Assessing the Impact of Climate-Related Risks on Canadian Real Estate Investment Trusts: Insights and Implications for Investors

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Abstract

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Iris Stefania Vasiliu

This study aims to analyze the impact of physical climate risks on the Canadian real estate market. Building upon the framework established by Duprey et al. (2021), we define and utilize a Multi-hazard Exposure Average Index (MHE) to measure the intensity and frequency of natural disaster exposure for each of the 1658 Forward Sortation Areas (FSA) in Canada. We examine the effects of the Average MHE on the operating and equity performance of Canadian Real Estate Investment Trusts (REITs). Our findings reveal that REITs with properties facing heightened exposure to climate change physical risks report lower rental revenues and operating expenses. Additionally, our analysis indicates no significant relationship between the exposure of property portfolios to physical climate risks and abnormal stock returns, suggesting that the effects of climate risks are already integrated into market valuations. We further develop our study by exploring the interactions between the MHE Average Index and the main property types within REIT portfolios, where we observe statistically significant effects. This paper contributes to the understanding of how environmental factors are reshaping the financial dynamics of Canadian real estate investments, highlighting the importance of considering climate risks in investment decisions and property management.

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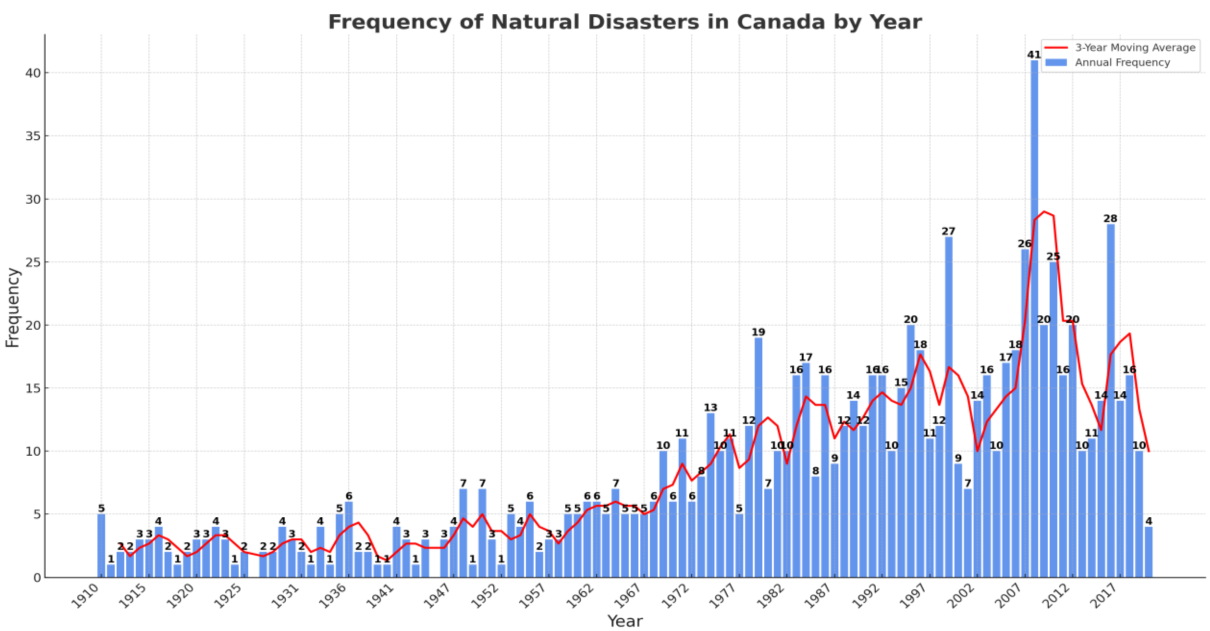
1. Introduction

This paper investigates the impact of physical climate risks, such as flooding and wildfires, on the Canadian real estate market, particularly focusing on how these risks impact real estate investments in Canada. As global temperatures rise and natural disasters occur more frequently, these climate risks present significant threats, including the potential loss of asset value from insufficiently insured properties and income disruptions due to business operations being affected or workplaces becoming inaccessible.

Our study considers the relationship between severe weather events and financial vulnerabilities of households, especially in Canadian regions that are historically susceptible to natural disasters. We aim to assess how climate risks affect different areas across Canada and their influence on the operating performance of Real Estate Investment Trusts (REITs). This includes an analysis of whether these impacts are manifested in the market beta or abnormal returns of REITs. To achieve this, we use data on REITs' property portfolios, encompassing property types, locations, acquisition and disposition dates, and asset sizes. Our methodology integrates approaches from Eicholtz and Yönder (2012) and Ozgur, Tsang, and Yonder (2023) to determine operating performance metrics for each REIT. Moreover, we leverage data from the Canadian Disaster Database, employing the methodology outlined in Duprey et al.'s "Household Financial Vulnerabilities and Physical Climate Risks" (2021), extending the dataset up to 2020. This research contributes to the existing literature by offering insights into the implications of climate risks on real estate investments, providing valuable information for policymakers, investors, and financial institutions.

As can be seen in Figure 1, the frequency of natural disasters has been increasing in Canada from 1910, with the highest incidence being storms and floods, further justifying the need to understand the relationship between REITs performance and the impacts of physical climate risks in the Canadian real estate market.

Figure 1: Annual Canadian Natural Disaster Frequency from 1910 to 2020



2. Literature Review

In recent years, the body of literature examining the influence of climate risk on Real Estate Investment Trusts (REITs) performance has expanded, providing instrumental insight into the dynamics at play within property markets. Athukorala et al. (2016) provide an analysis, showing how property markets respond to natural disasters. Their research indicates that prices in affected areas decline significantly post-disaster, influenced not just by physical damage but also by a prevalent stigma that lingers, affecting market valuations.

Bellosta (2021) showcases a shift in the financial industry's perception of climate change. Traditionally seen as an external factor, climate events are now being recognized for their systemic risk potential. This reclassification signifies an evolving awareness of the broad financial implications posed by climate change, suggesting a deeper integration of these risks into financial frameworks and strategies.

Furthermore, Schlenker and Taylor (2021) investigate market behaviors, contrasting the predictive alignment of financial derivative prices with scientific climate model predictions against historical weather data. Their findings argue for a market that is increasingly anticipatory of long-term climatic trends rather than being purely reactive to past weather events.

In addition, the work of Clayton et al. (2021) provides a structured approach to quantifying the impact of physical climate risks on real estate cash flows and valuations. Their framework aids in bridging the gap between the potential future impacts of climate risks and current market valuations, promoting a forward-looking stance in property assessments.

Ling et al. (2023) examine the downstream effects of climate shocks on capital markets. They find that REITs with properties in recently affected areas experience a reduction in stock returns, suggesting that the capital markets are sensitive to the localized impact of climate events. This sensitivity is further controlled by the degree of media attention on climate change, indicating that public discourse and perception significantly influence market responses.

García and Norli (2012) study investor behavior in the context of climate risk. They explore geographical dispersion and its impact on stock returns, presenting a case for the "local bias" in investment decisions. Their findings demonstrate how localized knowledge and investor familiarity with specific markets can lead to differentiated risk assessment and returns.

Baldauf, Garlappi, and Yannelis (2020) analyze the psychological foundations of market dynamics, particularly how divergent beliefs about climate change can materially affect property valuations. In areas where belief in climate change is strong, property prices reflect a discount, mirroring the concerns and risk perceptions of the residents.

