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Hedging Geopolitical Risks with Real Estate Investments - Evidence from the COVID-19 Pandemic

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Abstract:

This study investigates the potential of Real Estate Investment Trusts (REITs) as hedging instruments against geopolitical and physical risks, focusing on their performance during the COVID-19 pandemic. Using a comprehensive dataset from June 2014 to May 2024, the analysis incorporates daily data on REIT indices across seven regions alongside proxies for geopolitical risks (COVOL and GPR) and physical climate risks (e.g., hurricanes and global warming). