured return with the first market response that is available.

Caution is also observed to prevent overlapping of events. When two events are too near together, the market response to one event can pollute the market response to another event. It would then be hard to disentangle the impact of a single shock. That is why, only those events that can be distinguished well in the selected event windows are included in the sample. This is part of the reason the end number of observations is 25 instead of a significantly larger raw number of events.

The outcome is a purposely small yet clean dataset. That is the appropriate trade-off when it comes to this type of thesis. A larger sample with poor event separation would be of little use compared to a smaller sample with definite timing and accurate classification.

3.4 Measurement of Market Returns

The market reaction is measured using daily returns from the NIFTY 50 index. Returns are calculated from index values using the standard logarithmic return formula:

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right)$$

where P_t is the index level on day $t$and P_{t-1} is the index level on the previous trading day. Logarithmic returns are commonly used in finance because they are time additive and behave well in short window analyses.

The estimation window of the event study is 120 trading days before the event window. The window is used to estimate normal return behavior and provides a baseline of what the index would have done without the occurrence of the climate event. The 120-day period is long enough to give consistent estimates that are not too far back in time, making the benchmark less applicable to the current market conditions.

The event window in itself is focused on the event date. The main window that is utilized in the analysis is (-1, +1). This is to capture one day prior to the event, event day and a day after the event. Later in the empirical analysis, broader windows are used, but the fundamental structure of the data is based on the immediate market reaction.

3.5 Construction of Variables

The key variables that will be used in the thesis will be used to capture both the reaction of the stock market and the nature of the climate event. The definition of the variables is important since the regression analysis will be performed later and it will rely on them.

The main dependent variable is cumulative abnormal return (CAR) which acts as the main indicator of market response. CAR is constructed by first estimating expected returns and then comparing actual index returns with those expected returns. In this thesis, expected returns are estimated using the constant mean return model. In this model the expected value is the average value of the index over the estimation period.

Abnormal return is thus defined as:

$$AR_t = R_t - \bar{R}$$

Cumulative abnormal return is then calculated as:

$$CAR = \sum_{t=t_1}^{t_2} AR_t$$

This gives one an idea of the overall reaction to the market at each event. The primary analysis is the (-1, +1) window that reflects the immediate reaction.

The severity of the event is also an explanatory variable to measure the magnitude or intensity of the climate event. This variable is taken as a logarithmic transformation because the severity of the disasters is skewed. The transformation makes the very large values less influential and preserves the variation between events, making comparisons between events more balanced.

The event type is employed to draw the line between various types of climate shocks. This is done using dummy variables of flood and storm, with heatwave, as the reference category. This is a specification that can be compared across different types of events and helps identify whether the market responds differently to the different types of shocks.

It uses variables to capture the market conditions which describe the wider financial conditions before each event. These include market volatility and pre-event trend. Market volatility is the degree of uncertainty in the market, whereas the pre-event trend is the direction of the market, prior to the occurrence of the event. With these variables included, the analysis is able to capture the impact of any existing market conditions on how investors respond.

3.6 Final Sample and Data Structure

The last dataset is structured at the event level. The 25 climate events have cumulative abnormal returns, a measure of severity, a type of event and variables in market conditions.

Table 3. 2: Dataset structure

Component	Description
Country	India
Market index	NIFTY 50
Event source	EM DAT
Sample period	2015–2025
Number of events	25
Estimation window	120 trading days
Main event window	(-1, +1)

4 Methodology

4.1 Overview

This chapter introduces the empirical framework to study the response of stock markets to extreme climate events. The methodology is constructed to measure the short-term market responses and to determine the aspects that characterize the variation in such responses among events. The analysis is a combination of an event study design and cross-sectional regression designs, which enables the determination of abnormal returns and the assessment of their drivers.

The empirical design is constructed based on the framework of the dataset and the variables formed during the data preparation phase. The event study structure is applied to isolate the short-term effect of climate related shocks on market returns and the regression analysis provides a systematic way of determining the effect of event characteristics and market conditions on the results. These approaches provide a complete analysis of the presence and the determinants of market responses.

Moreover, the specification of expected returns is specifically considered since the accuracy of abnormal returns estimation relies heavily on the type of benchmark model selected. Although the constant mean return model is considered the main specification, its application should be well justified compared to more sophisticated models. The methodological decisions in this chapter thus clearly solve the trade-off between the simplicity of the model and its theoretical completeness, to make sure that the empirical framework is robust and suitable for the research goal.

4.2 Event Study Approach

Empirical analysis is informed by the event study methodology that is very popular in financial economics to assess the market reaction to new information. The model, which was first proposed by Fama et al. (1969) and formalized by MacKinlay (1997), is based on the notion that the price of an asset responds to information, and any variation of returns of an event around that event indicates the process of adjustment. This theoretical framework is directly connected to the Efficient Market Hypothesis formulated by Fama (1970) that indicates that the financial markets are capable of using new information in an efficient and quick manner.

In this paper, extreme climate events are considered information shocks that can impact investor expectations about future cash flows and risk exposure and the overall economic situation. They can bring uncertainty and initiate reconsideration of firm performance and market future. The event study framework offers a systematic means of isolating such effects by comparing the actual returns with a benchmark of the expected returns based on historical returns.

This is especially appropriate when it comes to climate-related shocks, as they tend to be abrupt and mostly exogenous. Their effect is best measured in a small-time frame around the date of the event. By concentrating on this time frame, the methodology reduces the effect of unrelated variables and enables us to identify the market response more clearly.

Although the event study framework assumes that markets react to new information, the rate and direction of the reaction may differ based on the nature of the shock and the degree of uncertainty surrounding the shock. When it comes to climate events, the information is usually complex and can be perceived differently by market participants, which can result in heterogeneous short-term responses. Existence or nonexistence of abnormal returns should then be viewed not only as a measure of market efficiency, but also of the speed and efficiency with which markets process complex and uncertain information.

Recent methodological studies also point to the further applicability of event study methods in the study of short-term financial market responses. According to studies by Corrado (2011) and Kothari and Warner (2007), event studies have proven to be a stable empirical method when properly applied, especially when dealing with exogenous shocks and when the event horizon is limited. The contributions point out the significance of proper specification of the model and inference processes in delivering sound and believable results.

4.3 Estimation Window and Event Window Design

The event study implementation involves the definition of two important elements, which are the estimation window and the event window. Both are used to measure abnormal returns in a different way and to make sure that the analysis accurately captures the market reactions.

The estimation window is 120 trading days before the event window and is applied to normal returns behavior estimation. This duration gives the number of observations to calculate a stable benchmark and make the estimated returns represent the recent market conditions. Narrowing the estimation window to pre-event observations helps to prevent contamination by the event itself, and is standard when analyzing event studies (MacKinlay, 1997).

The event window explains the time frame within which abnormal returns are taken. The main event window in this analysis is (-1, +1), which will span one trading day prior to the event, the event day, and one trading day following the event. This is a type of window to attract the direct reaction of the market and to restrain the impact of confounding factors that may occur in the long run.

Brown and Warner (1985) support the use of a short event window by demonstrating that event studies using daily data yield reliable findings when small event windows are used. The short windows work especially well when the aim is to capture the direct impact of an event as opposed to market trends.

In order to develop further understanding of the market reaction dynamic, longer windows like (-3, +3) and (-5, +5) are also used. These alternative windows enable the analysis to determine whether the abnormal returns continue to exist after the immediate period and to be able to differentiate between fast and slower adjustments. When abnormal returns are concentrated in the shortest window, it can be concluded that markets are quick at adopting information. In contrast, persistence across extended windows may indicate delayed adjustment or ongoing reassessment of the event’s implications.

It is necessary to mention that the comparatively short event windows, though being useful in isolating short-term market responses, might not be as effective in capturing longer-term impacts of climate events. Consequently, the methodology mainly aims to detect short-term adjustments, but not long-term changes in the asset prices.

4.4 Measurement of Returns and Abnormal Performance

Market returns are computed based on daily closing prices of the NIFTY 50 index, which is used as an indicator of the performance of the market as a whole. Computation of returns is done at a logarithmic transformation to give a consistent representation of percentage changes and the ability to aggregate overtime. Logarithmic returns have attracted extensive financial analysis because of their desirable statistical characteristics, especially in short-horizon analysis.

Constant means return model is used to estimate the expected returns. In this method, the anticipated return is set to be the average observed return in the estimation window. This model gives an easy and clear comparison of how normal market behavior acts and is usually used in event studies that emphasize immediate market responses (MacKinlay, 1997).

The constant mean return specification, however, is a rather simplified form of the specification since it does not directly capture systematic risk factors, market-wide trends or time-varying expected returns. More sophisticated models, e.g. the market model or the Capital Asset Pricing Model (CAPM) of Sharpe (1964) and John Lintner (1965), include these aspects and are said to be more theoretically complete.

Although these benefits exist, empirical studies indicate that in short-horizon event studies, especially those involving daily data with small event windows, the selection of the expected return model has less influence on the estimation of abnormal returns (Brown and Warner, 1985; MacKinlay, 1997; Corrado, 2011; Kothari and Warner, 2007). Such contexts often find more complex specifications yielding results similar to simpler specifications, with no extra estimation noise and parameter uncertainty.

