# Physical Climate Risk in Real Estate: The Wildfire Risk Exposure of US REITs

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KEYWORDS

*climate risk, wildfires, REITs*

ABSTRACT

This study examines how physical climate risk affects public real estate companies, particularly wildfire risk, using data on 62 US equity REITs from 2004 to 2023. First, the price volatility of REITs exposed to wildfire risk is estimated using market betas. Additionally, the dynamics of actual wildfire events in Arizona, California and Texas are studied to understand their effect on REIT returns and differentiate these effects from longer-term hypothetical risk measures. The empirical results show that decreasing exposure to high wildfire risk areas decreases REIT betas. Results from the event study suggest that REITs only experience negative abnormal returns when fires break out in the wildland-urban interface (WUI) as opposed to remote rural areas.

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## I. Introduction

As average temperatures worldwide continue to rise steadily, climate risk linked to increasingly destructive wildfires poses new challenges to the global real estate industry.[1] It is estimated that the total annual economic cost of wildfires in the USA, such as the record-breaking Smokehouse Creek fire in Texas in 2024, ranges from $394 billion to $893 billion, with reduced property values accounting for more than a third of this damage.[2] It is thus necessary to expand our current understanding of the impact of wildfires on real estate as an asset class, as wildfires are projected to become an even greater challenge in the future.[3] The review of the current literature reveals that no paper has yet attempted to analyse the impact of aggregated wildfire risk across REIT portfolios on these companies' share price volatility and returns. Hence, this paper aims to combine the methodologies used by Zhu & Fuerst[4] and Ling et al.[5] to run both a panel-regression as well as an event study, and try

[1] Venturini, Alessio. "Climate Change, Risk Factors and Stock Returns: A Review of the Literature." *International Review of Financial Analysis*, vol. 79, 2022, pp. 1-18.
[2] "Climate-Exacerbated Wildfires Cost the U.S. Between $394 to $893 Billion Each Year in Economic Costs and Damages." *JEC,* 2023.
[3] Tyukavina, Alexandra, et al. "Global Trends of Forest Loss due to Fire from 2001 to 2019." *Frontiers in Remote Sensing*, vol. 3, 2022, pp. 1-20.
[4] Zhu, Bing, and Franz Fuerst. "Natural Hazard Exposure and REIT Equity Risk." ERES Working Paper, 2023.
[5] Ling, David, et al. "Climate Change and Commercial Property Markets." *Journal of Regional Science*, vol. 64, no. 4, 2024, pp. 1066-1098.

to isolate the effect of wildfires on REIT stocks. Closing this research gap matters as REITs are often marketed to investors based on their appeal of "competitive total returns, based on high, steady dividend income and long-term capital appreciation".[6] Yet, it is crucial for both institutional and retail investors seeking exposure to the real estate markets to understand the effects of longer, more frequent wildfires in the future to the greatest extent possible when deciding how to deploy capital.

Rather than investigating the impact of wildfires on REITs at a global level, this article focuses on equity REITs in the United States. The USA was chosen given it is one of the world's largest real estate markets estimated to comprise more than $45 trillion worth of assets in 2023[7]. Furthermore, the US REIT market has long been established since 1960[8] which is reflected by the fact that over 220 REITs (both equity and mortgage) are currently trading on public stock exchanges[9]. This guarantees a large data sample size to carry out the quantitative analyses.

Moreover, it is well-known internationally that vast parts of the US are high wildfire risk areas. The US Environmental Protection Agency found that each July from 2003 to 2021 an average of 1.8 million acres of land burned.[10] It can be expected that the many different REITs with their portfolios are affected by this natural hazard to varying extents. Hence, a meaningful statistical analysis of how wildfire risk exposure affects REITs can be conducted. The thesis is that wildfires have a negative effect on the publicly listed real estate companies studied in this article.

To investigate the impact of wildfires on US equity REITs, this paper is structured as follows. The next Section summarises and reviews existing literature on the significance of climate risk, how it affects REITs as well as how wildfires in particular affect the real estate sector. The third Section provides an overview of the wildfire risk and REIT-level data collected. In the Data Section, it is specified which fires have been selected for the event study. Thereafter, the Methodology Section details the statistical and analytical techniques used to study the impact of wildfires on REITs. The results of the panel regression and event study are presented in the following Section before they are discussed and evaluated in the Discussion Section. Finally, this article concludes that wildfires do indeed negatively affect REIT volatility as well as returns.

## II. **Literature Review**

Rising temperatures globally expose real estate to greater climate risk resulting from extreme weather events and hazards such as wildfires.[11] Given that climate change is no recent phenomenon, there exists a range of papers exploring how greater exposure to climate risk affects REITs.[12] Feng et al. show that more exposure (typically measured either in area units or monetary value) and vulnerability to climate risk reduces REIT cash flows.[13] Capital expenditure related to repairs and refitting following natural hazards is viewed as the main reason for lower earnings. Market reports also show that higher insurance premiums can reduce cash flows as the cost of property insurance against natural hazards has increased by more than 60% between 2017 and 2023 in the US,[14] for instance. These findings imply that earnings

[6] "What is a REIT (Real Estate Investment Trust)?" *NAREIT,* 2024.
[7] Vernon, Hannah. "Total Value of All US Residential Real Estate Hits Record $47 Trillion." *Benoit Properties International,* 2023.
[8] "History of REITs & Real Estate Investing." *NAREIT,* 2024.
[9] "Frequently Asked Questions about REITs." *NAREIT,* 2024.
[10] "Climate Change Indicators: Wildfires." *US Environmental Protection Agency*, 2024.
[11] Salisu, Afees, et al. "Climate Change, Technology Shocks and the US Equity Real Estate Investment Trusts (REITs)." *Sustainability*, vol. 15, 2023, 14536.
[12] Feng, Zifeng, et al. "Commercial Real Estate in the Face of Climate Risk: Insights from REITs." *Journal of Real Estate Research*, 2024; Zhu & Fuerst (n 4) *supra*; Ling et al. (n 5) *supra.*
[13] Feng et al. (n 12) *supra.*
[14] "2023 US Wildfire State of the Market." *Gallagher RE*, 2023.

from REITs with greater climate risk can be less predictable which is likely reflected in their share price volatility.

Zhu & Fuerst explore the impact of events such as coastal floodings or hurricanes on the returns and share price volatility of REITs.[15] Analyses based on panel data for US equity REITs from 2004 to 2021 show that "REITs with a higher natural hazard exposure show a higher market beta".[16] The greater equity risk, according to the authors, is justified given lower certainty around cash flows which might be disrupted due to income loss resulting from repairs or higher insurance costs for properties in high-climate risk areas. Another paper relevant to our current understanding of how climate risk affects REIT returns uses an event study to investigate how a combination of hurricanes / tropical storms, tornadoes, wildfires and floods impact stock returns in the timeframe from 1996 to 2019.[17] The authors complement their analysis by examining the media attention these events received and the trading behaviour of institutional versus retail investors. The main finding is that REIT return declines are statistically significant in the aftermath of a natural disaster event.[18] Another interesting finding is that retail investors are more likely to sell REIT shares following such disasters due to fear that a company's property might have been damaged whilst not being informed well enough on the exact distribution of the REITs' holdings. Institutional investors, on the contrary, do not engage in such panic sales due to better information availability.[19]

The papers discussed above are important contributions to the current understanding of the relationship between various climate risks (often studied in combination) and REIT returns / volatility. They do not, however, provide a detailed perspective on the impact wildfires as a single climate risk have on REITs.

Focusing on wildfires exclusively, the current literature is limited to event studies of single fires. Kiel & Matheson examine the impact the Fourmile-Lefthand Canyon Forest fire which occurred in 2010 and burned over 6,000 acres had on local house prices.[20] The researchers use property-level data from Boulder County ranging from 2009 to 2012 and complement these with neighbourhood characteristics using census data to build hedonic pricing models. They incorporate a wildfire risk rating score with the categories "Very High", "High", "Moderate" and "Low" for the studied area published by the local Forest Service. They find a statistically significant value decline in "Very High" risk areas of 21.9%.[21] The researchers suggest that this effect is due to a change in the public perception of wildfire risk. Loomis reaches a similar conclusion after studying the impact of the Buffalo Creek fire in Jefferson County, Colorado using hedonic pricing models.[22]

Another insightful paper studying the local impact of fires was authored by Dong.[23] It examines how wildfires affect the house price dynamics at a state level in California from 2010 to 2021. This way the effect of over 504 wildfires which burned more than 10 million acres from 2016 until 2021 is analysed. The main finding of the investigation is that wildfires have a comparatively small impact on property values. Nevertheless, the fires have a statistically significant negative impact on prices when accounting for the size of the fire.[24]

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[15] Zhu & Fuerst (n 4) *supra*.
[16] ibid at 1.
[17] Ling et al. (n 5) *supra*.
[18] ibid.
[19] ibid.
[20] Kiel, Katherine, and Victor Matheson. "The Effect of Natural Disasters on Housing Prices: An Examination of the Fourmile Canyon Fire." *Journal of Forest Economics*, vol. 33, 2018, pp. 1-7.
[21] ibid.
[22] Loomis, John. "Do Nearby Forest Fires Cause a Reduction in Residential Properties." *Journal of Forest Economics*, vol. 10, no. 3, 2004, pp. 149-157.
[23] Dong, Hongwei. "Climate Change and Real Estate Markets: An Empirical Study of Impacts of Wildfires on Home Values in California." *Landscape and Urban Planning*, vol. 247, 2024, 105062.
[24] ibid.

The existing literature shows that physical climate risk generally, but also wildfire risk in particular, must be taken seriously by real estate investors to maximise returns. In the absence of a detailed study solely focused on uncovering the impact of wildfires on REITs, this article aims to close this gap in the current literature by drawing on the existing contributions both on REITs and single fires. Based on the current understanding of climate and wildfire risk, the following hypotheses will be tested:

- $H_1$: Decreasing exposure to wildfire risk areas decreases REIT volatility.
- $H_2$: REITs experience negative abnormal returns because of wildfires.

## III. **Data**

This Section summarises the quantitative data used for the panel regression and event study. First, the risk data used is discussed before examining which REIT data was collected. The fire selection for the event study is also explained in more detail.

### A. *Wildfire Risk Data*

To study the impact of wildfires as a distinct form of climate risk on REITs, this paper follows the approach of previous papers[25] relying on natural disaster datasets detailing the loss and economic damage caused by natural catastrophes. The Federal Emergency Management Agency (FEMA) provides such data in the form of a national risk index which, on the one hand, provides a total risk rating for every single county in the US, but also offers granular risk ratings on a county level for 18 distinct natural hazards, including wildfires. Overall, 3,231 counties are rated where each receives a ranking of "Very Low", "Relatively Low", "Moderate", "Relatively High" and "Very High" according to the risk of the given natural hazard occurring. Wildfire risk remained unspecified in only 88 out of 3,231 counties, with 87 of these being in either Puerto Rico, the US Virgin Islands, Guam, American Samoa or the Northern Mariana Islands. Only one county on mainland USA, Aleutians West County in Alaska was classified as "No Rating".[26]

The strength of using this index is that each county's risk rating is based on the expected annual loss, subdivided into agricultural, building and population loss due to a given natural hazard. Additionally, variables such as "Social Vulnerability" as well as "Community Resilience" are considered to evaluate the risk score and subsequent rating.[27] The fact that both "Social Vulnerability" and "Community Resilience" are also considered is a benefit because local vulnerability determines how destructive natural hazards will be.

Figures 1 to 3, below, illustrate the wildfire risk pattern across the USA, with the five colours indicating different levels of risk. Overall, 2023 counties exhibit very low wildfire risk (62.6%), 685 counties are rated relatively low (21.2%), 331 counties are rated moderate (10.2%) whilst 99 (3.1%) and 4 (0.1%) are classified as relatively high and very high respectively.

The figures above show that wildfire risk poses the greatest challenges on the West Coast especially in California and Arizona. Notably, the only 4 very high-risk ratings all occur in the following Californian counties: Los Angeles, Riverside, San Bernardino and San Diego. On the East Coast Florida is the only state where several counties are at relatively high risk of wildfires breaking out. Across the rest of the USA, wildfire risk is mostly locally constrained to single counties rather than affecting the whole state.

To control for the highly uneven wildfire risk distribution across the US when running the regression, the control variable "Vulnerable States" will be introduced. It controls for REITs exposure to California, Arizona and Florida.

[25] Doktycz, Charles, and Mark Abkowitz. "Loss and Damage Estimation for Extreme Weather Events: State of the Practice." *Sustainability*, vol. 11, no. 15, 4243; Zhu & Fuerst (n 4) *supra.*

[26] "National Risk Index." *FEMA,* 2024.

[27] "National Risk Index: Technical Documentation." *FEMA,* 2023.

To increase the number of observations across the categories and be able to run a robust panel regression risk categories very low and relatively low are combined as "Low" and very high and relatively high as "High" whilst the category "Moderate" remains.

B. *REIT-Level Data*

This study follows Zhu & Fuerst[28] and Feng et al.[29] in using equity REITs for the analysis, because these investment vehicles derive their income from owning and operating properties (mostly) in the US. REIT-specific data was downloaded from S&P Capital IQ.[30] A 20-year time window from 2004 to 2023 was chosen to discern the long-term effect of wildfire-risk exposure on REITs.

The information on 125 equity REITs which were operational and publicly listed at the time of this study served as raw data. Given the information on the street, city and state a REITs' property was in, each holding's county could be identified. This was achieved using an online tool named "city-to-county finder" from the US Economic Development Administration.[31] If a county could not be reliably assigned based on the city a property was in because the city belonged to two or more counties (e.g., Naperville Illinois), the county was determined by locating the street manually using Google Maps. To trace the evolution of the REITs' portfolios over time, acquisition date entries for each property were collected. Other important REIT-level variables collected were property size (in square metres), alternative size measure (usually rooms or beds) and acquisition price. Overall, a total of 29,531 unique property entries across the REITs were recorded.