Barnett, Brock, and Hansen (2019) integrate decision theory with asset pricing to model the uncertainties of climate change. They emphasize the need for comprehensive frameworks that can assess the impact of climate and emissions uncertainty on social and economic decision-making, advocating for a multi-faceted approach to capturing these risks.

Sayce et al. (2022), analyze the growing inclusion of climate risks in commercial real estate valuations. The authors present a methodological approach for understanding the direct and indirect effects of physical climate risks on real estate cash flows and valuations. Their work shows a trend where market valuations start to recognize these risks, but also pinpoints a notable lag in the full adoption of such considerations, with this recognition varying across different market segments. The paper calls for more research to fine-tune the understanding of these impacts, aiming to better guide those in the valuation and investment arenas. The practical aspects of this study highlight the imperative for valuers to align with progressive standards and include climate risks in their appraisals of Market Value and Investment Value. The authors further advocate for a refined and multi-layered approach to embed sustainability and climate-related factors in line with prevailing professional benchmarks and directives.

Feng et. al (2022) also explore the relationship between climate risk and commercial real estate performance, focusing on U.S. equity REITs from 1995 to 2020. The study uses county-level temperature data and a comprehensive dataset of REIT properties to construct a firm-level climate risk measure. Findings indicate that REITs with higher exposure to climate risks, specifically abnormal temperature changes, experience lower cash flows and reduced firm values. This negative impact is consistent across various models and control variables. The research provides empirical support to the temperature-based long-run risk model and highlights the economic implications of rising temperatures on commercial real estate, suggesting that climate risk significantly affects property returns and firm valuation in this sector.

Lastly, it is interesting to look at the findings of the study by Eichholtz, Yonder et al. (2015) that environmentally certified buildings achieve lower financing costs. These results not only highlight the financial benefits of sustainable practices but also highlight the role of climate risk management in investment decisions. Buildings with environmental certifications like LEED or Energy Star typically incorporate features that reduce energy consumption and greenhouse gas emissions, which are directly linked to climate change mitigation. By demonstrating lower cost of capital for these properties, the research suggests that financial markets are beginning to recognize and incorporate climate risk into their valuation models. This recognition signals a shift towards more climate-resilient portfolios and provides a financial incentive for investors to prioritize sustainability. Consequently, as climate risk increasingly influences market dynamics, investments in environmentally certified properties may serve as a protective hedge, offering financial stability in a market that is gradually pricing in the long-term impacts of climate change.

3. Data and Methodology

Multi-Hazard Exposure (MHE)

The methodology for reproducing the Multi-Hazard Exposure (MHE) Index as originally conceptualized by Duprey et al. (2021) involves a detailed analysis of natural disaster data to assess the vulnerability of various geographical areas to multiple hazards.

In this methodology, a disaster is defined as a hazard that impacts a vulnerable community in a manner that exceeds the community's ability to cope, which may lead to adverse effects on safety, health, welfare, property, or the environment. The criteria for inclusion in the dataset, drawn from the Canadian Disaster Database[1], requires that a disaster event must meet one or more of the following: (i) cause 10 or more fatalities; (ii) involve 100 or more individuals injured, evacuated, or left homeless; (iii) prompt an appeal for national or international assistance; (iv) possess historical significance; or (v) result in significant damage or disruptions that hinder the community's independent recovery. The assessment of natural disaster exposure across Forward Sortation Areas (FSAs) involves classifying the exposure level to each disaster type as low (at or below the 40th percentile), medium (between the 40th and 80th percentiles), or high (at or above the 80th percentile) based on the frequency distribution of events. This classification is then

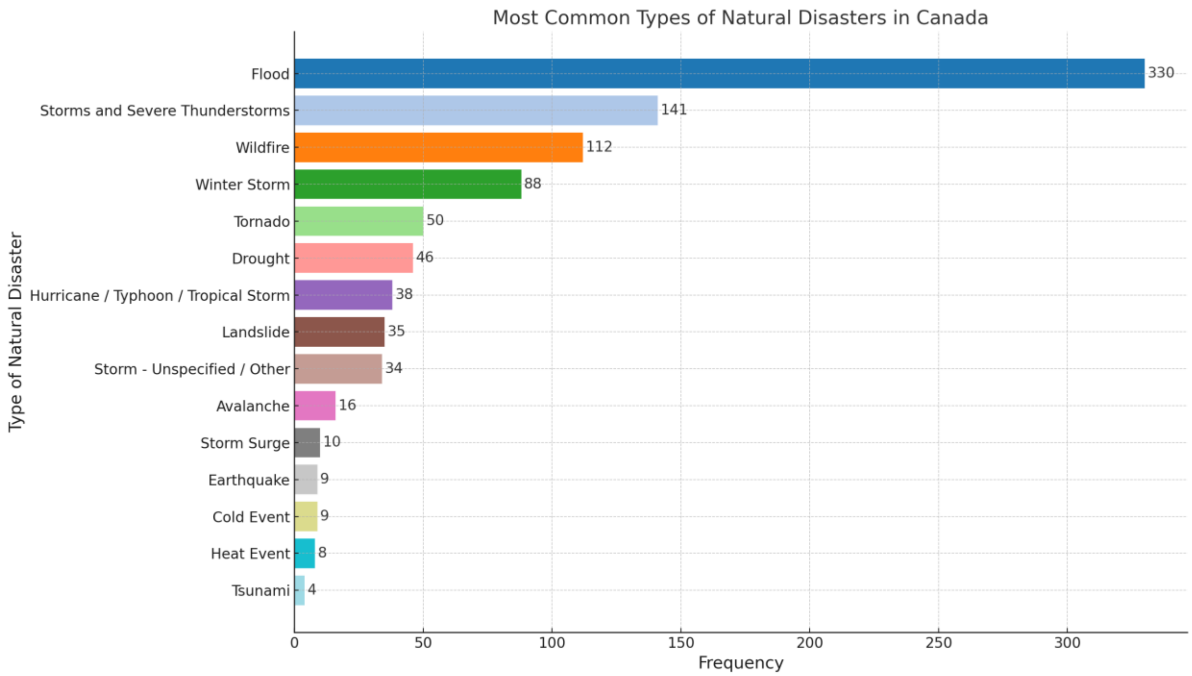
[1] https://www.publicsafety.gc.ca/cnt/rsrcs/cndn-dsstr-dtbs/index-en.aspx

integrated into a multi-hazard exposure index, which categorizes FSAs into three levels: low exposure to all disasters, medium exposure to at least one type of disaster, and high exposure to one or more types, with a further classification for areas with high exposure to multiple disasters.