In addition, recent studies of asset pricing reveal that the advantages of multifactor and risk-adjusted models are stronger in the long-term analysis, but less strong in the short-term analysis, where the models are used to describe the short-term price changes (Asness et al., 2019; Nagel, 2012). Since the current research targets on short event window and aggregate market index data, the constant mean return model offers a parsimonious and strong benchmark to increase interpretability without significantly reducing the empirical validity.

Meanwhile, the constant mean return model is not used as an unproblematic one. In order to overcome the possible issues related to the model specification, alternative processes that generate returns are included in the robust analysis. This makes it possible to directly evaluate whether the empirical results are sensitive to the expected return model chosen, which enhances credibility of the findings.

Abnormal return is defined as the difference between actual return and expected return:

$$\boldsymbol{AR_t = R_t - E(R_t)}$$

where $R_t$represents the actual return on day t, and $\bar{R}$represents the expected return based on the estimation window.

Cumulative abnormal returns are calculated by summing abnormal returns over the event window:

$$\boldsymbol{CAR_{(t_1, t_2)} = \sum_{t=t_1}^{t_2} A\,R_t}$$

This measure will capture the aggregate market reaction to every event in the given period. This is especially relevant to the aggregation of abnormal returns into cumulative abnormal returns, since information about the climate might not be fully processed on a single trading day. This methodology makes sure that the measured response indicates the entire process of adjustment and not the daily changes.

4.5 Statistical Testing of Market Reactions

The study uses t-tests to compare cumulative abnormal returns across events to determine the statistical significance of the observed abnormal returns. The null hypothesis is that the mean CAR = 0, which implies that climate events do not produce systematic market responses.

The test statistics are obtained by dividing the average CAR with the standard error of the average CAR. Statistical significance is evaluated in terms of traditional levels of significance. One major finding indicates that the abnormal returns observed are not likely to be due to random variation.

Application of t-tests in event study analysis is not new. Brown and Warner (1985) show that standard statistical processes are dependable in event studies that involve daily data especially when event windows are short. This gives a solid ground on the analysis of statistical significance of the findings.

However, financial return data are often characterized by time-varying volatility, heteroskedasticity, and potential cross-sectional dependence, which may affect statistical inference. Recent studies point out the need to consider such characteristics when doing empirical analysis (Bollerslev et al., 2007). Although the current research is conducted according to the usual event study protocols, these factors justify the careful interpretation of statistical findings and the inclusion of robustness checks.

While statistical significance provides evidence of systematic market reactions, it is also important to consider economic magnitude. The outcome can be statistically significant but economically insignificant or the opposite. This is the reason why both statistical and economic relevance are taken into account in the interpretation of the results of the analysis.

4.6 Regression Framework and Model Specification

Although the event study methodology determines the existence of abnormal returns, it fails to explain why the responses to events vary. To overcome this shortcoming, the research uses cross-sectional regression analysis to test the determinants of accumulated abnormal returns.

The regression model is specified as:

$$\boldsymbol{CAR_i} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1}\textbf{Log Severity}_{\boldsymbol{i}} + \boldsymbol{\beta_2}\textbf{Flood}_{\boldsymbol{i}} + \boldsymbol{\beta_3}\textbf{Storm}_{\boldsymbol{i}} + \boldsymbol{\beta_4}\textbf{Market Volatility}_{\boldsymbol{i}} + \boldsymbol{\beta_5}\textbf{Pre Event Trend}_{\boldsymbol{i}} + \boldsymbol{\epsilon_i}$$

where i indexes individual events. This specification is also directly determined by the variables defined in the process of data construction and presents the main factors that can cause market responses. Log Severity captures the magnitude of the climate event, while Flood and Storm are dummy variables representing event types, with Heatwave serving as the reference category. Market Volatility and Pre-Event Trend offer wider market conditions prior to any given event.

The regression model builds on the analysis by shifting to explanation as opposed to detection. Although the event study can recognize the presence or absence of abnormal returns, the regression model can give us an insight into the mechanisms by which climate events affect market outcomes. Through the correlation of abnormal returns with other characteristics that can be observed, the analysis can determine the circumstances in which there is an enhancement in market responses. In this sense, the regression findings can shed some light on the fact that market responses are mostly influenced by the inherent nature of climate events or the general financial landscape within which events are taking place.

This strategy aligns with recent empirical studies that have focused on the significance of attributing asset price dynamics to underlying economic factors and dispersion in shocks across cross-section (Koijen and Yogo, 2019). These structures emphasize how specific event-related factors as well as general market environment contribute to the development of financial performance.

Nevertheless, it is necessary to note that the explanatory capability of the regression model can be conditioned by the limitations of data, such as the relatively small sample size and possible limitations in measuring variables. Such factors can have an impact on the statistical significance of the estimates and must be considered when interpreting the results.

4.7 Estimation and Inference

Ordinary least squares are used to estimate the regression model, and this is a common method of modelling linear relationships among variables. With a few basic assumptions, OLS leads to unbiased and consistent parameter estimates (Wooldridge, 2016).

Robust standard errors are applied in the estimation to make the statistical inference reliable. Strong standard errors correct any possible heteroskedasticity in the error, which can occur in cross-sectional data because of variations in event characteristics. This heterogeneity is considered so that statistical inference can be valid and that model misspecification is not at work (Petersen, 2009). T-statistics and p-values are used to test the statistical significance of each coefficient, and the F-test is used to test the overall explanatory power of the model.

4.8 Robustness Analysis

Another model to estimate the expected returns is used in order to determine the stability of the results. Besides the constant mean return model, there is an autoregressive AR (1) specification.

AR (1) model enables current returns to be dependent on past returns, and it was used to model potential autocorrelation of the data. By comparing results obtained from the constant mean model and the AR (1) specification, the analysis evaluates whether the findings are sensitive to the choice of expected return model.

It is well understood that robustness analysis is a vital element of empirical financial studies because findings can be dependent on modelling decisions and specifications (Campbell et al., 2018). The study confirms the findings produced by the alternative procedures of producing returns so that the empirical findings are not motivated by the methodological orientation.

The fact that alternative models are incorporated enhances the validity of empirical analysis as it proves that the findings are not reliant on a single modelling specification. The similarity in these specifications increases the trustworthiness of the results and facilitates their generalization. This enhances internal validity of the analysis and makes sure that empirical conclusions are not predetermined by model-specific assumptions.

Even with such robustness checks, it is worth noting that no given model can elaborate all the factors behind the market behavior. These findings must consequently be viewed as data under the adopted empirical system and not absolute findings on all potential market forces.

5 Empirical Results and Discussion

5.1 Introduction

In this chapter, the empirical findings regarding the stock market reaction to extreme climatic events in India are stated and critically reviewed. The analysis has three major components. First, the descriptive statistics will give a summary of how the abnormal returns are distributed and the range of the cumulative returns. Second, event study method is used to test whether statistically significant abnormal returns exist around the occurrence of climate events. Third, regression analysis is also performed to determine the determinants of such abnormal returns, and more specifically the nature of the event and the market conditions at the time.

Other than providing statistical outcomes, this chapter contextualizes the findings in the context of a wider economic and theoretical framework. The discussion connects the empirical findings to the existing literature on climate finance, market efficiency, and investor behavior, and compares other ways to interpret the findings and the degree to which the findings represent underlying economic processes as opposed to methodological or data-related limitations. Special emphasis is placed on the interpretation of statistically insignificant variables and the effect of the existing market conditions on the development of the observed outcomes.

5.2 Descriptive Statistics

Descriptive statistics give the general idea of the distribution of cumulative abnormal returns and the way they respond to extreme climate events. This section introduces the summary statistics of the short event window and supplements the numerical analysis with the visual representation to gain a better idea of the variability of market reactions and the dataset structure.

Table 5. 1: Descriptive Statistics of CAR (-1, +1)

Statistic	Value
Observations	25
Mean	0.0079
Standard Deviation	0.0187
Minimum	-0.0215
Maximum	0.0576

The average cumulative abnormal return of 0.79 per cent indicates that, on average, the stock market has a somewhat positive response in the short period of the event around extreme climatic events. This outcome, however, should be considered with care because they might not be a direct positive reaction to climate shocks but could be a reflection of current market momentum or coexisting macroeconomic conditions at the time of the sample. Instead of reflecting good economic results, the outcome is most probable to be a temporary market response to investor expectations, existing market patterns and market macroeconomic factors during the occurrence of the event.

The standard deviation of 1.87 per cent implies that there is a wide range of abnormal returns in the different events which shows that market reactions are not homogeneous. Such variability implies that the reaction is context-dependent based on the sentiment of investors, the state of the economy and the timing of the event. This observation is further supported by the range between the minimum and maximum values, where there are negative abnormal returns that are related to some of the events and some strong positive responses. These variations suggest that in some instances the overall market conditions or recovery prospects can override the short run effect of climate shock. Meanwhile, some of these variations could be noise in short-term returns data, as opposed to systematic differences in market responses. Since the sample size is small, an individual observation may have a disproportionate impact on summary statistics, restricting the strength of general conclusions based on these patterns.