To clean the raw data, observations were screened for missing entries. REITs were dropped if it was impossible to determine the county, size (either in sq m or units), acquisition year or wildfire risk for more than 15% of the assets owned. Given total area was stated more frequently than acquisition price, this paper follows Zhu & Fuerst[32] in computing the relative exposure to wildfire risk zones as a percentage of total area. Where possible, the area was measured in square meters, but in some instances, notably for hospitality REITs such as Xenia Hotels & Resorts Inc., units were selected to ensure the largest possible data set. Wherever observations were missing for only one area measure, the missing fields were replaced using conversion rates. An apartment unit was assumed to be 85 square meters and a "bed" typically owned by healthcare REITs was 70 square meters large based on the overall trend in the size of these two units among the given REITs. Overall, the final data set included 62 REITs, with a total of 7,926 property entries where area was measured using square meters in 41 instances and using units in 21 cases. The REIT's holdings were distributed across 836 counties in all 51 states.

Apart from collecting information on natural hazard exposure, previous studies also included a range of control variables impacting commercial property and REIT performance.[33] These include both financial variables as well as portfolio exposure to various sectors and urban hubs. Financial data was converted into 2004 dollars using inflation data from the four main census regions (Northeast, West, Midwest, South) as published by the US Bureau of Labour Statistics.[34] FRED released the relevant state-level GDP data.[35] Table 1, below, provides an overview of the variables underlying the subsequent panel regression.

Furthermore, to determine the impact of wildfire risk exposure on REIT volatility, data on the daily share price of all 62 REITs was collected. Where possible the data covered the entire 20-year period or the time frame since

[28] Zhu & Fuerst (n 4) *supra.*
[29] Feng et al. (n 12) *supra.*
[30] "Estimate Comparison." *S&P Capital IQ*, 2024.
[31] "City-to-County Finder." *EDA,* 2024.
[32] Zhu & Fuerst (n 4) *supra.*
[33] West, Tracey, and Andrew Worthington. "Macroeconomic Risk Factors in Australian Commercial Real Estate, Listed Property Trust and Property Sector Stock Returns." *Journal of Financial Management of Property and Construction*, vol. 11, no. 2, pp. 105-116.
[34] "Consumer Price Index: Census Regions." *US Bureau of Labour Statistics*, 2024.
[35] "Gross Domestic Product by State." *FRED*, 2024.

the IPO of the REIT until December 2023. Previous papers used Fama-French factor models[36] to estimate the beta coefficients for companies as a volatility indicator. This article follows that approach and thus data on the small-minus-big "SMB", high-minus-low "HML", robust-minus-weak "RMW" and conservative-minus-aggressive "CMA" factors were retrieved from the website of Ken French[37]. The one-month US treasury bill rate served as a proxy variable for the risk-free rate whilst the Dow Jones Equity All REIT Index[38] was used as a proxy for the overall market returns on US equity REITs.

Based on all the data mentioned above, Table 2, below, summarises the main descriptive statistics and trends in the panel data set. Table 2 shows that on average REITs allocated 66% of total assets to low, 14.2% to moderate and 19.7% to high-risk counties. This distribution points to a proportionately greater exposure to riskier areas as only 3.2% of counties have a high wildfire risk. A possible explanation is that REITs invest an average of 28.1% in the USA's largest cities many of which are in high-risk areas such as San Francisco. The average size of the REITs both in square meters (1.91 million) and units (21,482) shows the vast scale of these investment vehicles. In terms of sectoral exposure, it becomes clear that REITs frequently invest in residential, office, hospitality and retail assets. Other asset classes such as healthcare, multi-use or industrial constituted comparatively lower shares in the REITs' portfolios over the past 20 years. It can also be seen that some REITs focus exclusively on individual real estate sectors.

C. *Fire Selection: Event Study*

Five wildfires summarised in Table 3, below, were selected for the event study. The US Fire Administration[39] distinguishes between remote forest fires typically large in size but not dangerous to cities on the one hand and smaller but more destructive[40] fires in the wildland-urban-interface (WUI).

This difference is reflected in the choice of fires. The Dixie and Smokehouse Creek fires were selected given their record-breaking scale of destruction in remote areas. The Bush, Woolsey and Route fires were much smaller but broke out on the outskirts of Phoenix and Los Angeles. The Woolsey fire was one of the most economically destructive fires[41] in recent years whilst the Bush fire not only came close to Phoenix but also was among the largest wildfires in Arizona in recent years.[42] Finally, the Route fire was selected to test how REITs are affected by much smaller fires which nevertheless break out very close to major cities. Overall, a sample of five distinct fires varying in location and time of occurrence should allow for an insightful comparison of the impact fires differing in scale and proximity to urban hubs have on REIT returns.

## IV. **Methodology**

This Section explains the methods used in this paper to test the previously stated hypotheses. First, the techniques used to study the effect of wildfire exposure on volatility are discussed before outlining the methodology of the event study. Table 4, below, summarises the main abbreviations used for the model specification.

A. *Panel Regression*

To test the impact of wildfire exposure on REIT-share price volatility, this paper follows the two-step methodology used by Zhu & Fuerst.[43] First, market-beta coefficients were estimated for each REIT for each year using the Fama-French model. Betas will be estimated on an annual basis for each REIT

[36] Zhu & Fuerst (n 4) *supra*.
[37] French, Kenneth. "Description of Fama / French Factors." Kenneth R French Data Library, 2024.
[38] "Dow Jones Equity All REIT Index." *S&P*, 2024.
[39] "Wildfire and the Wildland Urban Interface (WUI)." *US Fire Administration,* 2024.
[40] Alexander, Sadof, and James Anderson. "5 Ways Wildfires Affect People Near and Far." *World Resources Institute,* 2023;
[41] Hatakeyama, T. "The Growing Cost of Wildfires." *S&P Global*, 2021.
[42] ibid.
[43] Zhu & Fuerst (n 4) *supra*.

using one, three and five factors for comparison—

$$R_{i,d,y} - Rf_{i,d,y} = \alpha_{i,y} + \beta^{M}_{i,y} Mar_{d,y} + \epsilon_{i,d,y} \quad (1)$$

$$R_{i,d,y} - Rf_{i,d,y} = \alpha_{i,y} + \beta^{M}_{i,y} Mar_{d,y} + \beta^{S}_{i,y} SMB_{d,y} + \beta^{H}_{i,y} HML_{d,y} + \epsilon_{i,d,y} \quad (2)$$

$$R_{i,d,y} - Rf_{i,d,y} = \alpha_{i,y} + \beta^{M}_{i,y} Mar_{d,y} + \beta^{S}_{i,y} SMB_{d,y} + \beta^{H}_{i,y} HML_{d,y} + \beta^{R}_{i,y} RMW_{d,y} + \beta^{C}_{i,y} CMA_{d,y} + \epsilon_{i,d,y} \quad (3)$$

—where "i" stands for a given REIT, "d" for a given day and "y" for a given year. "R" represents the daily return on a share, "Rf" the prevailing risk-free rate. $\beta^{M}_{i,y}$ represents the REIT's sensitivity to the market performance in excess of the risk-free rate and will be used for the subsequent regressions. $\beta^{S}_{i,y}$ indicates the coefficient to the "SMB" factor, $\beta^{H}_{i,y}$ indicates the coefficient to the "HML" factor, $\beta^{R}_{i,y}$ indicates the coefficient to the "RMW" factor whilst $\beta^{C}_{i,y}$ indicates the coefficient to the "CMA" factor. $\epsilon_{i,d,y}$ represents the error term and $\alpha_{i,y}$ the abnormal return.

The second step involved running the panel regression with the market betas estimated in step one as the dependent variable and the wildfire exposure as independent variables along with the previously mentioned control variables. "Age" and "Adjusted Market Cap 000s" were converted in log-form to be able to interpret the coefficients in per cent. When running the regression, the wildfire exposure variable high and the sector variable "Other" were dropped to avoid perfect multicollinearity. This means that the coefficients of "Low" and "Moderate" can be interpreted as the change relative to high. An analysis of the correlation coefficients among the remaining variables showed no signs of multicollinear relationships. Furthermore, results of the Breusch-Pagan and White-Test were significant at the 5% level, indicating the presence of heteroskedasticity. To mitigate this, the regressions were estimated using heteroskedasticity-robust standard errors. An analysis of the distribution of residuals showed the pattern followed a normal distribution which is necessary for statistical inference. An analysis of Cook's distance to understand whether single outliers have a disproportional effect on the regression outcomes showed that this was not the case across the three regressions.

Trying to study the impact of a single natural hazard, such as wildfires, on the systematic risk of REITs is highly complex because a multitude of factors affects the share price movements over any given period. Whilst it might seem that REITs with greater wildfire risk exposure are generally more volatile, it could also be the case that other factors such as management issues or inconsistent communication with investors drive share price fluctuations. Given greater inherent volatility due to such reasons, REIT managers might thus be more willing to take on more risk and acquire properties in wildfire risk areas to boost their returns by obtaining higher yields. This could lead to a problem of reverse causality whereby higher volatility explains greater wildfire exposure as opposed to vice versa. To mitigate the possibility of such endogenous factors influencing results, this paper adopted a firm-fixed and year-fixed effect model, as recommended by Venturini.[44] The null hypothesis of a Hausman test, stating that a random-effect model is preferable could be rejected at a 5% significance level. This meant the model was estimated using firm-fixed effects. Additionally, year-fixed effects were included to control for unobserved time-specific conditions. The final model's equation is shown below—

$$\beta_{i,y} = \delta Low_{i,y} + \partial Moderate_{i,y} + \varphi C_{i,y} + \lambda_i + \theta_y + \epsilon_{i,y} \quad (4)$$

—where "i" stands for a particular REIT in year "y". $\beta_{i,y}$ represents a REIT's sensitivity to the market as estimated in equations one to three and is the dependent variable. Three

[44] Venturini (n 1) *supra*.

separate regressions using betas estimated with one, three and five factors as the dependent variable will be run for comparison. $\delta$ and $\partial$ are the coefficients of interest, capturing the predicted impact a change in exposure to "Low" and "Moderate" risk areas has on REIT-betas. $C_{i,y}$ represents the control variables. These include the financial, geographic and REIT-specific variables described in the data section before. $\lambda_i$ and $\theta_y$ capture firm and year-fixed effects respectively. The random error is captured by $\epsilon_{i,y}$.

B. *Event Study*

Apart from strengthening the analysis using a fixed-effect model, this paper also seeks to address the potential issue that proximity to woodlands or dry grasslands necessary for wildfire risk to be present affects the price and return structures of REITs. This assumption appears reasonable given Donovan et al.[45] point out that forests and nature provide amenity value to property owners and their tenants. This could be expected to lower tenant fluctuation and thus make cash flows more stable, reducing market beta. To address this second problem of endogeneity, the event study is carried out aiming to identify whether and how wildfires translate into abnormal REIT returns depending on how far away and where (WUI or remote forest area) they occur. This approach should complement the panel regression by providing a more localized perspective on the impact wildfires have on REITs and given the comparatively short time frames chosen provide insights into the immediate reaction of the stock market.

The event study seeking to identify the impact of single wildfires on REIT-returns followed a three-step methodology used and recommended by Dasgupta et al.[46] and Al Amin & Qin.[47] First, the market beta using the CAPM model was determined for each REIT using the equation below—

$$R_{i,d,y} - Rf_{i,d,y} = \alpha_i + \beta_i^M Mar_{d,y} + \epsilon_{i,d,y} \qquad (5)$$

The underlying data used for the beta estimations is the same as the one used in the previous equations. One difference, however, is that betas were not estimated on an annual basis but one beta per REIT was estimated based on data from 2012 until the start of each wildfire event. 2012 was chosen as a starting point to avoid that results are distorted because of the global financial crisis on REIT-volatility given industry experts pointed out that such effects were still visible four years after the crisis occurred.[48] At the same time, the time window ensures a large enough data sample before the onset of the COVID-19 pandemic which had drastic impacts on REIT share prices.

Secondly, the cumulative abnormal returns are calculated for all REITs 10 days before, throughout and 10 days after the event. To limit the distortionary effect other fires might have on REIT returns before and after the events studied, the pre- and post-event windows are limited to 10-days. This duration is in line with the timespans chosen in other papers[49] testing the stock price reaction of publicly listed companies to unique events—

$$ER_i = R_f + \beta_i^M * (R_m - R_f) \qquad (6)$$

$$AR_i = R_{a,d,i} - ER_i \qquad (7)$$

$$CAR_i = \sum_{d_1}^{d_2} AR_i \qquad (8)$$

Finally, the expected return is calculated using equation 6 ($R_m$ indicates the return on the Dow Jones Equity All REIT Index). To obtain

[45] Donovan, Geoffrey, et al. "Wildfire Risk and Housing Prices: A Case Study from Colorado Springs." *Land Economics*, vol. 83, no. 2, pp. 217-233.
[46] Dasgupta, Susmita, et al. "Capital Market Responses to Environmental Performance in Developing Countries." WB DRG Policy Research Working Paper 1909, 1998.
[47] Al Amin, Muhammad, and Yufei Qin. "Event Study with STATA: A Step-by-Step Guide." *Princeton University Library,* 2023.
[48] Wheeler, Miriam. "US Offices Are under Pressure, but Real Estate May Still Offer a Hedge for Investors." *Goldman Sachs*, 2023.
[49] Brown, Stephen, and Jerold Warner. "Using Daily Stock Returns: The Case of Event Studies." *Journal of Financial Economics*, vol. 14, no. 1, 1985, pp. 3-31; Dasgupta et al. (n 46) *supra*.

the abnormal return "AR" the expected return (ER) is subtracted from the observed return $R_a$ on the given day as suggested by Strong[50]. Cumulative abnormal returns (CAR) are then calculated through summation for REITs holding property (i.e. Exposure > 0%) within a 100km and 101km to 200km radius for the different time windows lasting from date $d_1$ until $d_2$. Finally, the cumulative average abnormal return (CAAR) is calculated across all REITs affected. In the case of wildfires occurring in remote areas, REITs with positive exposure to the state are used to compute the abnormal returns as none owned property in the surroundings of the fires. Next, it is determined whether the CAARs are statistically different from zero using t-tests.

## V. **Results**

The subsequent section presents and describes the results of the panel regression as well as the event study in more detail.

### A. *Panel Regression*

Table 5, below, summarises the results of the panel regression with 861 firm-year observations where the column headings 1-Factor, 3-Factor and 5-Factor indicate how the dependent variable (the beta coefficients) was estimated.