The following details the approach we used to replicate the MHE Index for the purpose of this research:

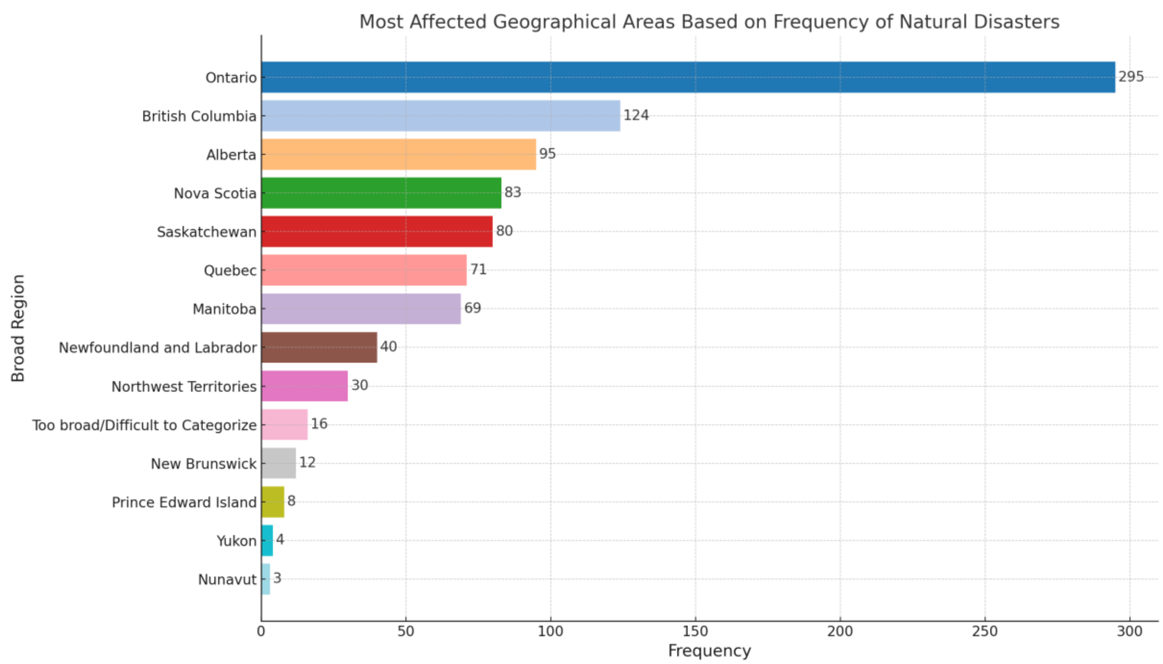
i) **Data Collection:** The initial step involves extracting data from the Canadian Disaster Database, focusing on the 15 primary categories of natural disasters which include floods, storms, severe thunderstorms, and wildfires. This comprehensive dataset covers events from 1910 to 2020, with Figure 2 illustrating that floods, storms, and wildfires are among the most frequent natural disasters in Canada.

Figure 2: Most Common Types of Natural Disasters in Canada



ii) Geographic Mapping: The extracted data is then mapped to Forward Sortation Areas (FSAs), which divide Canada into 1658 regions, each identified by the first three characters of their postal codes. This spatial mapping allows for the assessment of disaster frequency across different regions, with the Prairies notably highlighted in Figure 3 as the area most frequently affected by natural disasters.

Figure 3: Most Affected Geographical Areas Based on Frequency of Natural Disasters



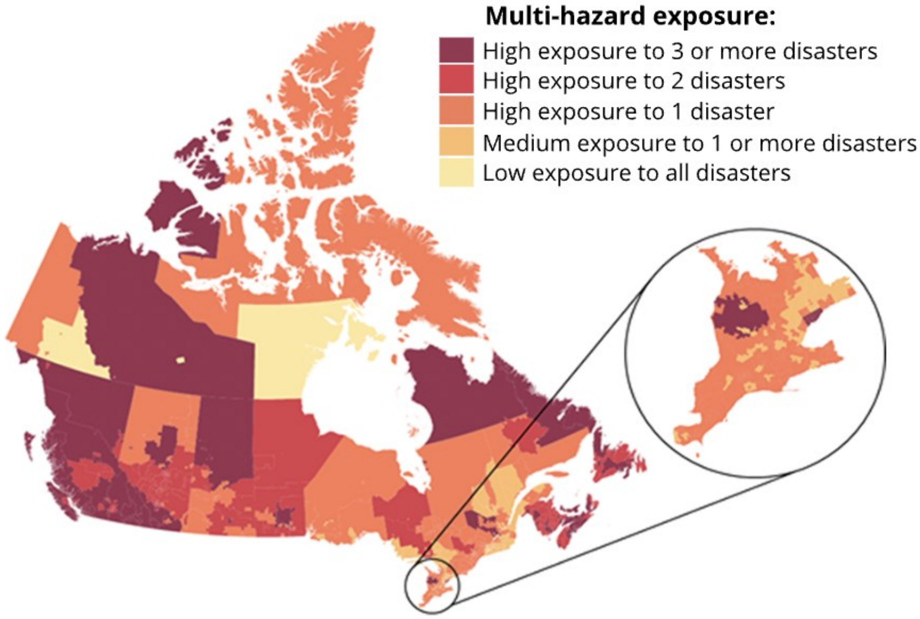
iii) Assessment of Disaster Exposure: Despite the straightforward frequency data, the study cautions against a simplistic interpretation of disaster exposure based solely on frequency. The study argues that certain disasters, such as wildfires, although less frequent than floods or storms, may still indicate a high level of exposure. Furthermore, it is noted that disasters are not always independent events; one type of natural disaster may trigger another, complicating the exposure assessment. The study introduces a nuanced measure, the MHE Index, which classifies FSAs into low, medium, or high exposure categories based on the distribution of event frequency—specifically, low exposure is identified at or below the 40th percentile, medium exposure between the 40th and 80th percentiles, and high exposure above the 80th percentile.

iv) Classification of FSAs: In the final step of the methodology, FSAs are categorized into comprehensive exposure levels across all disaster types, using a scale from 1 to 5 in the MHE Index. This classification is defined as follows:

- **1:** Low Exposure to all 15 types of natural disasters
- **2:** Medium Exposure to one or more types of disasters
- **3:** High Exposure to one type of disaster
- **4:** High Exposure to two types of disasters
- **5:** High Exposure to three or more types of disasters

This categorization helps in identifying the regions most at risk, with FSAs classified within the 3 to 5 range considered the most vulnerable. Figure 4 illustrates the different MHE Indices across Canada. Please refer to Appendix A for a summary illustration of the classification methodology for MHE index employed.

Figure 4: MHE Index Across Canada (Source: Duprey et. al. (2021))



REITs Data

In our research on Real Estate Investment Trusts (REITs), we follow the approach established by Ozgur, Tsang, and Yonder (2023) to systematically gather and analyze property portfolio data for REIT companies in Canada. The period of study spans from the first quarter of 2000 (2000Q1) through to the second quarter of 2023 (2023Q2). This data is extracted from S&P Global Market Intelligence, which offers comprehensive details on each REIT's property assets. These details include types of properties, their geographic locations, and dates of acquisition and disposition, along with a variety of financial and operating performance metrics.