To better understand this variation, Figure 5.1 presents the distribution of cumulative abnormal returns across all events.

Figure 5. 1: Distribution of Cumulative Abnormal Returns (CAR (-1, +1))

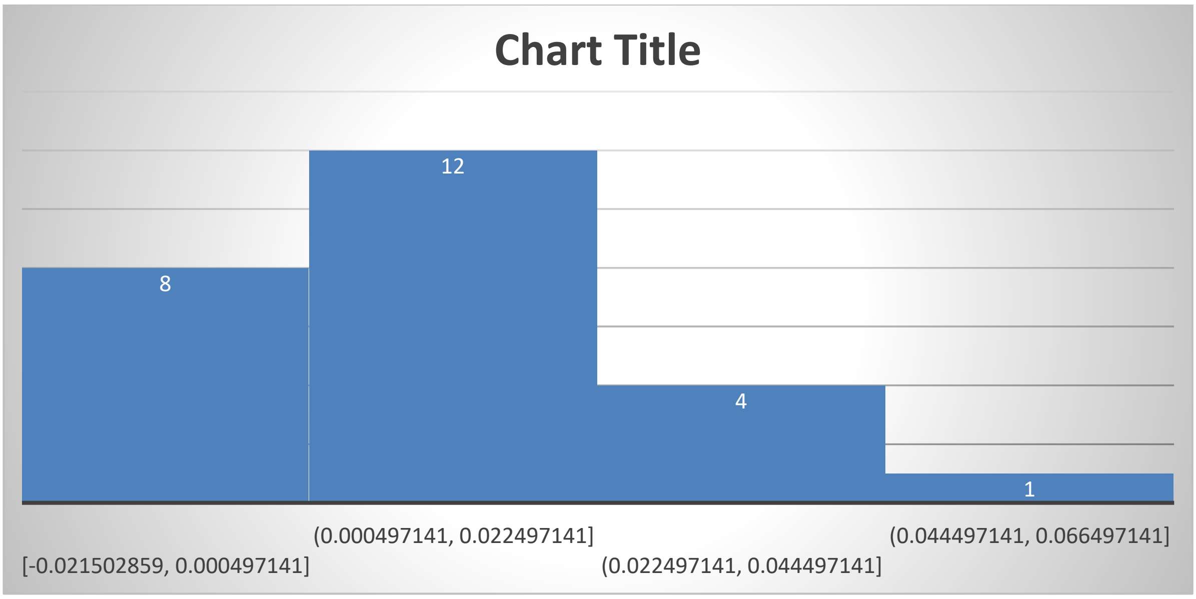


Figure 5.1 demonstrates that the abnormal returns are split between the negative and the positive, indicating the heterogeneity of the market respondence to climate events. This positive mean as indicated in Table 5.1 is heavily influenced by a combination of data concentration around small positive values. Simultaneously, negative abnormal returns are present, which may suggest that the climate events do not always result in positive market reactions.

The distribution is moderately skewed towards positive values. Although this can indicate that the overall market dynamics, including bullish and recovery periods, can occasionally take precedence over immediate negative impacts of climate shocks, it can also indicate sample-specific processes, or when a particular market phase is being experienced at a given time as opposed to systematic process. The distribution dispersion also demonstrates the contribution of uncertainty and volatility, meaning that there are event-specific components and broader market conditions that drive the realized abnormal returns.

In addition to the behavior of abnormal returns, the composition of the dataset is also important. Figure 5.2 presents the distribution of climate event types included in the sample.

Figure 5. 2: Distribution of Climate Event Types

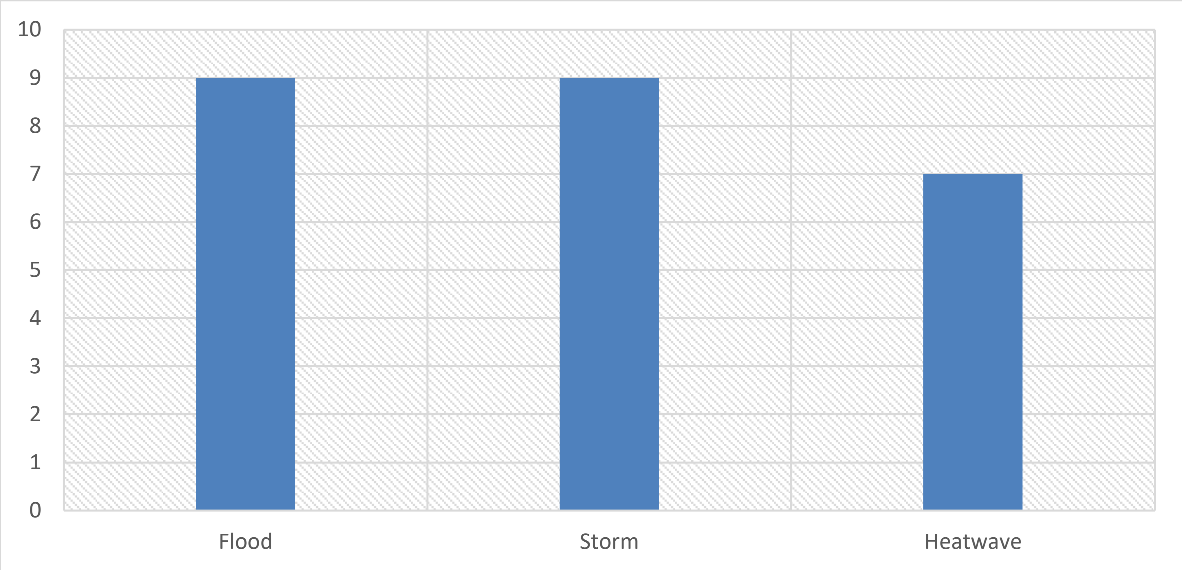


Figure 5.2 demonstrates that in the data set, floods and storms form the majority of the events whereas heatwaves are less common. This distribution is a product of the climatic nature of India in which floods and storms are caused by monsoon patterns and geographical exposure.

However, such an imbalance has significant implications on how the results can be interpreted. The sample is dominated by floods and storms, so the results can be skewed by these types of occurrences. This unequal representation also offers a viable explanation on the insignificance of event type variables in the regression analysis that will be provided later. The fact that there are few observations of some categories implies that it is less able to determine meaningful differences between event types. This also has a possible estimation inaccuracy as the coefficients of the less frequent event categories can be sensitive to few observations and thus inaccurate.

Also, the data used is relevant to real-life climatic conditions, but the imbalance restricts the statistical strength of the analysis. Consequently, certain variations in market reactions to disaster types might escape detection. This is a limitation that should be taken into account in interpreting the empirical results.

Overall, the descriptive statistics indicate that the average market response to climate events is positive but relatively small in magnitude and highly event specific. Nevertheless, such tendencies must be viewed with care, since they can be affected by the composition of the sample, current market conditions, and the time of events and not a stable structural relationship. The presence of dispersion and composition of the dataset indicates that market reactions are dependent on several interacting factors not related to the event itself. These results form a basis of further analysis when the formal statistical techniques will be applied in order to evaluate the relevance of abnormal returns and to study the determinants of market reactions.

5.3 Event Study Results

In the event study analysis, the effect of extreme climate events on the stock market is investigated by determining whether they produce statistically significant abnormal returns. In this part, the occurrence and continuation of market reaction is assessed by quantifying cumulative abnormal returns in various event windows.

Table 5. 2: CAR and Statistical Significance Across Event Windows

Event Window	Mean CAR	T-statistic	P-value	Significance
(-1, +1)	0.0079	2.115	0.0449	Significant
(-3, +3)	0.0067	1.350	0.1890	Not significant
(-5, +5)	0.0052	0.629	0.5350	Not significant

Table 5.2 results indicate that the cumulative abnormal returns are statistically significant only in the short event window (-1, +1) with a p-value of 0.0449, and it is possible to reject the null hypothesis at a 5 per cent level. This means that extreme weather events can be detected to have a short-term effect on the returns of the stock market. This finding,

however, should be viewed with some caution since the level of significance is rather small and can be biased by sample structure or model specification.

This importance, however, decreases with the widening of the event window. The p-values in both (-3, +3) and (-5, +5) windows are greater than the standard significance levels, which shows that abnormal returns are no longer statistically significant compared to zero. This trend indicates that the market reaction is short-term and will not last long after the event ends. Meanwhile, the non-significance in longer windows might also be partly due to the presence of more noise and the fact that more irrelevant information is collected, and the impact of the original event becomes more difficult to isolate. To further illustrate this pattern, Figure 5.3 presents the variation in mean cumulative abnormal returns across the three event windows.