The values below show the respective coefficients and their level of significance whilst the robust standard error is shown in parenthesis. "Yes" indicates whether the regression was estimated using the control variables "sectoral exposure" and "Vulnerable States" as well as firm-fixed and year-fixed effects. The r-squared value is the highest when predicting betas estimated using the 1-Factor model and lowest when predicting betas estimated using the 3-Factor model. This implies that whilst roughly a third of the variance is explained by the model, there remain other factors not included in this model (e.g., other natural hazards) which also explain variation in systematic risk across REITs.

It can clearly be seen that the coefficients for the variables "Low" and "Moderate" are consistently negative. They range from -0.659 to -0.769 for "Low" and from -0.7019 to -0.915 for "Moderate". All these coefficients are statistically significant at the 5% level with the only exception being the coefficient of the variable "Low" when using the betas from the 1-factor model which is significant at the 10% level. Interestingly, the magnitude of the "Moderate" coefficients is slightly bigger than that of "Low".

Given the variable high was dropped to avoid perfect multicollinearity, the coefficients of low and moderate can be interpreted as the change in systematic risk relative to high. This implies that as exposure to high-risk areas declines in favour of either "Moderate" or "Low" risk areas, the REIT's market-beta falls as well. These results show that reducing exposure to areas rated as high-risk has a positive impact on a REIT's systematic risk.

Other consistently statistically significant control variables are age (in log form) and leverage. Surprisingly, the coefficients indicate a positive relationship between age and market beta. In the case of leverage, the findings confirm that more leveraged REITs are predicted to be more volatile which is in line with expectations. REITs' exposure to the largest US gateway cities (MSA) returns negative coefficients, as one would expect, though not statistically significant.

### B. *Event Study*

The results of the event study are shown Tables 6-8, below, where the column "Before" indicates the average cumulative abnormal return in the 10 days before the fire across the number of affected REITs stated in the "Observations" column. "During" captures the average cumulative abnormal return throughout the fire whilst "After" represents the CAAR in the 10 days after the fire.

[50] Strong, N. 1992. Modelling abnormal returns: A review article. *Journal of business finance & accounting*. vol. 19, no. 4, pp. 533-554.

Table 6 shows the results for the REITs owning property within 100km of the Woolsey, Bush and Route fires. In the run-up to all three fires, the CAAR is positive in all and statistically different from zero in two instances. This trend is then reversed for the duration of the fires where in all cases the REITs experience negative cumulative abnormal returns statistically different from zero. The effect is larger for the Woolsey and Bush fires, which is likely because these fires lasted much longer and were much greater in scale than the Route fire. In the period after the fires, the REITs recover with positive abnormal returns. When combining the trend across all three fires, this trend of positive-negative-positive cumulative abnormal returns is clearly discernible and statistically different from zero, suggesting that REITs owning property within a 100km radius of a fire threatening urban areas experience negative abnormal returns.

Table 7 shows the results for REITs owning property 101km to 200km away from the three fires in the WUI. It became obvious that many REITs owning property in a 100km radius also held investments at a greater distance away, which likely explains the similarity in trends. Only in the case of Bush fire the number of REITs dropped drastically from 21 to two. In the run-up to the Route and Bush fire, REITs experienced positive CAAR though not statistically different from zero at a 5% level. The REITs owning property 101km to 200km away from the Woolsey fire experienced slightly negative abnormal returns, though not statistically different from zero. During the fire, all three REITs experienced negative cumulative abnormal returns which are significant at the 1% level during the Woolsey and Route fire. The small sample size in the case of the Bush fire likely explains the lack of significance. In the aftermath of the fires, REITs in all three instances showed positive abnormal returns. Overall, the trend is comparable to the REITs owning property within a 100km radius where the REITs experience statistically significant negative abnormal returns for the duration of the fire and a positive recovery once they are over.

Table 8 reports the results of the event study focusing on two of the record-breaking fires in recent US history. In the period before each fire, the cumulative abnormal returns were negative and statistically different from zero at a 5% level. It must be noted, however, that in the pre-event window of the Dixie fire, the Beckwourth Complex and Tamarack fires broke out which destroyed over 173,000 acres and possibly had a distortionary effect on returns.[51] Shortly before the Smokehouse Creek fire officially broke out, the Texan governor publicly warned of severe weather threats and activated state emergency resources.[52] Again, this likely influenced REIT returns explaining the negative abnormal returns in the pre-event window. Throughout both fires, however, REITs experienced only minimal negative CAARs which were not statistically different from zero. This suggests that wildfires in remote areas, even if vast in scale, do not have a significant negative effect on REIT returns. In the 10-day after-event window REITs generated positive abnormal returns which could be attributed to more optimistic sentiments among REIT investors after the good news that the fire was contained.

## VI. **Discussion**

This article aimed to test the hypotheses that decreasing exposure to wildfire risk areas decreases REIT volatility and that REITs experience negative abnormal returns because of wildfires. To investigate these hypotheses a panel regression with firm-fixed and year-fixed effects as well as an event study based on the Bush, Dixie, Route, Smokehouse Creek and Woolsey fires were performed.

The results of the panel regression show that an increase in “Low” and “Moderate” risk

[51] “Dixie Fire.” *Department of Forestry and Fire Protection*, 2021; “Woolsey Fire.” *DFFP*, 2021; “Route Fire.” *DFFP*, 2021.

[52] “Governor Abbott Activates State Emergency Response Resources Ahead of Tropical Weather Threat.” *Office of the Texas Governor,* 2024.

areas reduces systematic risk. The effect for both categories is negative and statistically significant at the 5% level in all cases except the "Low" coefficient when using betas estimated through a 1-factor model which was significant at the 10% level. These results imply that increasing the exposure to low-risk counties by one standard deviation can be expected to decrease market betas by 16.7% to 19.4%, depending on the model used for the beta-estimations. Similarly, increasing the exposure to moderate-risk counties by one standard deviation is predicted to result in a reduction in systematic risk ranging from 9.6% and 12.6%. This finding suggests that REIT managers could de-risk their companies by choosing to invest in areas with lower wildfire risk. The r-squared values suggest that roughly a third of the variance is explained by the presented model which includes wildfire risk as an independent variable. Whilst robustness checks show that excluding wildfire-related variables decreases the r-squared, a sizeable share of the variance remains unexplained, meaning that factors such as other natural hazards or external shocks such as the Covid-19 pandemic likely also affect REIT volatility.

The findings of this panel regression are in line with those of previously published papers studying the impact of climate risk on (REIT) volatility. Bonato et al. also find that heightened risk from natural hazards has a statistically significant impact on the volatility of the stock market more broadly.[53] Zhu & Fuerst show that an increase in expected annual loss caused by several different natural hazards increases REITs' systematic risk.[54] Whilst this paper only focused on wildfire risk, it can be assumed that the results are driven by similar mechanisms as wildfires are very difficult to predict and thus investors might be more sensitive to news about outbreaks fearing reduced earnings.

The event study showed that across the Woolsey, Bush and Route fires, average cumulative abnormal returns for REITs owning property up to 100 kilometres away are -2.59% for the duration of the fires and statistically significant at the 1% level. REITs owning property 101km to 200km away from those fires experience on average -2.16% in abnormal cumulative returns for the duration of the fires which was also statistically significant at the 1% level. The average cumulative abnormal returns in the 10-day post-event window are positive for REITs owning property up to 100km as well as 101km to 200km away suggesting that the positive news of extinguishing a fire might lead to a share-price recovery.