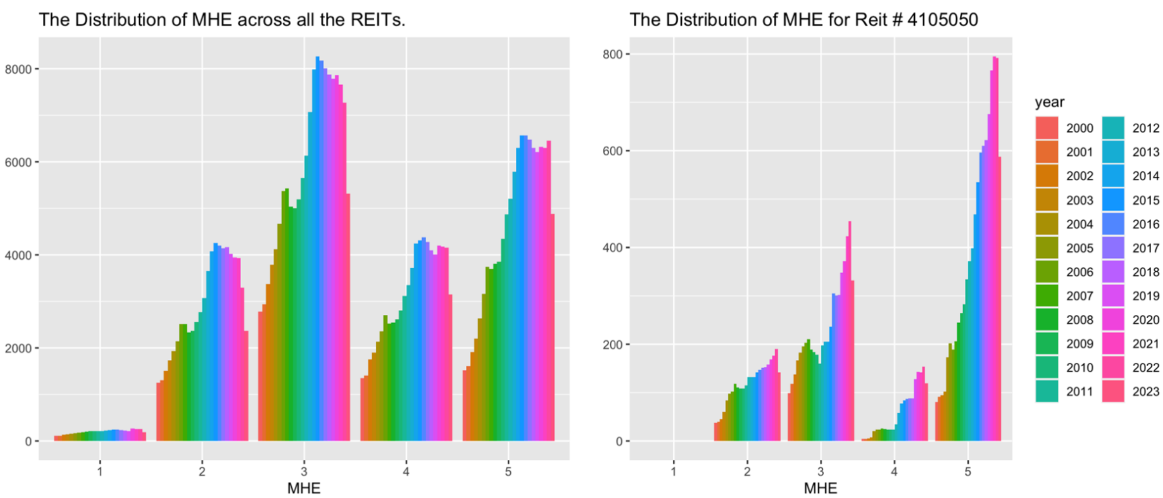
Utilizing the acquisition and disposition dates provided, we construct a dynamic, quarterly timeline of property holdings for each REIT. This results in the formation of an unbalanced panel data frame, reflecting the fluctuating portfolio compositions over the studied quarters. Additionally, we leverage the geographical coordinates—longitudes and latitudes—of the properties to geocode them to their respective postal codes. This geocoding process enables us to identify the Forward Sortation Areas (FSAs) associated with each property, which are needed for determining their Multi-Hazard Exposure (MHE) Index.

Our analysis encompasses a total of 64 REITs. It is important to note that while the initial datasets vary in the number of REITs they include, our final analytical sample comprises 64 REITs. This number is the result of merging the datasets and cleansing them of any missing values. Appendix B details the 64 REITs considered in our final analysis.

The distribution of MHE

Figure 5 illustrates the distribution of MHE. The left panel of Figure 5 shows the distribution of MHE across all the REITs' properties. As can be seen from this figure, MHE tends to increase over time across all the REITs' portfolios. The right panel of Figure 5 narrows down the distribution for a specific REIT portfolio as an example (See Appendix B for REITs' SNL Key)

Figure 5: Portfolio Distribution of MHE



Defining the MHE Average Index

We define an aggregate MHE index for the portfolio of a REIT in each quarter. The index is calculated as the average of the MHE of the properties weighted by the number of properties with an MHE equal to {1,2,3,4,5} in each quarter:

$$MHE\ avg.Index_{\ it} = \frac{\sum_j \#Property_{ijt} \times MHE_j}{Portfolio\ Size_{it}} \qquad (1)$$

For REIT i with properties with MHE value of j in its portfolio, at quarter t.

This yields a time series for the MHE Average Index[2].

Figure 6 illustrates the time series for the MHE Average Index for two selected REITs:

Figure 6: Illustration of the MHE Average Index across time for 2 REITs' portfolios

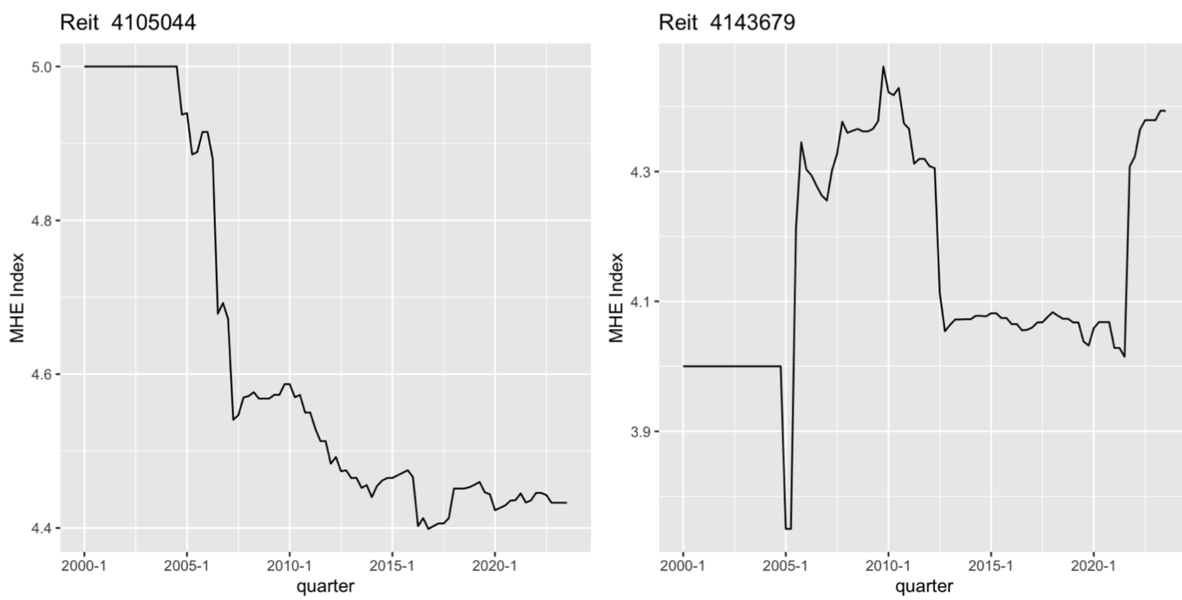
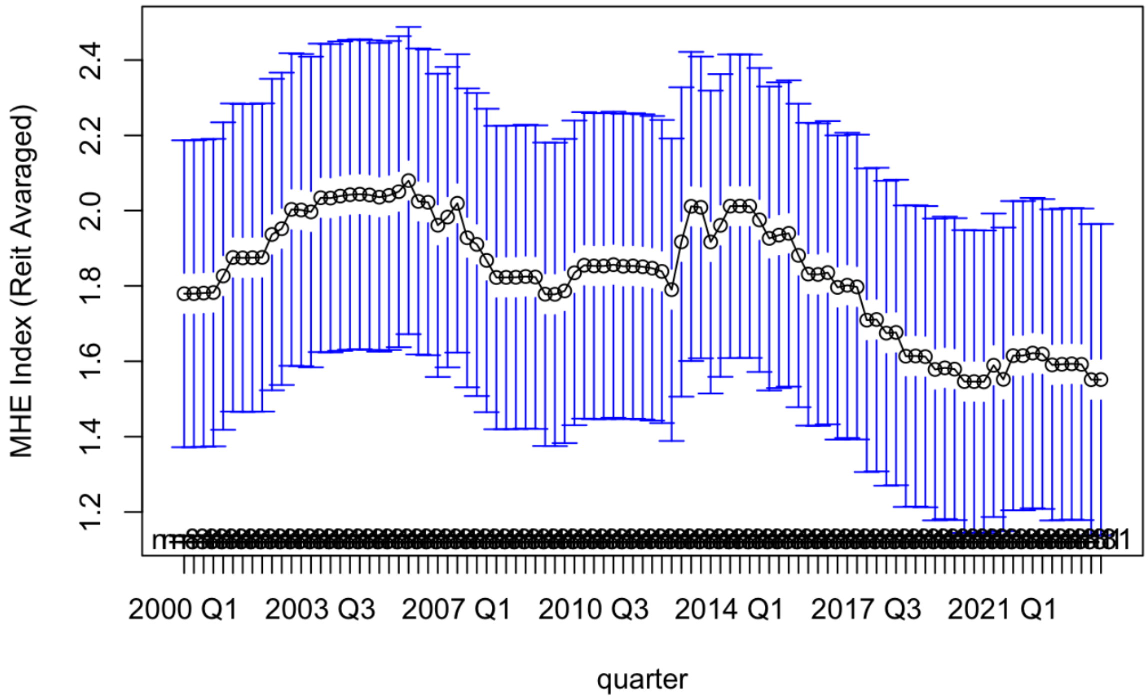


Figure 7 demonstrates the time variability in the MHE Average Index which is once again averaged over all the REITs.