Figure 5. 3: Mean CAR Across Event Windows

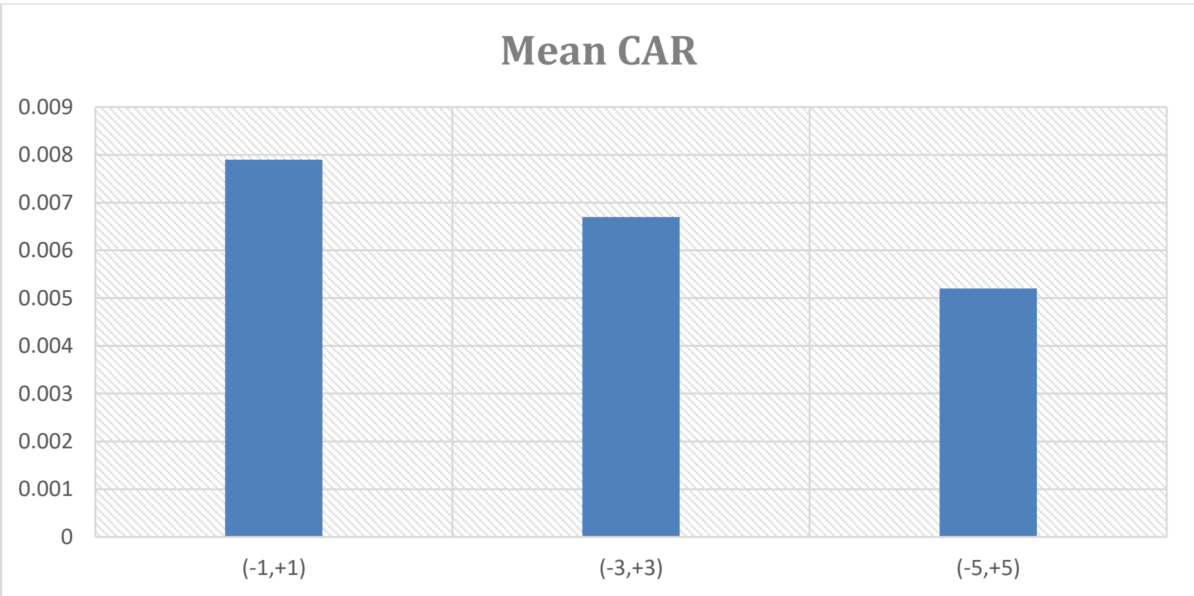


Figure 5.3 indicates that there is an evident decreasing trend in cumulative abnormal returns as the event window expands. The mean CAR is greatest in the immediate three-day window, with steady declines in the seven-day and eleven-day windows. This graphical trend supports the statistical data and proves the fact that market response decreases with time. Nevertheless, with such a small difference in the means values between windows, the economic importance of such a decline must be viewed with reservations.

The decreasing abnormal returns that are observed with longer windows can be attributed to the growing role of new information entering the market. Over time, the initial effect of the climate event will be less relevant in comparison with other macroeconomic and firm specific changes. This causes the event specific effect to be gradually diluted and the cumulative abnormal returns approach zero. But this trend can also be a sign of short-term over-reaction than correction, instead of efficient adjustment, especially in uncertain and information incomplete environments. There are also possibilities that some of the observed adjustment is a result of general market forces and not necessarily related to the event itself.

In terms of market behavior, the existence of statistically significant abnormal returns within the short window shows that investors are prompt in reacting to climate-related information. The lack of significance in the longer windows implies the short-term nature of this reaction, which is widely in line with the semi-strong version of the Efficient Market Hypothesis. Meanwhile, this trend must be taken with a grain of salt. The quick adaptation can also indicate an instance of temporary mispricing under uncertainty where immediate responses are later adjusted as more complete information is revealed. This implies that the behavior observed can be a combination of efficient information processing and overreaction in the short run. Moreover, the fact that the observed effect could be due to general short-term volatility and non-event specific information cannot be completely discounted.

The other significant point is that even at statistical significance, the size of the abnormal returns is relatively small. This shows that market behavior is not affected by climate events in its entirety, even though there is a certain effect on the aggregate index level. This can be partially explained by diversification of the index; however, it is not likely to be the only factor. Another possibility is that counter-sectoral effects balance out, or that the aggregation at the index level conceals more powerful firm or industry-specific responses that are not included in this analysis. This limitation implies that the results cannot be construed as a demonstration of weak underlying effects but is instead a consequence of aggregation.

Moreover, the positive mean cumulative abnormal returns are expected to remain positive in all event windows but should be taken with care. These values do not mean that there are good economic results of climate events. Rather, they probably represent a response of event-related information to the existing market conditions. In other situations, more general market dynamics, possibly bullish momentum or recovery cycles, can overshadow short-term responses, causing positive abnormal returns despite negative shocks. Also, the events could be coincidental with other macroeconomic events that could affect the results observed and thus it would be hard to establish the pure effect of climate shocks. It is then possible that some of the observed trends are due to natural coincidence with the overall market trend instead of a predictable reaction to climate occurrences.

Overall, the findings of the event study suggest that extreme weather events produce a statistically significant, yet short-lived response on the stock market. The impact is focused on the short-term event and is rapidly diffused as additional information is reflected on prices. Although this trend is typical of efficient market behavior, it can also be an indication of a mixture of quick information processing, short term uncertainty and possible corrections of first responses. Meanwhile, the findings cannot be deemed conclusive because of the possible sensitivity to sample size, model, and duplicating market effects. These results emphasize the sensitivity of financial markets to climate-related information as well as the short-lived nature of the effects.

5.4 Regression Analysis

Regression analysis is performed to describe the differences in abnormal returns across events using cumulative abnormal return as a dependent variable. The independent variables are Log Severity, Flood and Storm (event type dummy variables, with Heatwave to provide the baseline category to avoid perfect multicollinearity), and control variables which reflect market conditions, namely Market Volatility and Pre Event Trend. Strong standard errors are taken to guarantee strong statistical inference.

Table 5. 3: Regression Results for CAR (-1, +1)

Variable	Coefficient	Robust SE	t-statistic	P-value
Log Severity	0.0014	0.0043	0.324	0.746
Flood	-0.0011	0.0104	-0.110	0.913
Storm	0.0023	0.0114	0.201	0.841
Market Volatility	0.8598	0.8790	0.978	0.328
Pre Event Trend	-0.0767	0.0384	-1.996	0.0459

Model statistics: R^2 = 0.446, F-test p-value = 0.035

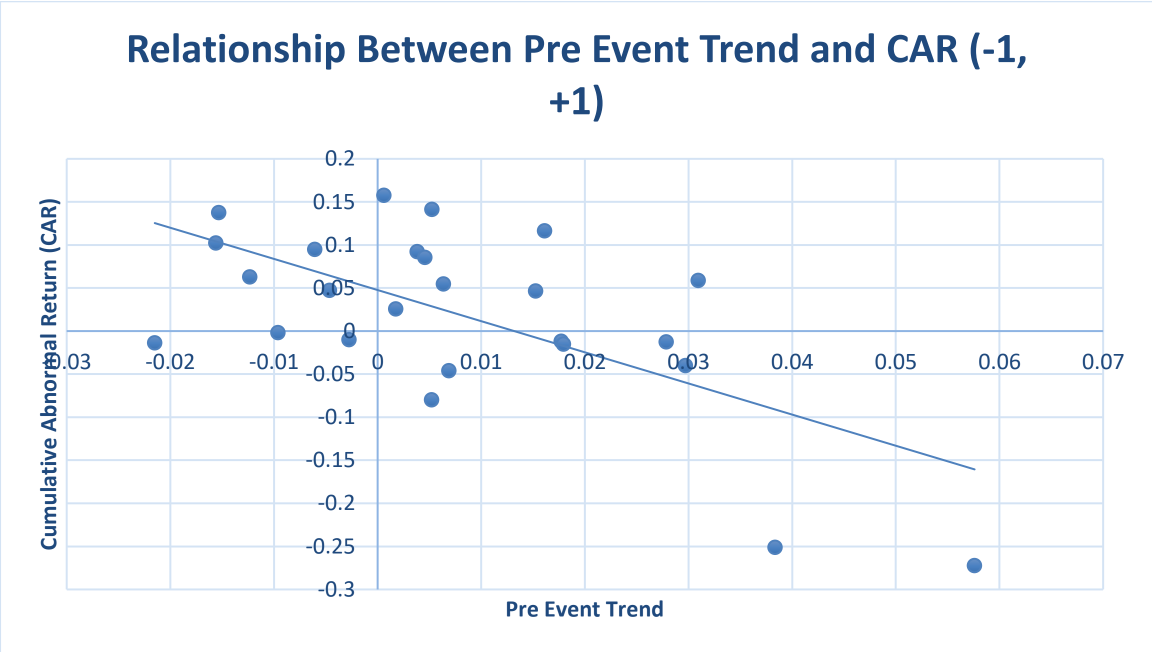
Table 5.3 describes the regression findings of the short event window. The model is statistically significant (F-test p-value = 0.035) and explains about 44.6 per cent of the variation in cumulative abnormal returns. This shows that the chosen variables reflect a significant number of variables affecting the short-term market reactions. This explanatory power, however, should be seen with caution since it might in part indicate a sample-specific variation as opposed to stable relationships.

Pre-event trend is the only variable statistically significant at the 5 per cent level. The negative coefficient indicates that the better performance of the market prior to the event is correlated with lower abnormal returns during the event window, which suggests the reversal effect whereby markets adjust downwards because of positive performance before the event.