A different pattern emerged when studying the two largest wildfires in recent US history. In both cases, average cumulative abnormal returns are negative in the run-up to the fire. This is likely due to the distortionary effect of other major wildfire breakouts in the case of the Dixie fire as well as the public warning by the Texan governor about severe weather threats in the run-up to the Smokehouse Creek fire. To the best knowledge of the authors, no such events distorted the results for the Woolsey, Bush and Route fires. REITs with exposure to the state of the large wildfires did not experience abnormal returns statistically different from zero. This is likely because investors are less concerned by these natural disasters as they typically destroy vast forestland or small rural communities where REITs typically do not hold property. In the aftermath of the fires, statistically significant positive returns were recorded. These could be explained by more optimistic investor sentiments towards REITs investing in the state of the fire after the positive news that it has been put out.

The findings confirm the negative impact Ling et al. found when studying a range of different natural hazards also using an event-study format.[55] They show that natural disasters result in statistically significant negative REIT returns. Nevertheless, it must be said that

[53] Bonato, Matteo, et al. "Climate Risks and State-Level Stock Market Realized Volatility." *Journal of Financial Markets*, vol. 66, 2023, 100854.

[54] Zhu & Fuerst (n 4) *supra*.

[55] Ling et al. (n 5) *supra*.

Ling et al. find that the negative consequences last for two quarters following an event, whereas this study showed that REITs exhibit positive returns in the 10 days after fires. A possible explanation for the difference in outcomes is that Ling et al.'s results do not focus on wildfires exclusively but include a range of several other natural hazards from which REITs might recover more slowly. The fact that among the fires in the WUI, the negative abnormal returns were comparatively lower in magnitude during the Route fire which was the smallest in size resembles the findings of Dong who finds that the number of acres burned matters.[56] No such trends were discernible for the Smokehouse Creek and Dixie fires.

REIT managers could hence benefit from a more active communication towards shareholders as fires occur close to their investments. By reassuring investors that the fire will not affect REITs' earnings due to physical distance or sufficient mitigation strategies in place, for example, the negative impact of wildfires on abnormal returns could potentially be reduced. Similarly, this finding suggests that retail investors should be cautious to conclude that a wildfire in a WUI will automatically affect their REIT-investments leading to panic sales. Instead, it would be advisable to first understand a REIT's approximate portfolio allocation before deciding on whether to sell or not. Based on such information it could even make sense to buy more shares in a given company if other investors failed to carefully evaluate the wildfire risk and sold off their shares only to observe a recovery after the fires are put out.
Overall, the first hypothesis could be confirmed that decreasing exposure to wildfire risk areas decreases REIT volatility. The second hypothesis could only be confirmed in cases where fires erupted in the WUI whilst no negative abnormal returns could be observed for wildfires in remote parts of the USA. These results indicate that investors, such as pension funds or individuals saving for retirement, seeking to reduce volatility in their portfolio should focus on REITs whose assets face comparatively low wildfire risk. Moreover, urban planners and local authorities in high-risk areas such as California should continue exploring measures to reduce the likelihood of fires both breaking out and spreading in their communities. Lowering this risk would likely boost regional prosperity if institutional real estate investors became more willing to invest into the area as a result, thereby driving up property values to the advantage of local real estate owners. Additionally, housing supply shortages might to some extent also be overcome this way as publicly listed real estate businesses would have more incentives to capitalise on supply shortages by starting new developments in areas previously considered too risky.

Whilst the authors of this articles sought to minimise the impact of omitted variables or distortions by potential confounding variables, there remain some limitations. In the case of the panel regression, one significant challenge when collecting the data for the regression was that wildfire-risk ratings were only available at a county level. Whilst this offers a high level of granularity, the internal validity of the results would be improved if city-level or even property-level risk ratings were used for the analysis. The reason for this is that counties like Los Angeles County span more than 10,000 square kilometres.[57] As a result, it is likely that there is a significant variation in wildfire risk even within each county. Capturing this risk distribution even more accurately than it was possible in this analysis would help paint an even clearer picture of how exposure to wildfire risk affects REIT volatility.

Furthermore, it must be acknowledged that all risk-ratings were based on the 2023 estimations and due to a lack of time-series data capturing how wildfire risk evolved over the years. Yet, it must be said that counties are rated relative to each other. This means that even as wildfires became more frequent and

[56] Dong (n 23) *supra.*

[57] "Los Angeles County, California." *United States Census Bureau*, 2024.

devastating, the risk distribution should not have changed significantly over the past twenty years in relative terms, assuming that on average climate change affected all the US to a similar extent. Historical evidence supports this assumption, showing that, in 2004, wildfire risk posed the greatest threat in California as well as Arizona and generally dominated on the West, as opposed to the East coast.[58] This substantiates that the results of the panel regression can still be deemed valid. A limitation of the event study is that during wildfire season fires break out almost daily across states like California or Arizona and overlap both temporally as well as geographically. This makes it more difficult to reliably isolate the effect of a single fire on REIT returns which in fact might be driven more generally by the bad news about fires as was likely the case in the pre-event window of the Dixie fire. Constraining the pre- and post-event windows to 10 days was seen as the best way to avoid noise from other wildfires.

## VII. **Conclusion**

This paper sought to investigate how exposure to wildfire risk areas affects REIT volatility as well as returns once a fire breaks out. To understand the impact of the natural hazard on publicly listed real estate companies, a panel regression with firm-fixed and year-fixed effects using data of 62 US equity REITs from 2004 to 2023 was performed. Secondly, an event-study format using data of five different fires in Arizona, California and Texas was adopted to understand how wildfires affect REIT returns.

The panel regression coefficients substantiate that decreasing portfolio exposure to high-risk counties in favour of "Low" or "Moderate" risk areas reduces the market beta of REITs. Results from the event-study show that REIT returns are more sensitive to fires in the WUI leading to negative abnormal returns. No evidence could be found that large fires in remote, rural areas have a statistically significant effect on REIT returns. Overall, it can therefore be concluded that REIT volatility as well as returns are negatively affected as wildfire risk increases. The practical implications of these findings for REIT managers are that allocating a larger portion of the portfolio to low-risk areas such as the East Coast could help de-risk their companies and make them more attractive for investors such as pension funds who value stable cash flows. Additionally, it seems worthwhile to deploy pre-emptive communication strategies to reassure investors once wildfires break out in the vicinity of portfolio assets. This could help reduce or potentially even eliminate the negative abnormal returns related to fire outbreaks likely driven by retail investors' fears.

To further the current understanding of the relationship between wildfires and REITs, future researchers could explore possibilities to obtain more granular risk ratings to produce even more detailed results. Furthermore, it could be worthwhile to repeat this study by looking at other individual natural hazards to better understand their impact on the REIT industry.

[58] "September 2004 Wildfires Report." *NOAA*, 2004.