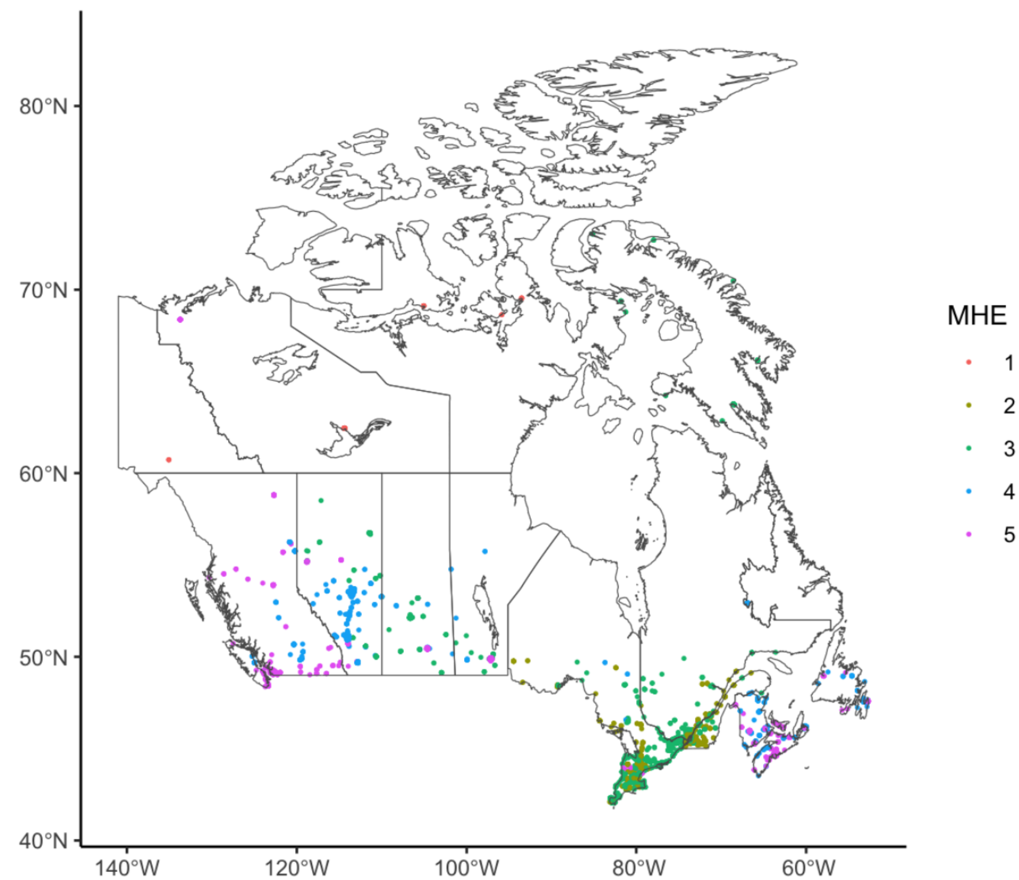
[2] In our approach, the MHEs are averaged based on the number of properties in a REITs' portfolio. Another alternative would be averaging based on the size or number of units of properties. However, this alternative approach leads to a considerable loss of data due to a significant number of missing values.

Figure 7: Time-varying Distribution of the MHE Average Index averaged over REITs



Finally, in Figure 8, we categorize and plot the geographical distribution of properties of all the REITs in the based on their MHE Average Index.

Figure 8: Geographical Distribution of REITs and MHE Average Index



Data Description and Summary Statistics:

Our data processing yields a panel data with 3949 observations across variables pertinent to REITs' company specification, their portfolios, and financials. As described earlier, this data is augmented with the MHE Average Index. Table 1 summarizes a sub-set of variables which are used in our analysis.

Table 1. Summary Statistics[3]

Variable	N	Mean	Std. Dev.	Min	Pctl. 25	Pctl. 75	Max
MHE Index	3949	3.6	0.6	2	3.2	4	5
Green Index	3949	2	4.5	0	0	2.2	29
Rental Revenue to Asset	2586	0.025	0.0096	0	0.02	0.029	0.1
Rental Operating Expense to Asset	2584	0.0098	0.0063	-0.00008	0.0067	0.012	0.08
NOI to Asset	2591	0.016	0.0065	-0.0079	0.013	0.018	0.09
Adj. FFO to Asset	1876	0.0073	0.0039	-0.068	0.0059	0.0093	0.019
Total Assets (log)	2594	21	1.4	12	20	22	23
Debt to Asset	2594	0.57	0.18	0	0.47	0.64	2.3
Cash to Asset	2572	0.013	0.037	0	0.0018	0.012	1
Price to FFO	2429	14	8.8	2.2	10	15	197
Market to Book	2583	7.7	5.5	0	3.6	10	48
Reit Property Type	3949						
… Diversified	1057	27%					
… Health Care	183	5%					
… Hotel	130	3%					
… Industrial	363	9%					
… Multifamily	800	20%					
… Office	382	10%					
… Retail & Shopping Center	997	25%					
… Self-Storage	37	1%					

[3] Market to Book is defined as the price per share divided by book value calculated in turn as the ratio of Total Assets to (Total Assets - Common Equity).

Empirical Regression Analysis Specification for Natural Disaster Exposure (MHE)

The first part of the analysis takes a measure of the operating performance as the dependent variable. Equation 2 presents our regression model for the natural disaster exposure framework:

$$y_{it} = \beta_0 + \beta_1 MHE\ Average\ Index_{it} + \beta_2 X_{i,t-1} + \mu_i + \omega_t + \epsilon_{it} \qquad (2)$$

Summary of Regression specification:

- The dependent variable y_{it} is the Net Operating Income, Rental Revenue, Rental Operating Expense, and Adjusted FFO for REIT i at quarter t, all normalized by the Total Assets.
- The variable of interest is the MHE Average Index which captures the time varying exposure of a REIT's portfolio. This variable is influenced both by the REITs portfolio re-balancing and also the geographical distribution of historical natural disasters.
- Our control variables include financial profile of REITs, including the natural logarithm of total assets, debt to asset ratio, cash to asset ratio, price to FFO, and market to book ratio.
- In addition, we include year-quarter and REIT property type fixed effects. Heteroskedasticity robust standard errors are clustered by firm and year-quarter.

We perform a fixed effect (unbalanced) panel data regression with REIT code (snlkey) and year-quarter as the individual and time indexes, respectively.

In the following section, we detail the choice for the dependent and control variables in our methodology.

Dependent Variables

- *Rental Revenue to Asset*: This ratio indicates how effectively a Real Estate Investment Trust (REIT) is generating revenue from its assets. It's a measure of operational efficiency and profitability, making it a key indicator of a REIT's performance.
- *Rental Operating Expense to Asset*: This ratio shows the expenses incurred in operating the rental properties relative to the asset value. It helps in assessing the cost efficiency of managing the assets.
- *Net Operating Income to Asset*: This ratio is critical for evaluating the operational success of a REIT. It measures the net income generated from real estate operations in relation to the total asset value.
- *Adjusted Funds From Operations (FFO) to Asset*: Adjusted FFO is a common metric used to assess a REIT's cash flow performance. This ratio to assets provides insight into the cash flow generation capacity relative to the asset base.