This highlights how market context plays out in influencing investor responses. Market performance prior to an event can also result in elevated valuations that can be more sensitive to adverse information or uncertainty. In this instance, a climate event can lead to reviewing risk or profits, leading to reduced abnormal returns. On the other hand, when market conditions are weaker, negative expectations might already be priced in, and thus additional shocks have a diminished marginal impact.

However, this reading must be taken with a grain of salt. The relationship that has been observed might be in part due to the general mean reversion of stock returns, and not necessarily because of the direct interaction between climate events and previous market conditions. Strong performance periods tend to be followed by corrections irrespective of external shock which suggests that the estimated effect may not be solely event dependent. Moreover, it is not possible to rule out potential endogeneity since factors that may influence pre-event conditions cannot go unobserved and might also affect investor responses during the event window. Figure 5.4 illustrates the relationship between pre-event market performance and abnormal returns.

Figure 5. 4: Relationship Between Pre Event Trend and CAR (-1, +1)



As illustrated in Figure 5.4, it is evident that there is a downward sloping relationship between pre-event market performance and abnormal returns. This confirms the findings of the regression, as well as supports the existence of a reversal pattern, but does not prove causality.

The economic magnitude of this effect is meaningful. The estimated coefficient suggests that a ten per cent increase in cumulative returns in the pre-event period is associated with a decline in abnormal returns in the event window of approximately 0.77 per cent. This is a non-trivial adjustment, which suggests both statistical and economic significance. This magnitude, however, must be taken with some caution, since it can be sensitive to outliers or to particular observations in a relatively small sample.

In contrast, variables capturing disaster characteristics, including Log Severity, Flood, and Storm, are not statistically significant. It is taken at face value to imply that the market does not differentiate systematically between events at the aggregate index level, but rather in terms of severity or type. This, however, would be too simplistic to attribute this to index diversification alone, and a number of other alternative explanations are to be considered.

First, there might be information constraints involved. During the immediate aftermath of a climate event, the actual information on the economic impact of a climate event is sometimes incomplete or delayed. Consequently, investors will respond more to the fact that the event took place and the nature of the event, than they would respond to the level of severity and type of event that took place.

Second, the explanatory power of the severity variable may be weakened due to measurement problems. When the failure of Log Severity to capture the market-relevant impact of an event is not well addressed by the lack of significance, the lack of significance may be due to the inadequacy of the proxy in capturing the market-relevant impact of an occurrence.

Third, index-level aggregation can potentially hide heterogeneous effects across sectors and firms. Some industries might be affected significantly but others might not be affected at all and the effects may offset and this reduces statistical significance in the aggregate measures.

Fourth, the sample size used is relatively small and this can potentially diminish the statistical power of the study as it becomes harder to determine significant relationships. This is especially so when one has a number of explanatory variables. Also, there is a chance that the coefficients of less frequent types of events may be imprecisely estimated and sensitive to a small sample. All these factors put together indicate that the lack of statistical significance is not to be perceived as a sign of no economic impact, but as a limitation of measurement, aggregation and data constraints.

Similarly, Market Volatility does not show a statistically significant effect. This indicates that the conditions of volatility in the short term prior to the occurrence do not explain abnormal returns independently. This should, however, be taken with some caution because volatility can interact with the other variables, which may not be fully reflected in the model, and its impact can be absorbed elsewhere.

Overall, these findings suggest that market reactions in the short term are determined more by the existing market conditions than by the particularities of the climate event. But this conclusion must be understood with great caution, as it serves perhaps to indicate a lack of measurement and aggregation and not necessarily the lack of event-specific effects. This highlights the significance of wider market forces in examining financial effects of environmental shocks.

To assess whether these relationships persist over longer horizons, the regression analysis is extended to broader event windows.

Table 5. 4: Regression Results for CAR (-3, +3)

Variable	Coefficient	Robust SE	t-statistic	P-value
Log_Severity	0.0079	0.0102	0.774	0.438
Flood	0.0095	0.0175	0.544	0.587
Storm	0.0183	0.0291	0.628	0.530
Market_Volatility	0.1187	3.1713	0.037	0.970
Pre_Event_Trend	-0.1469	0.0927	-1.585	0.113

Model statistics: R^2 = 0.339, F-test p-value = 0.714

Table 5. 5: Regression Results for CAR (-5, +5)

Variable	Coefficient	Robust SE	t-statistic	P-value
Log_Severity	0.0047	0.0082	0.570	0.569
Flood	-0.0046	0.0172	-0.267	0.790
Storm	0.0089	0.0251	0.356	0.722
Market_Volatility	3.4250	2.7328	1.253	0.210
Pre_Event_Trend	-0.0754	0.0981	-0.769	0.442

Model statistics: R^2 = 0.421, F-test p-value = 0.609

The results of extended event windows reveal that the models no longer have statistically significant values. The F-test p-values are greater than the conventional values and none of the explanatory variables have significant values indicating that the explanatory power is limited to the immediate events window.

This lack of significance is also in line with the event study results and in support of the fact that the effect of climate events is short-lived. The larger the time window, the greater the significance of other macroeconomic and firm specific factors, and hence the less relative impact the original event has.

Meanwhile, the lack of significance can be the sign of more noise as more information and irrelevant market dynamics appear. This complicates the ability to isolate the effect of the original event and weaken the explanatory power of the model. It can also indicate that the model is more appropriate in capturing short-term relationships than longer-horizon relationships.

Overall, the regression analysis indicates that even though climate events do produce short-term market responses, such responses are not mainly due to the magnitude or type of the event. Rather, they are mostly affected by the general market trends, especially those before the event. However, this conclusion should be interpreted with caution due to potential limitations related to sample size, measurement, and model specification. These results not only demonstrate the significance of more general market forces in influencing investor responses, and it also suggests that market behavior is influenced by climate-related shocks, but not by them alone.

5.5 Robustness and Model Validity

The main model applied to estimate expected returns in this research is the constant mean return model. This method is suitable since the market-index level of analysis is where a classical market model might not be appropriate. In order to evaluate the strength of the results, an alternative AR (1) autoregressive model is also applied. The consistency of the results under these specifications is used to consider whether the findings are sensitive to the selection of expected return model.

Moreover, a number of diagnostic and robustness tests are undertaken so that model specification or statistical bias do not drive the empirical results. These are multicollinearity tests and the use of the alternative model specification.

Table 5. 6: Variance Inflation Factor (VIF)

Variables	**VIF Values**
Log Severity	2.03
Flood	1.86
Storm	1.86
Market Volatility	3.02
Pre Event Trend	2.89

The Variance Inflation Factor (VIF) is a measure that is used to determine whether multicollinearity exists between the independent variables. Multicollinearity at a high level may illustrate the coefficient estimates and decrease the accuracy of statistical inference. An agreed upon level is that VIF values greater than 5 can indicate a problematic multicollinearity.

Table 5.6 results indicate that all values of VIF are much lower than this value, with the largest value of VIF being 3.02, which corresponds to Market Volatility. This implies that multicollinearity is not a major problem in the regression equation and that the regression coefficients are not very volatile and inconvenient to explain. Nevertheless, the lack of high values of VIF is not a complete method of ruling out the possibility of weaker forms of correlation influencing coefficient estimates, especially in a small sample context.

Though the correlation between Market Volatility and Pre-Event Trend is found to be negative in the correlation matrix, the relationship is not translated to problematic multicollinearity in the regression framework. This implies that the two variables represent two different aspects of market conditions, i.e. market uncertainty and prior performance, although there is some level of interaction between the two factors that cannot be fully ruled out.

Figure 5. 5: Multicollinearity Assessment (VIF Values)

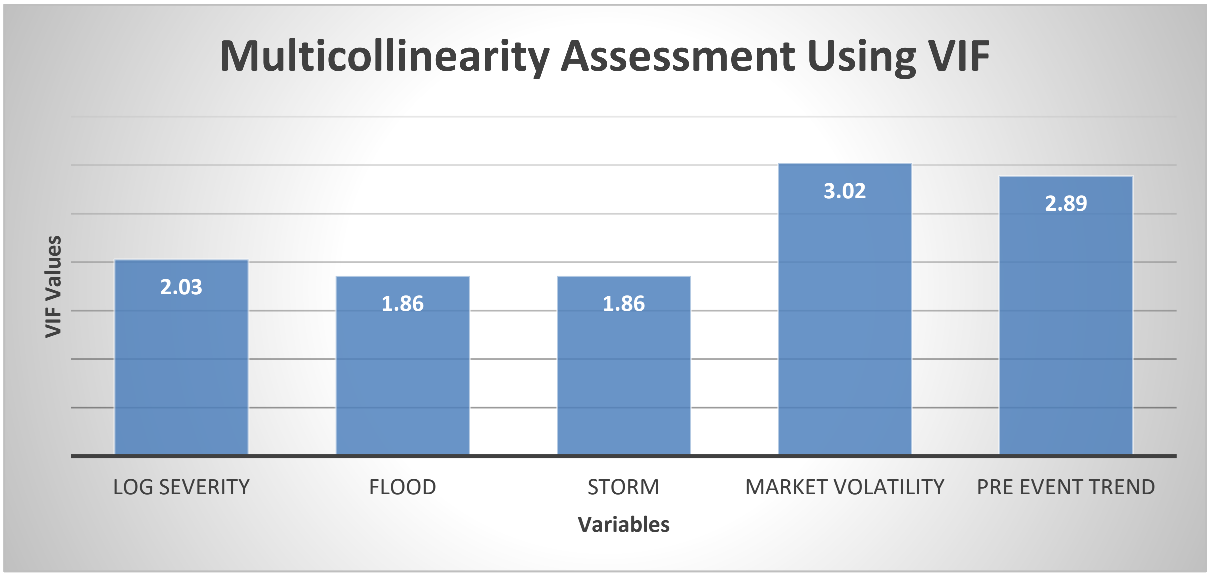


Figure 5.5 gives a visual validation of the VIF results. All the variables are within acceptable limits, which supports the conclusion that the regression model is not susceptible to instability because of correlated predictors.