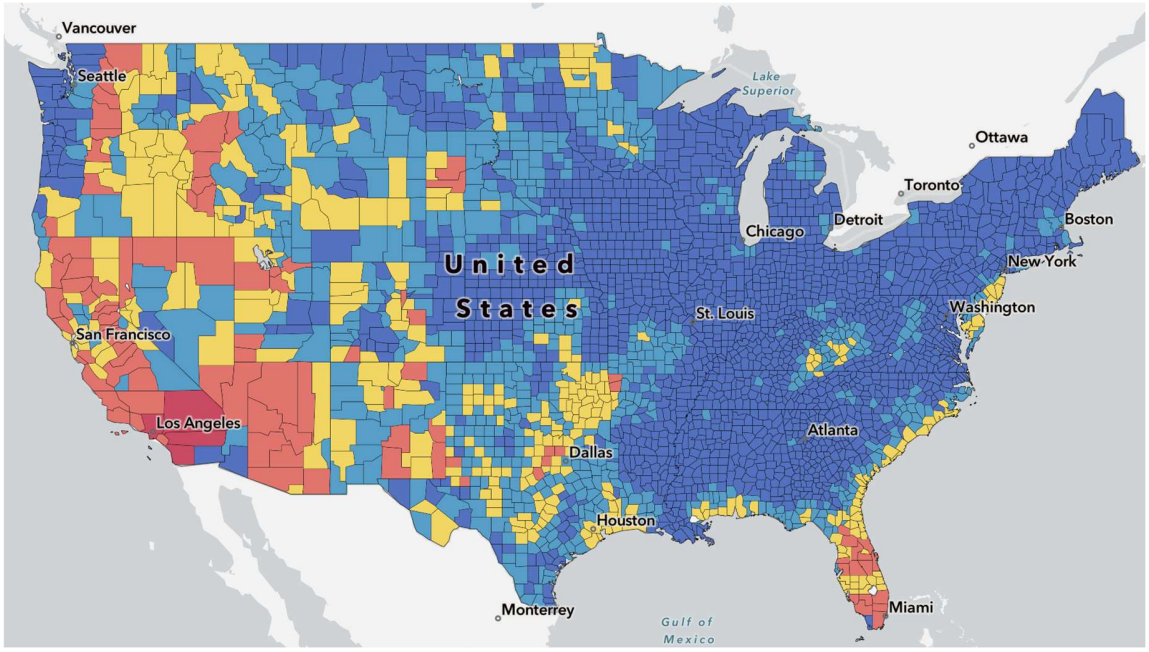
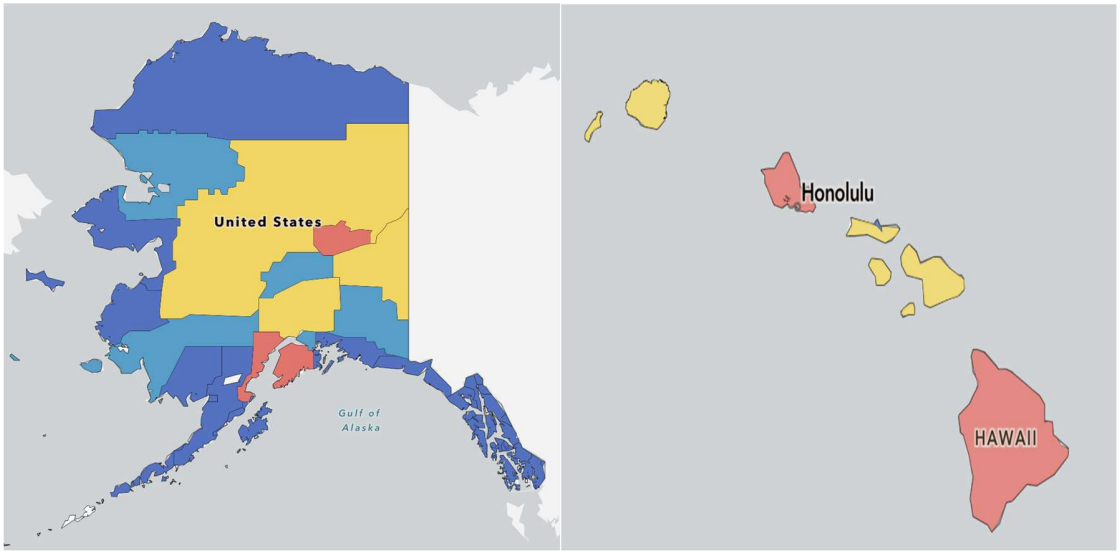



*Figure 1: Wildfire Risk Distribution across Mainland US (Source: FEMA).*




*Figures 2-3: Wildfire Risk Distribution across Alaska / Hawaii (Source: FEMA).*

| Variable name | Measurement unit | Description |
|---|---|---|
| Low | % | Share or properties located in Low wildfire risk counties |
| Moderate | % | Share or properties located in Moderate wildfire risk counties |
| High | % | Share or properties located in High wildfire risk counties |
| HealthCare | % | Sectoral portfolio exposure |
| Hospitality | % | Sectoral portfolio exposure |
| Industrial | % | Sectoral portfolio exposure |
| Leisure | % | Sectoral portfolio exposure |
| MultiUse | % | Sectoral portfolio exposure |
| Office | % | Sectoral portfolio exposure |
| Other | % | Sectoral portfolio exposure |
| Residential | % | Sectoral portfolio exposure |
| Retail | % | Sectoral portfolio exposure |
| Specialty | % | Sectoral portfolio exposure |
| AdjustedMarketCapoOOs | $ | Market Cap in 2004 Thousands USD |
| Age | Years | Years since IPO |
| Leverage | % | Share of total liabilities over total assets |
| MSA | % | Share of portfolio located in 25 US gateway cities[1] |
| NOITA | % | Net operating income relative to total assets |
| RealGDPGrowth | % | Annual weighted real GDP growth rate based on portfolio exposure to different US states |
| VulnerableStates | % | Share of properties located in Arizona, California & Florida |

*Table 1: Description of Variables and Their Units*

[1] Austin; Boston; Charlotte; Chicago; Columbus; Dallas; Denver; El Paso; Fort Worth; Houston; Indianapolis; Jacksonville; Las Vegas; Los Angeles; Nashville; New York City; Oklahoma; Philadelphia; Phoenix; San Antonio; San Diego; San Francisco; San Jose; Seattle; Washington DC