Control Variables

- *Natural Logarithm of Assets*: The natural log of assets is often used to control for the size of the company. Larger companies might have different operational efficiencies and risk profiles compared to smaller ones. Using the logarithmic scale helps in normalizing the data for better comparison.

- *Debt to Asset Ratio*: This is a measure of financial leverage. It indicates what proportion of a company's assets is financed through debt. A higher ratio suggests higher risk due to increased debt financing.
- *Cash to Asset Ratio*: This ratio indicates liquidity. It reflects how much of the company's assets are in liquid form, which can be crucial for operational flexibility and risk management.
- *Price to FFO Ratio*: This is a valuation metric specific to REITs, similar to the Price/Earnings ratio in other industries. It compares the market price of the REIT's shares to its funds from operations, giving an indication of how the market values the company's cash flow.
- *Market to Book Value*: This ratio compares the market value of a company to its book value. It can indicate whether the company's assets are undervalued or overvalued by the market. For REITs, this is particularly relevant as it can show the market's perception of the underlying real estate assets.

We have two-way fixed effects for both Time (year-quarter) and REITs. Heteroskedasticity standard errors are also two-way clustered.

4. Empirical Results

We have organized the results into three distinct subsections, each looking at the impact of the MHE Average Index on REIT operations and financial performance.

The first subsection highlights the effects of the natural disaster exposure index on various operating measures of REITs. Here, we analyze how exposure to natural disasters correlates with changes in operational efficiency, property management costs, and overall asset performance. This section provides an examination of how physical risk factors influence day-to-day operations within the real estate investment sector.

The second subsection explores the interaction between the MHE Average Index and the property types managed by the REITs. Different types of properties, such as residential, commercial, industrial, and retail, may exhibit varying levels of vulnerability to natural disasters. We assess how the risk exposure of these diverse property portfolios affects the investment strategies and risk management practices of REITs. This analysis helps identify which property types are more resilient and which are more susceptible to the impacts of natural disasters.

Finally, the third subsection focuses on the implications of the MHE Average Index on some financial performance measures of REITs, additionally extending the analysis to property types once again. By understanding these dynamics, we aim to provide insights into how environmental risks are reflected in the financial health and investor perceptions of REITs.

Effects of MHE Average Index on REITs' operating performance

Table 2 presents the results of our regression analysis on the effect of MHE Average Index on four variables related to REITs' operating performance.

Table 2. Effect of MHE Average Index on REITs' operating performance

	Dependent variable:			
	NOI	Rent Revenue	Rental Operating Expence	Adjusted FFO
	(1)	(2)	(3)	(4)
MHE Index	-0.145	-0.285**	-0.152*	0.034
	(0.099)	(0.138)	(0.083)	(0.098)
Total Assets (log)	0.017	0.074	0.055*	0.013
	(0.044)	(0.070)	(0.032)	(0.037)
Debt to Asset	0.671**	1.577***	0.817***	-0.004
	(0.324)	(0.431)	(0.208)	(0.309)
Cash to Asset	-0.092	-0.123	-0.054	0.010
	(0.527)	(0.715)	(0.350)	(0.543)
Market to Book	0.002	-0.008	-0.010	0.009
	(0.010)	(0.013)	(0.007)	(0.009)
Price to FFO	-0.004***	-0.003*	0.001	-0.003**
	(0.002)	(0.002)	(0.001)	(0.001)
Year Quarter FE	Yes	Yes	Yes	Yes
Reit Property Type FE	Yes	Yes	Yes	Yes
R.sq	0.364	0.51	0.336	0.111
N	2346	2343	2342	1757
Note:				$p<0.1$; $p<0.05$; $p<0.01$
				The Coefficients are expressed in percentage.

We observe that the MHE Average Index negatively impact the Rental Revenue and NOI (normalized by total assets), while the effect on the former is statistically significant. The result shows a positive impact on Adjusted FFO, however this impact is not statistically significant. On the other hand, the Rental operating expenses are also decreasing with an increase in MHE index. These simultaneous decreasing effects on the revenue and expenses indicate that although Reits' higher portfolio exposure to areas with higher physical climate risk would expectedly decrease the rental revenue, the REITs might strategically take advantage of decreasing rental expenses.

Operating Performance Effects by Property Type

We extend the results of the effect of the MHE Average Index on the operating performance by breaking down the effects by property types. We do so by interacting the MHE Average Index with the REITs' main property type. These property types include Health Care, Industrial, Multifamily, Office, Hotel, Self-Storage, and Retail& Shopping Center. Table 3 illustrates the results.

Table 3. Effect of MHE Average Index on REITs' operating performance- Interaction with REITs' Property Type

	Dependent variable:			
	NOI	Rent Revenue	Rental Operating Expence	Adjusted FFO
	(1)	(2)	(3)	(4)
MHE Index (baseline: Diversified)	0.020	-0.087***	-0.088***	0.027**
	(0.014)	(0.026)	(0.021)	(0.011)
Total Assets (log)	-0.099***	0.007	0.071***	-0.029***
	(0.011)	(0.016)	(0.011)	(0.007)
Debt to Asset	0.015	0.996***	0.586***	-0.178***
	(0.117)	(0.091)	(0.050)	(0.048)
Cash to Asset	-0.613	-0.704	-0.726*	-0.700**
	(0.560)	(0.751)	(0.440)	(0.343)
Market to Book	0.019***	-0.002	-0.017***	0.015***
	(0.003)	(0.003)	(0.002)	(0.002)
Price to FFO	-0.008***	-0.010***	-0.003*	-0.005***
	(0.002)	(0.003)	(0.002)	(0.001)
MHE Index:Health Care	-0.002	0.003	0.031	0.032**
	(0.016)	(0.072)	(0.069)	(0.013)
MHE Index:Hotel	0.447***	-1.020***	-0.489***	
	(0.076)	(0.029)	(0.022)	
MHE Index:Industrial	0.030*	-0.183***	-0.198***	0.066***
	(0.016)	(0.028)	(0.021)	(0.012)
MHE Index:Multifamily	-0.033**	-0.137***	-0.078***	-0.029**
	(0.015)	(0.027)	(0.021)	(0.012)
MHE Index:Office	-0.020	-0.062**	-0.031	0.014
	(0.014)	(0.027)	(0.021)	(0.012)
MHE Index:Retail&Shopping Center	0.034**	-0.128***	-0.136***	0.050***
	(0.014)	(0.027)	(0.022)	(0.012)
MHE Index:Self-Storage	-0.182***	-0.369***	-0.183***	-0.038**
	(0.025)	(0.032)	(0.023)	(0.018)
Year Quarter FE	Yes	Yes	Yes	Yes
Reit Property Type FE	No	No	No	No
R.sq	0.387	0.542	0.37	0.157
N	2346	2343	2342	1757
Note:				*p<0.1;* ***p<0.05;*** p<0.01

The Coefficients are expressed in percentage. The interaction terms are adjusted to show the total effects rather than the differential effects.

These results highlight the effect of property type on the operating measures of a REIT and give a more granular view of how MHE Average Index associates with these measures depending on the property type. The results are generally in agreement with the aggregate results presented in Table 2. However, we can have more in-depth observations as follows:

- While the effect of MHE Average Index on NOI is (significantly) negative when the main property type of an REIT is Multifamily or Self-Storage, this effect is (significantly) positive for Hotel and Retail&Shopping.
- The interaction terms have consistent signs for Rental Revenue and Rental Expense. The effect of MHE Average Index is (significantly) negative for all main property types with the exception of Healthcare and Office not being statistically significant for Rental Expense.
- While the effect of MHE Average Index on Adjusted FFO is (significantly) negative when the main property type of an REIT is Multifamily or Self-Storage, this effect is (significantly) positive for Healthcare, Industrial and Retail&Shopping.
- The final takeaway is that the effect of MHE Average Index on the operating measures is not uniform across property types and REITs with different property types in their portfolio are exposed to the physical climate risk differently.