In addition to multicollinearity diagnostics, an alternative expected return model is also used to measure robustness. In particular, an autoregressive AR (1) specification is used as an alternative to the constant mean return model of estimating abnormal returns.

The findings of the alternative specification agree with the key results. Specifically, the statistical significance of the short-term event window and the significance of pre-event market conditions do not change. This stability motivates the belief that the findings are not predetermined by a certain model selection. Simultaneously, the non-use of additional alternative specification restricts the scope of the establishment of full robustness since other forms of models can have different sensitivities.

Nevertheless, although these robustness tests contribute to the stability of the results, they do not remove all possible limitations. The small size of the sample might limit statistical power, and it may be harder to find significant relationships when they exist. Moreover, simplified models, e.g., constant mean return and AR (1) specifications, may not be sufficient to fully represent all underlying market dynamics, especially in the presence of structural breaks or time-varying volatility. Alternatively, it is also possible that model assumptions, including linearity and stationarity, do not fully apply to the situation of extreme events.

Overall, the robustness tests make the main conclusions not so sensitive to the model specification or the problem of multicollinearity. Meanwhile, the extent of the robustness analysis is limited, and the findings should be viewed as indicative, but not fully conclusive. The consideration of these limitations gives a more moderate read of the same and points to areas that can be refined in subsequent studies.

5.6 Discussion of Findings

This section explains the empirical findings by relating it to the theoretical framework, and more broadly, the economic rationale, with a specific focus on the mechanisms through which extreme climate events affect stock market behavior.

The results show that the stock market reactions to extreme weather episodes are highly concentrated over a limited period of time. The reaction observed can be viewed as an immediate adjustment to the expectations of the investors in the event of new information coming in. This effect does not, however, extend beyond the initial event window and this indicates that the adjustment is quickly internalized and does not translate into more permanent deviations in asset prices. Simultaneously, this trend can be partially explained by the lack of possibilities to isolate event-specific effects over longer horizons as more information and market noise are collected.

This trend is widely in line with the semi-strong version of the Efficient Market Hypothesis, which holds that the publicly available information is promptly updated in the price of assets. Extreme climate events bring some level of uncertainty regarding economic activity, firm performance and any form of disruption that may arise, causing a rapid response in the market. The first effect disappears as more information becomes available and uncertainty is lessened and the broad market forces start dominating price changes. In this sense, climate events can be construed as one-time information shock and not the cause of enduring market trends. This interpretation, however, assumes that the observed abnormal returns can be entirely ascribed to the event per se, which is not necessarily the case in practice.

Meanwhile, this interpretation cannot be regarded as the indication of perfectly efficient pricing. Short term response can also be a case of initial overreaction or adjustment in response to uncertainty followed by a correction as more accurate information becomes available. This implies that the observed trend is probably due to both quick information processing and short-term behavioral response, and not necessarily just frictionless market efficiency. There is also the possibility that some of the initial responses are a redirection or an emotional response and not necessarily a re-evaluation of economic value.

These results are in line with the available literature on climate finance. As an example, Schuster and Lueg (2026) demonstrate that the market reaction to climate events is temporary and is largely influenced by short term uncertainty and investor attention. Similarly, prior studies have found that aggregate market indices tend to be less sensitive to geographically localized shocks, which helps explain the lack of significance of disaster severity and event type in the present study. This finding, however, can be different to those studies that find stronger sector level or firm level effects, implying that the use of aggregate indices in this analysis may be hiding more localized or heterogeneous effects.

One of the main findings of this analysis is that the nature and the severity of disasters per se does not play a significant role in shaping the market responses at the aggregate level. This implies that investors do not engage in systematic differentiation of events as per their characteristics in establishing short term expectations. Instead, the occurrence of an unexpected event appears sufficient to trigger a market reaction. Nevertheless, such an interpretation can exaggerate the importance of the event's occurrence itself when measurement constraints do not allow one to distinguish event specific effects.

This discovery, however, must be interpreted very carefully. Lack of statistical significance does not always mean that the features of disasters are unimportant. One reason is that in the immediate aftermath of an event, detailed and reliable information regarding its economic impacts may not be all available. Consequently, investors can use general indicators of disturbance, instead of specific indicators of magnitude.

Furthermore, the application of an aggregate market index can obscure the fact that there are heterogeneous effects across sectors and firms. Whereas some industries can be quite sensitive to certain forms of climate events, other industries can be rather resilient, or even find a positive response, leading to counterbalancing effects that diminish observable significance at the aggregate level. Inaccuracies in measurement in the severity variable and the fact that the sample size is relatively small may also be a cause of the inability to achieve a statistically significant result. This view is in line with firm level evidence that climate risk is manifested in the returns to investment, which may suggest that aggregate market analysis can hide underlying heterogeneous effects across firms and sectors (Song, 2025). So, there is a possibility that the lack of significance is not indicative of the data and model limitations but rather indicative of the absence of economically significant effects.

The most significant finding of this research is that the pre-event market conditions determine the investor responses. The negative correlation between previous market performance and abnormal returns suggests that the impact of climate events is conditional on the current market conditions.

Asset valuations can be relatively high with optimistic investor expectations when markets have performed strongly in the lead-up to an event. When such situations occur, the negative or uncertain information coming in may cause reassessment of risk, with the negative adjustment in returns being stronger. On the other hand, when market conditions are already weak, expectations can be lowered and much of the negative information can already be reflected in prices resulting in a more muted reaction.

Nevertheless, this association cannot be understood in terms of a strictly causal relationship. The reversal pattern witnessed might in part be due to general mean reversal in financial markets, where episodes of good performance are followed by corrections independent of external shocks. The estimated effect, in this case, might reflect wider market forces, instead of the direct interplay between climate events and preliminary conditions. Furthermore, the possible endogeneity and missing variables can affect both the pre-event trends and the investor reactions and therefore the ability to make definite causal conclusions.

This trend shows a conditional reaction to the market where the same exogenous shock will yield different responses depending on the initial market condition. It implies that the responses of investors are determined not only by the new information but also the interplay of the new information and the prior expectations and feelings of the investors. In this respect, climate events are more like amplifiers or moderators of the existing market forces than drivers of price changes.

This economic importance of the relationship is high, since it shows that relatively small changes in the conditions of the previous market can lead to significant changes in the abnormal returns. This makes it clear why it is important to consider the broader market context when assessing the financial consequences of external shocks. Simultaneously, the estimated magnitude is to be viewed with a grain of salt as the sample size used is too small and the magnitude may be sensitive to certain observations.

These findings are directly related to the hypotheses of the study. The initial hypothesis is accepted since the existence of statistically significant abnormal returns in the short event window confirms that extreme climate events have immediate market responses. But the second and third hypotheses are rejected as the event type and severity are not found to be statistically significant. This result must be taken within the context of the limitations mentioned and not as conclusive evidence to dismiss the relevance of event characteristics.

In the behavioral perspective, the findings indicate that both information processing and sentiment affect the decision making of investors. Investors can also be more receptive to negative signals during strong market performance periods, resulting in more abrupt adjustments. Conversely, when market conditions are weaker, expectations can already be pessimistic, and as a result, the responses to any more shocks will be less pronounced.

This asymmetry implies that market reactions are not necessarily solely mechanical but rather depend on the interpretation of information in a particular context. It also facilitates the argument that financial markets bring together both rational and behavioral factors, especially during a response to a complex and uncertain event such as climate-related shocks. This has a significant implication for the investors and policymakers as it implies that the financial effects of the shocks caused by climate conditions are determined by more than just the occurrence of the shock.

Overall, the results reveal that extreme climate events impact stock market behavior mostly due to short-term adjustments and their interaction with the existing market conditions. The lack of such information in the long run demonstrates that markets are not very inefficient in processing such information, and importance of pre-event trends helps to underline the role of broader economic conditions in shaping the effect of such information in the market. These findings, however, must be viewed with some caution as they may in part be the result of data limitations, aggregation effects, and model constraints. The results are consistent with the explanation that climate-related shocks are catalysts in the context of existing market dynamics, rather than independent determinants of price movements.

5.7 Limitations of the Study

It is noted that this study offers significant information into short-term stock market reactions to extreme climate events, but it has several limitations that need to be considered when interpreting the results.