| Classification | Variable | Mean | STD | Minimum | Maximum |
|---|---|---|---|---|---|
| Volatility | 1-Factor beta | 0.947 | 0.318 | -1.041 | 2.353 |
| | 3-Factor beta | 0.894 | 0.298 | -1.117 | 2.027 |
| | 5-Factor beta | 0.889 | 0.298 | -1.613 | 1.981 |
| Wildfire Exposure | Low | 0.66 | 0.254 | 0.000 | 1.000 |
| | Moderate | 0.142 | 0.138 | 0.000 | 1.000 |
| | High | 0.197 | 0.206 | 0.000 | 1.000 |
| REIT-specific variables | Age (Years) | 20.05 | 16.045 | 0.000 | 62 |
| | Adj.MarketCap | 2,788,889 | 3,685,711 | 7,662 | 23,600,000 |
| | Area (SQM) | 1,910,040 | 2,054,959 | 19,516 | 10,200,000 |
| | Area (Units) | 21,482 | 33,015 | 31 | 162,722 |
| | Leverage | 0.551 | 0.153 | 0.008 | 1.07 |
| | MSA | 0.281 | 0.263 | 0.000 | 1.000 |
| | NOITA | 0.075 | 0.023 | -0.027 | 0.133 |
| | RealGDPGrowth | 0.02 | 0.021 | -0.046 | 0.09 |
| | Vuln. States | 0.244 | 0.255 | 0.000 | 1.000 |
| Sectoral exposure | HealthCare | 0.031 | 0.151 | 0.000 | 1.000 |
| | Hospitality | 0.192 | 0.394 | 0.000 | 1.000 |
| | Industrial | 0.085 | 0.261 | 0.000 | 1.000 |
| | Leisure | 0.002 | 0.018 | 0.000 | 0.455 |
| | MultiUse | 0.022 | 0.073 | 0.000 | 0.44 |
| | Office | 0.221 | 0.383 | 0.000 | 1.000 |
| | Other | 0.019 | 0.113 | 0.000 | 1.000 |
| | Residential | 0.255 | 0.422 | 0.000 | 1.000 |
| | Retail | 0.146 | 0.303 | 0.000 | 1.000 |
| | Specialty | 0.028 | 0.087 | 0.000 | 0.563 |
| N | 886 | | | | |

*Table 2: Summary Statistics of Key Variables*

| Fire[2] | State | Counties | Category | Duration | Acres destroyed |
|---|---|---|---|---|---|
| Smokehouse Creek Fire | Texas | Hutchinson; Roberts; Hemphill | Remote | 26.02.2024 - 14.03.2024 | 1,058,482 |
| Dixie Fire | California | Butte; Plumas; Shasta; Lassen; Tehama | Remote | 13.07.2021 - 25.10.2021 | 963,309 |
| Bush Fire | Arizona | Maricopa; Gila | WUI | 13.06.2020 - 06.07.2020 | 184,674 |
| Woolsey Fire | California | Los Angeles; Ventura | WUI | 08.11.2018 - 04.01.2019 | 96,949 |
| Route Fire | California | Los Angeles | WUI | 31.08.2022 - 06.09.2022 | 5,208 |

*Table 3: Fire Selection Showing Fire Name, State, Category, Duration, and Area Destroyed.*

| Regression variable names | Description |
|---|---|
| $\alpha_{i,y}$ | Abnormal return |
| $\beta^{C}_{i,y}CMA_{d,y}$ | Fama-French Conservative-Minus-Aggressive "CMA" factor coefficient |
| $\beta^{H}_{i,y}HML_{d,y}$ | Fama-French High-Minus-Low "HML" factor coefficient |
| $\beta^{M}_{i,y}Mar_{d,y}$ | Coefficient capturing sensitivity to market |
| $\beta^{R}_{i,y}RMW_{d,y}$ | Fama-French Robust-Minus-Weak "RMW" factor coefficient |
| $\beta^{S}_{i,y}SMB_{d,y}$ | Fama-French Small-Minus-Big "SMB" factor coefficient |
| $\delta Low_{i,y}$ | Coefficients capturing impact of exposure to "low-risk" areas on volatility |
| $\partial Moderate_{i,y}$ | Coefficients capturing impact of exposure to "moderate-risk" areas on volatility |
| $\varphi\ C_{i,y}$ | Coefficients capturing impact of control variables |
| $R_{i,d,y}$ | Daily return of a given REIT share |
| $Rf_{i,d,y}$ | Prevailing risk-free rate |
| $\lambda_i$ | Coefficients for firm-fixed effects |
| $\theta_y$ | Coefficients for year-fixed effects |
| $\epsilon_{i,d,y}$ | Error term |

*Table 4: Summary of Abbreviations Used to Specify Model*

[2] McCormick, M, et al. "Texas Battles Second Largest Wildfire in US History–in Winter." *Financial Times,* 2024; "Dixie Fire", *DFFP,* 2021; "NASA Catches Satellite Image of Bush Fire in Arizona, Nation's Largest Fire at Present." *NASA*, 2020; "Woolsey Fire." *DFFP,* 2021; "Route Fire." *DFFP,* 2021.

| | 1-Factor | 3-Factor | 5-Factor |
|---|---|---|---|
| Low | -0.659* | -0.765** | -0.759** |
| | (0.365) | (0.358) | (0.350) |
| Moderate | -0.701** | -0.890*** | -0.915*** |
| | (0.305) | (0.298) | (0.293) |
| Age | 0.128*** | 0.120*** | 0.117*** |
| | (0.035) | (0.033) | (0.033) |
| Adj.MarketCapooos | 0.008 | 0.054* | 0.060* |
| | (0.034) | (0.031) | (0.031) |
| Leverage | 0.552** | 0.416** | 0.395** |
| | (0.225) | (0.188) | (0.183) |
| MSA | -0.145 | -0.081 | -0.069 |
| | (0.218) | (0.189) | (0.183) |
| NOITA | -1.747** | 0.079 | 0.364 |
| | (0.824) | (0.752) | (0.777) |
| RealGDPGrowth | -0.455 | -1.261 | -1.328 |
| | (0.831) | (0.836) | (0.815) |
| Sector-Exposure | Yes | Yes | Yes |
| Vulnerable States | Yes | Yes | Yes |
| Year-FE | Yes | Yes | Yes |
| Firm-FE | Yes | Yes | Yes |
| R-squared | 0.330 | 0.281 | 0.290 |
| F-statistic | 39.470*** | 44.750*** | 51.750*** |
| N | 861 | 861 | 861 |

*Table 5: Panel Regression Results; (*), (**), and (***) Indicate Significance at the 10%, 5%, and 1% Level.*

| Fire | Type | Observations | Before | During | After |
|---|---|---|---|---|---|
| Woolsey Fire | WUI | 21 | 0.04% | -3.23%*** | 1.30%*** |
| Bush Fire | WUI | 21 | 3.54%*** | -4.08%** | 0.07% |
| Route Fire | WUI | 29 | 0.79%** | -1.04%** | 3.08%*** |
| Total | WUI | 71 | 1.38%*** | -2.59%*** | 1.66%*** |

*Table 6: Event Study Results for WUI Fires: 0-100km Radius; Significance Markers as Above.*

| Fire | Type | Observations | Before | During | After |
|---|---|---|---|---|---|
| Woolsey Fire | WUI | 27 | -0.49% | -2.93%*** | 1.26%*** |
| Bush Fire | WUI | 2 | 1.26% | -7.01% | 1.14%* |
| Route Fire | WUI | 33 | 0.58% | -1.24%*** | 3.69%*** |
| Total | WUI | 62 | 0.14% | -2.16%*** | 2.55%*** |

*Table 7: Event Study Results for WUI Fires: 101-200km Radius; Significance Markers as Above.*

| Fire | Type | Observations | Before | During | After |
|---|---|---|---|---|---|
| Dixie Fire | Remote | 37 | -3.60%** | -0.18% | 3.36%*** |
| Smokehouse Creek Fire | Remote | 43 | -1.86%*** | -0.14% | 2.29%*** |
| Total | Remote | 80 | -2.66%*** | -0.16% | 2.78%*** |

*Table 8: Event Study Results for Remote Fires at a State Level; Significance Markers as Above.*