Alpha and Beta as financial measures – MHE Average Index

Our research extends to analyzing the financial impact of the Multi-Hazard Exposure (MHE) Average Index on the financial metrics of REITs. We first extract financial indicators from our dataset, focusing specifically on the abnormal returns (Alpha) and market risk (Beta) of the REITs. These parameters are derived annually and quarterly for each REIT, using the Capital Asset Pricing Model (CAPM).

For the implementation of the CAPM, we select the S&P/TSX Composite Index (SPTSX) as our market proxy, which provides a comprehensive benchmark reflecting the overall market conditions in Canada. The risk-free rate is sourced from the yields on 3-Month Canadian Treasury bills, representing a stable and conservative benchmark for calculating the theoretical rate of return on risk-free investments.

Having obtained these financial measures (Alpha and Beta), we then proceed to investigate their sensitivity to variations in our physical climate risk measure, the MHE Average Index. This analysis aims to uncover any significant correlations between the financial performance of REITs and their exposure to multi-hazard risks. By doing so, we seek to provide insights into how physical climate risks, as quantified by the MHE Average Index, might affect the valuation and risk assessment of real estate investments within the context of evolving market dynamics. This approach not only enhances our understanding of the financial implications of natural disasters on REITs but also aids in the development of more resilient investment strategies in the face of environmental uncertainties. Table 4 summarizes our results. Lastly, Table 5 applies the same analysis, however, differentiates the effect on property type as well.

Table 4. Effect of MHE Average Index on REITs' financial performance

	Dependent variable:	
	Alpha	Beta
	(1)	(2)
MHE Index	0.096	0.042
	(0.375)	(0.071)
Total Assets (log)	-0.027	0.022
	(0.142)	(0.048)
Debt to Asset	-4.083***	0.578
	(1.264)	(0.355)
Cash to Asset	-7.495*	2.396***
	(4.541)	(0.911)
Market to Book	0.103***	-0.004
	(0.027)	(0.007)
Price to FFO	-0.001	-0.005***
	(0.017)	(0.002)
Constant	1.182	0.298
	(3.602)	(1.209)
Year Quarter FE	Yes	Yes
Reit Property Type FE	Yes	Yes
R.sq	0.139	0.052
N	2406	2406
Note:	*p<0.1;* ***p<0.05;*** p<0.01	

Table 5. Alpha and Beta as financial measures - MHE Average Index by Property Type

	Dependent variable:	
	Alpha	Beta
	(1)	(2)
MHE Index (baseline: Diversified)	0.654	0.099
	(0.456)	(0.083)
Total Assets (log)	-0.141	0.025
	(0.150)	(0.051)
Debt to Asset	-4.710***	0.698*
	(1.431)	(0.420)
Cash to Asset	-8.968*	2.347***
	(4.764)	(0.816)
Market to Book	0.122***	-0.005
	(0.033)	(0.008)
Price to FFO	-0.003	-0.003
	(0.014)	(0.002)
MHE Index:Health Care	0.641	-0.113
	(0.518)	(0.096)
MHE Index:Hotel	1.532**	-0.014
	(0.646)	(0.154)
MHE Index:Industrial	1.164**	0.081
	(0.512)	(0.100)
MHE Index:Multifamily	0.747	0.040
	(0.484)	(0.088)
MHE Index:Office	0.284	0.076
	(0.492)	(0.088)
MHE Index:Retail&Shopping Center	0.732	0.100
	(0.471)	(0.090)
MHE Index:Self-Storage	-2.275***	0.068
	(0.477)	(0.088)
Constant	1.726	0.017
	(3.814)	(1.297)
Year Quarter FE	Yes	Yes
Reit Property Type FE	No	No
R.sq	0.373	0.214
N	2406	2406
Note:		*p<0.1;* ***p<0.05;*** p<0.01
		The interaction terms are adjusted to show the total effects rather than the differential effects.

As it is evident from Table 4, on an aggregate property level, the MHE Average Index does not impact the Alpha and Beta of the REITs' stock return. This indicates that the effect of the physical climate risk is already priced in the REITs' stock performance.

Based on Table 5, when the interaction of the property type with MHE Average Index is considered, a more nuanced picture can be drawn. The insignificance of MHE Average Index on Beta uniformly holds across different property types. However, depending on the main type of property in REITs portfolio, Alpha shows variation across MHE Average Index. On average, there is a positive relation between Alpha and this Index when the property type is Hotel and Industrial, while this relation is negative when the Self-Storage becomes the main property type.

5. Conclusion

This study examines the influence of physical climate risks on the Canadian real estate market through a detailed analysis of the Multi-hazard Exposure (MHE) Average Index and its impact on the operating and financial performance of Canadian Real Estate Investment Trusts (REITs). Our findings indicate that REITs with properties highly exposed to climate risks tend to report lower rental revenues and operating expenses. This suggests that while high-risk properties may generate lower income, they also incur lower operational costs, possibly due to reduced activity or strategic cost management.

Furthermore, the analysis reveals no significant direct correlation between physical climate risk exposure and abnormal stock returns, indicating that market prices might already reflect the financial implications of higher risk exposure in REITs' property portfolios. This finding aligns with the market efficiency hypothesis, suggesting that investors are already factoring these risks into stock prices.

By extending our study to examine the interactions between the MHE Index and property types within REIT portfolios, we uncover significant variations in how different types of properties are affected by climate risks. Notably, the impact on operating performance varies significantly with property type, highlighting the complex nature of climate risk as it relates to specific real estate sectors. This nuanced view provides deeper insights into the differential resilience and vulnerability of property types to natural disasters.

Furthermore, the analysis reveals no significant direct correlation between physical climate risk exposure and abnormal stock returns, indicating that market prices might already reflect the financial implications of higher risk exposure in REITs' property portfolios. This finding aligns with the market efficiency hypothesis, suggesting that investors are already factoring these risks into stock prices. Nevertheless, the analysis by property type did reveal some variability, suggesting specific conditions under which climate risks might influence financial outcomes.

In conclusion, this research contributes to the understanding of how evolving environmental factors are reshaping the financial landscape of real estate investments in Canada. It offers valuable insights for investors, policymakers, and financial institutions aiming to navigate the complexities of climate risks. The findings encourage the incorporation of sophisticated risk assessment tools in investment strategies and highlight the importance of considering specific property types when evaluating the vulnerability and resilience of real estate assets to natural disasters.

Finally, as a caveat, the construction methodology of the Multi-Hazard Exposure (MHE) Index, while comprehensive in its use of historical data and classification system, presents several limitations that may impact its accuracy and relevance. One significant limitation is the reliance on historical data dating back to 1910, which may not fully reflect current climate conditions or recent shifts in natural disaster patterns. As climate change continues to alter the frequency and intensity of natural hazards, the MHE Index could benefit from recalculating exposure based on more recent data, such as the last five years, to better capture contemporary trends. Additionally, the index currently emphasizes the frequency of disaster events without adequately accounting for their severity, which could result in regions exposed to numerous minor disasters being assessed similarly to those experiencing fewer but more severe events. Incorporating additional filters for disaster severity and conducting robustness tests could refine the index's accuracy. Moreover, some of the insignificant results observed in the current study may be attributed to these methodological limitations. Further research with a revised MHE Index that considers the scale and impact of disasters more carefully could enhance the significance of the overall findings, providing a more nuanced understanding of multi-hazard exposure and its potential effects on communities.