First, the statistical power of the analysis is limited by the relatively small size of the sample of 25 events. When the number of observations is small, it becomes less able to identify significant relationships, especially when dealing with event specific variables like severity and type. This raises the probability that economically meaningful effects might not be found to be statistically significant, particularly in the regression framework where there is a large number of explanatory variables.

Second, when an aggregate market index is used, this can mask the heterogeneous effects on sectors and firms. Although the index level method is suitable in the sense that it can be used to capture overall behavior in the market, it might also hide higher local effects. Some industries may be overrepresented in the impact of certain kinds of climate events or may be underserved by reconstruction activity or changes in demand. Such counter-acting influences may diminish evident importance at the aggregate stage, preventing the determination of differentiated reactions.

Third, the fact that the severity of events is measured is a significant limitation. The proxy applied in this study might not necessarily reflect the actual economic impact of climate events, especially in terms of infrastructure damage, regional exposure, or even supply chain disruptions. Consequently, the non-statistical significance of severity may be due to the measurement limitations and not the lack of significant economic connection.
Fourth, there is some imbalance in the types of events in the dataset, with floods and storms represented by the largest number of observations and heatwaves underrepresented. Such imbalanced distribution can bias the results and decrease the reliability of estimates regarding low frequency categories of events. Specifically, coefficients of underrepresented event types can be poorly estimated and vulnerable to a few observations.

Fifth, the event study methodology is based on the following assumptions: events are independent and that no confounding information affects returns inside the event window. Practically this assumption might not be completely true. Other macroeconomic news or specific news of the company might coincide with the timing of any climate event, making it hard to isolate the pure effect of the event on stock returns.

Sixth, the analysis is only short-term based on market responses and does not reflect any potential long-term impacts of climate events. The economic impact of such events could manifest over a longer period, especially through structural adjustments, response of policies, or change in investor expectations, which are not captured in the current framework.

Finally, potential endogeneity and omitted variable bias cannot be entirely ruled out. Event pre-market conditions (e.g. pre-event trends) can be subjected to alterations that also affect the investor reactions during the event window. The causal meaning of certain relationships can only be restricted unless a more sophisticated identification strategy is employed.

A combination of these restrictions implies that the findings are to be treated with care. Although the findings are useful in providing evidence on the short-term market dynamics, it also highlights the necessity of more specific data, larger samples, and alternative empirical methods in future research to better illustrate the complexity of financial responses to climate-related shocks.

5.8 Conclusion

In this chapter, the stock market response to extreme weather events in India was analyzed based on an event study and regression design. Instead of rephrasing the individual findings, this section shows the main implications of the findings and their contribution to the understanding of how financial markets react to environmental shocks.

The findings reveal that extreme climate events influence the stock market's behavior mostly in the short term. The fact that abnormal returns exist in the short-term event window confirms that investors are fast in reacting to new information. Nevertheless, the fact that such effects are not significant in longer windows indicates that the effect is momentary and dims out as more information gets into the market. Although such a trend is widely consistent with the opinion that markets are efficient incorporators of publicly available information, it can also be an indication of short-term adjustment dynamics that are not entirely motivated by fundamental changes in valuation.

It is further revealed in the analysis that the nature and severity of events is not significant in explanations of variations in abnormal returns at the aggregate level. This implies that market responses are influenced more by the fact that the shock has occurred as opposed to its nature. This must however be taken with a pinch of salt because it could be an indicator of either the use of a broad market index that hides sectoral differences, or limited availability of information and measurement constraints.

Among the most important contributions of this research is that the identification of pre-event market conditions as a determinant of investor responses was made. The results indicate that market performance in the past is a key influencer of response to climate-related shocks, which, in turn, implies that the effects of the former are contingent on the overall market environment in which external shocks interact with the existing dynamics. Simultaneously, such a relationship can partially be a reflection of more general behavior like mean reversion, which should be taken into account when interpreting the results.

From the theoretical perspective, the findings are generally in line with the Efficient Market Hypothesis, although also suggest the inclusion of behavioral factors. The quick adjustment of the prices is a manifestation of efficient information processing and the impact of the previous market conditions on the determination of the market reactions is significant.

Overall, this research paper will be added into the literature since it will be an empirical study of the short-term stock market response to extreme climate events in an emerging market environment. It also emphasizes the significance of looking at market conditions in the assessment of the financial effects of environmental shocks and points to the need to look cautiously at the interpretation of the financial impacts of environmental shocks given the limitations on data and methods.

6 Conclusion

6.1 Summary of the Study

This paper explored the short-run stock market reactions to extreme climatic conditions and specifically in the case of the Indian stock market as a typical emerging economy. The study was motivated by the growing economic and financial importance of climate-related risks, especially physical risks related to extreme events like floods, storms, and heatwaves. Although there has been a growing literature that has discussed the exposure to the long-term climate risks, there has been a relative dearth of literature that has discussed short-term market response to sudden and unexpected climate shocks, particularly in the context of emerging markets.

To fill this gap, the research followed a systematic empirical research design that involves both the event study research design and the cross-sectional regression analysis. The event study design was applied to determine whether extreme climate events do cause abnormal stock market returns during specific event windows, and the regression analysis examined the degree to which variation of these abnormal returns can be explained by specific event properties and general market conditions.

The empirical analysis was based on a dataset of 25 extreme climate events in India over the period 2015 to 2025. The returns were calculated using daily market data of the NIFTY 50 index, and cumulative abnormal returns were computed across various event windows, with the main focus on the (-1, +1) window to capture immediate market reactions. Additional windows (-3, +3) and (-5, +5) were included to assess the persistence of market responses over time.

The cumulative abnormal returns were modeled using regression analysis as a factor of event-related variables as well as market conditions. The characteristics of events were measured in terms of severity, and the type of event and broader market dynamics were represented by the market volatility and the pre-event market trends. This integrated structure enabled the study not only to identify the presence of abnormal returns but also the relative significance of various elements in determining market responses.

Overall, the study was planned to be able to provide comprehensive and context-specific analysis of short-term stock market reactions to extreme climate events, combining the results of the event study methodology, asset pricing theory and behavioral finance.

6.2 Main Findings

The empirical findings give a belief that extreme weather events create a statistically significant short-term response in the stock market. The event study analysis indicates that cumulative abnormal returns in the near event window (-1, +1) are statistically significant at the 5 per cent level, which means that financial markets react to climate-related information, once it is available. Nevertheless, this degree of significance is quite peripheral and is to be taken with reservations.

This effect is not persistent. The results of the extended event windows (-3, +3) and (-5, +5) do not show any statistical significance, indicating that abnormal returns dissipate rapidly over time. This trend points to the fact that the influence of climatic events is limited within a short time interval and that the market is quick to assimilate the effects of climatic events and to adapt to them. Meanwhile, the non-significance of longer windows can also be partly due to the growing contribution of irrelevant market movements to the effect of the initial event.

The abnormal returns are not that big in terms of economic magnitude. Though statistically significant, the average cumulative abnormal return is low, which means that the total market effect of extreme climate events is not high. This could be indicative of diversification in the market index, and counterbalancing effects across industries.

One of the main conclusions of the regression analysis is that the pre-event market conditions are central to stock market responses. The only statistically significant determinant of cumulative abnormal returns is the Pre Event Trend variable, and the coefficient is negative indicating the reversal effect. This suggests that a higher market performance before an event is correlated with smaller abnormal returns after the event. This relationship, however, should not be understood as strictly causal, and may partially reflect some larger market effects, such as mean reversion.

In contrast, event-specific variables such as severity and event type are not statistically significant. This implies that, at the aggregate market, investors do not systematically distinguish between events based on their characteristics in the short term. It must be taken with a grain of salt though as it might be caused by measurement limitations, aggregation effects, and information constraints instead of the lack of economic relevance.

Overall, the findings indicate that short-term market reactions to extreme climate events are driven more by broader market conditions than by the intrinsic characteristics of the events themselves.

6.3 Theoretical Implications

The findings present valuable data on the manner in which financial markets process information on climate change. The fact that there are statistically significant abnormal returns in the immediate event window is consistent with the semi-strong form of the Efficient Market Hypothesis, which predicts that publicly available information is quickly incorporated into the prices of assets.

Simultaneously, the fact that the observed effect is temporary makes it possible that the reaction of the stock market can also be regarded as an overreaction in the short term, followed by a correction. The fact that the significance of the responses across extended event windows decreases significantly, points to the fact that the initial responses might be affected by uncertainty, lack of information or behavioral factors, which are subsequently dispelled as more accurate information becomes available.

The results also emphasize the significance of market context that cannot be described in the traditional structures of event studies. The importance of the pre-event market trends implies that the abnormal returns cannot be determined exclusively by the event itself but dependent on how new information interacts with the existing market conditions. This means that the efficiency of the market would be perceived as conditional as opposed to absolute, especially in a market that is full of uncertainty and heterogeneous expectations.

6.4 Practical Implications

This research has various implications for investors, policymakers, and researchers. The findings are that extreme weather events have short-term market responses, but they are not sustained in the long term. This implies that trading rules that are solely dependent on the frequency of such events are not likely to generate long-term abnormal returns. Rather, more weight should be given to broader market conditions, which are more important in determining the short-run price dynamics.

The findings indicate to policymakers and regulators that financial markets are not only responsive to climate-related shocks but also, capable of absorbing those shocks relatively fast. Although this is a pointer to a certain level of market resilience, the fact that this is accompanied by short-term reactions is an indicator of the critical role of timely and transparent information in reducing uncertainty and assisting in the efficient adjustment of prices.

In the view of researchers, the conclusions demonstrate the significance of including market conditions in the study of the impact of climate on financial risk analyses. Research which concentrates solely on the nature of events might ignore major causes of market action, at least in the short run. Further studies ought to be based on newer and more comprehensive frameworks that consider both event-specific and market-wide factors.

6.5 Directions for Future Research

Based on the results of the empirical research, it is possible to outline several directions of further research. Further research may increase the sample size and the types of climate events in different areas to enhance statistical power and generalizability. A bigger data set would enable us to better estimate relationships and better evaluate event-specific effects.

Moreover, it would be possible to perform a more detailed analysis of heterogeneous impacts which could not be observed at the aggregate market level. This would assist in determining the reaction of various industries to certain kinds of weather occurrences.

Further research could also develop more refined measures of event severity that better capture the economic and financial consequences of climate shocks. Adding alternative data sets, like damage estimates or local exposure predictors, can enhance explanatory power of empirical models.

Finally, the analysis would have been useful to provide information on whether the impacts of climate events are long-lasting beyond the short run. This would assist in deciding whether such events result in structural adjustments in asset prices and investor behavior in the long run.

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APPENDICES

Appendix A: Climate Event Dataset

Table A1 details the final sample of extreme climate events in India.

Event ID	Date	Type	Location	Severity	Source
2015-0189-IND	2015	Heatwave	India	2248.0	EM-DAT
2015-0317-IND	2015	Flood	India	293.0	EM-DAT
2015-0504-IND	2015	Flood	India	325.16	EM-DAT
2016-0133-IND	2016	Heatwave	India	300.0	EM-DAT
2016-0485-IND	2016	Storm	India	24.07	EM-DAT
2017-0144-IND	2017	Heatwave	India	264.0	EM-DAT
2017-0342-IND	2017	Flood	India	514.12	EM-DAT
2017-0508-IND	2017	Storm	India	884.0	EM-DAT
2018-0295-IND	2018	Flood	India	504.21	EM-DAT
2018-0385-IND	2018	Storm	India	85.07	EM-DAT
2018-0431-IND	2018	Storm	India	45.06	EM-DAT
2019-0164-IND	2019	Storm	India	50.13	EM-DAT
2019-0217-IND	2019	Heatwave	India	90.0	EM-DAT
2019-0331-IND	2019	Flood	India	1900.74	EM-DAT
2020-0211-IND	2020	Storm	India	91.0	EM-DAT
2020-0304-IND	2020	Flood	India	1922.56	EM-DAT
2021-0252-IND	2021	Storm	India	198.1	EM-DAT
2021-0435-IND	2021	Flood	India	1282.23	EM-DAT
2022-0248-IND	2022	Heatwave	India	25.0	EM-DAT
2022-0293-IND	2022	Flood	India	2035.31	EM-DAT
2023-0328-IND	2023	Heatwave	India	179.0	EM-DAT
2023-0428-IND	2023	Flood	India	1529.0	EM-DAT
2023-0792-IND	2023	Storm	India	20.01	EM-DAT
2024-0246-IND	2024	Heatwave	India	733.0	EM-DAT
2024-0320-IND	2024	Storm	India	51.0	EM-DAT

Appendix B: Variable Definitions

Definitions and calculation methods for all variables utilized in the regression models.

Variable	Definition	Calculation Method	Data Source
CAR	Cumulative Abnormal Return	Sum of daily abnormal returns	BSE/NSE
Log Severity	Normalized impact score	LN (Severity + 1)	EM-DAT
Flood	Flood indicator	Binary Dummy (1=Yes)	EM-DAT
Storm	Storm indicator	Binary Dummy (1=Yes)	EM-DAT
Heatwave	Reference category	Baseline (0/0)	EM-DAT
Market Vol.	Pre-event market risk	Std dev of Nifty 50 (110-day)	BSE/NSE
Pre Trend	Macroeconomic momentum	Cumulative log return (110-day)	BSE/NSE

Appendix C: Event-Level Results

Cumulative Abnormal Returns (CAR) calculated for each individual event across all windows.

Event ID	CAR (-1,+1) %	CAR (-3,+3) %	CAR (-5,+5) %
2015-0189-IND	0.69%	2.05%	2.98%
2015-0317-IND	1.77%	3.32%	1.55%
2015-0504-IND	-2.15%	-3.69%	-2.74%
2016-0133-IND	0.52%	0.49%	-1.3%
2016-0485-IND	-0.28%	0.19%	0.31%
2017-0144-IND	-0.46%	-2.01%	-1.58%
2017-0342-IND	-1.53%	-2.41%	-4.0%
2017-0508-IND	-1.24%	-2.38%	-1.28%
2018-0295-IND	0.63%	0.39%	0.47%
2018-0385-IND	1.52%	2.27%	-5.71%
2018-0431-IND	1.79%	1.21%	0.43%
2019-0164-IND	-1.56%	-3.1%	-3.61%
2019-0217-IND	0.38%	-1.07%	0.1%
2019-0331-IND	0.45%	-0.19%	-4.87%
2020-0211-IND	3.84%	0.33%	5.63%
2020-0304-IND	5.76%	12.22%	13.72%
2021-0252-IND	0.06%	0.39%	2.18%
2021-0435-IND	0.52%	1.49%	2.1%
2022-0248-IND	-0.96%	-7.28%	-5.12%
2022-0293-IND	2.97%	0.86%	-0.69%
2023-0328-IND	2.78%	3.77%	4.34%
2023-0428-IND	0.18%	1.79%	2.69%
2023-0792-IND	3.09%	3.88%	4.88%
2024-0246-IND	1.61%	0.32%	0.08%
2024-0320-IND	-0.61%	-0.79%	2.54%

Appendix D: Event Study Summary

One-sample t-tests determining the statistical significance of mean CARs.

Event Window	Mean CAR	T-Statistic	P-Value	Significance
CAR(-1,+1)	0.0079	2.116	0.0449	Significant (p<0.05)
CAR(-3,+3)	0.0048	0.687	0.4984	Not Significant
CAR(-5,+5)	0.0052	0.629	0.5352	Not Significant

Appendix E: Full Regression Output

Ordinary Least Squares (OLS) regression outputs (HC3 robust standard errors).

Table E1: Regression Model CAR (-1, +1)

Model Statistics: R^2 = 0.446 | Adj R^2 = 0.301 | F-statistic = 3.040 | Prob (F) = 0.035

Variable	Coefficient	Robust SE	t-Statistic	P-Value
Intercept	-0.0073	0.0253	-0.290	0.771
Log Severity	0.0014	0.0043	0.324	0.746
Flood	-0.0011	0.0104	-0.109	0.912
Storm	0.0023	0.0114	0.201	0.840
Market Vol	0.8598	0.8790	0.978	0.328
Pre Event Trend	-0.0767*	0.0384	-1.996	0.045

Table E2: Regression Model CAR (-3, +3)

Model Statistics: R^2 = 0.339 | Adj R^2 = 0.166 | F-statistic = 0.581 | Prob (F) = 0.714

Variable	Coefficient	Robust SE	t-Statistic	P-Value
Intercept	-0.0475	0.0649	-0.732	0.463
Log Severity	0.0079	0.0102	0.774	0.438
Flood	0.0095	0.0175	0.543	0.586
Storm	0.0183	0.0291	0.628	0.529
Market Vol	0.1186	3.1712	0.037	0.970
Pre Event Trend	-0.1469	0.0927	-1.584	0.113

Table E3: Regression Model CAR (-5, +5)

Model Statistics: R^2 = 0.421 | Adj R^2 = 0.268 | F-statistic = 0.730 | Prob (F) = 0.609

Variable	Coefficient	Robust SE	t-Statistic	P-Value
Intercept	-0.0548	0.0580	-0.946	0.343
Log Severity	0.0046	0.0082	0.570	0.568
Flood	-0.0045	0.0172	-0.266	0.789
Storm	0.0089	0.0250	0.356	0.721
Market Vol	3.4249	2.7327	1.253	0.210
Pre Event Trend	-0.0753	0.0980	-0.768	0.442

Appendix F: Multicollinearity Test

Variance Inflation Factor (VIF) test for severe multicollinearity among the independent variables.

Variable	VIF Score	Status
const	35.44	Warning (> 5.0)
Log_Severity	2.04	Safe (< 5.0)
Flood	1.86	Safe (< 5.0)
Storm	1.86	Safe (< 5.0)
Market_Volatility	3.02	Safe (< 5.0)
Pre_Event_Trend	2.9	Safe (< 5.0)

Figure F1: Variance Inflation Factor (VIF) Assessment