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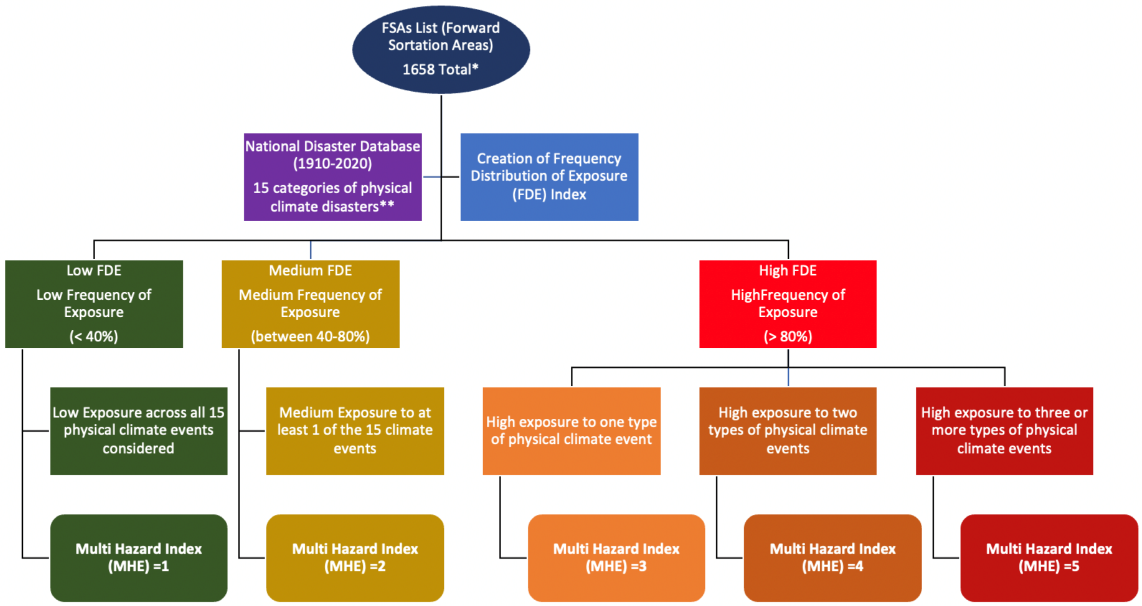
7. Appendix A



*As with Duprey et. Al

** Excludes any climate disaster that is not physical in nature such as geomagnetic storms

8. Appendix B

REITs by SNL Key and Property Type

	Institution Name	SNL Institution Key	Property Type
1	Agellan Commercial Real Estate Investment Trust	4343595	Diversified
2	Allied Properties Real Estate Investment Trust	4105044	Office
3	Artis Real Estate Investment Trust	4143679	Diversified
4	Automotive Properties Real Estate Investment Trust	4599975	Retail & Shopping Center
5	BLF Real Estate Investment Trust	4544181	Multifamily
6	Boardwalk Real Estate Investment Trust	4105048	Multifamily
7	Boulevard Industrial Real Estate Investment Trust	4439783	Industrial
8	Brookfield Canada Office Properties	4105114	Office
9	BTB Real Estate Investment Trust	4261040	Diversified
10	Canadian Apartment Properties Real Estate Investment Trust	4105050	Multifamily
11	Canadian Hotel Income Properties REIT	4105051	Hotel
12	Canadian Net Real Estate Investment Trust	4603658	Retail & Shopping Center
13	Canadian Real Estate Investment Trust	4105059	Diversified
14	CANMARC Real Estate Investment Trust	4260543	Diversified
15	Choice Properties Real Estate Investment Trust	4391351	Retail & Shopping Center
16	Cominar Real Estate Investment Trust	4105054	Diversified
17	Crombie Real Estate Investment Trust	4143678	Retail & Shopping Center
18	CT Real Estate Investment Trust	4409814	Retail & Shopping Center
19	Dream Industrial Real Estate Investment Trust	4333623	Industrial
20	Dream Office Real Estate Investment Trust	4105058	Office
21	Firm Capital Property Trust	4620265	Diversified
22	First Capital Real Estate Investment Trust	4074792	Retail & Shopping Center
23	Granite Real Estate Investment Trust	4325276	Industrial
24	H&R Real Estate Investment Trust	4105060	Diversified
25	HealthLease Properties Real Estate Investment Trust	4323912	Health Care
26	Homburg Real Estate Trust	4105020	Diversified
27	ING Summit Industrial Fund LP	4094175	Industrial

28	InnVest Real Estate Investment Trust	4105064	Hotel
29	InStorage Real Estate Investment Trust	4160147	Self-Storage
30	InterRent Real Estate Investment Trust	4202785	Multifamily
31	KEYreit	4122038	Diversified
32	Killam Apartment REIT	4143687	Multifamily
33	Lanesborough Real Estate Investment Trust	4167218	Multifamily
34	Legacy Hotels Real Estate Investment Trust	4105075	Hotel
35	Marwest Apartment Real Estate Investment Trust	28794902	Multifamily
36	Melcor Real Estate Investment Trust	4388005	Diversified
37	Minto Apartment Real Estate Investment Trust	10687522	Multifamily
38	Morguard North American Residential Real Estate Investment Trust	4315478	Multifamily
39	Morguard Real Estate Investment Trust	4105065	Diversified
40	Nexus Industrial REIT	4573165	Diversified
41	Nobel Real Estate Investment Trust	4603659	Diversified
42	Northview Apartment Real Estate Investment Trust	4105074	Multifamily
43	Northview Residential REIT	20085575	Diversified
44	NorthWest Healthcare Properties Real Estate Investment Trust	4256963	Health Care
45	NorthWest Healthcare Properties Real Estate Investment Trust	4346640	Health Care
46	O&Y Real Estate Investment Trust	4105076	Office
47	OneREIT	4122036	Retail & Shopping Center
48	Partners Real Estate Investment Trust	4256966	Retail & Shopping Center
49	Plaza Retail REIT	4305303	Retail & Shopping Center
50	Primaris Real Estate Investment Trust	101459644	Retail & Shopping Center
51	Primaris Retail Real Estate Investment Trust	4105140	Retail & Shopping Center
52	Pro Real Estate Investment Trust	4381232	Diversified
53	Pure Industrial Real Estate Trust	4256969	Industrial
54	Retirement Residences Real Estate Investment Trust	4105077	Health Care
55	RioCan Real Estate Investment Trust	4105107	Retail & Shopping Center
56	Slate Office REIT	4342791	Office
57	SmartCentres Real Estate Investment Trust	4105055	Retail & Shopping Center
58	Summit Industrial Income REIT	4339972	Industrial

59	Sunrise Senior Living Real Estate Investment Trust	4097277	Health Care
60	TGS North American Real Estate Investment Trust	4105176	Office
61	TransGlobe Apartment REIT	4255961	Multifamily
62	True North Apartment Real Estate Investment Trust	4331165	Multifamily
63	True North Commercial Real Estate Investment Trust	4336700	Office
64	Whiterock Real Estate Investment Trust	4143684	Diversified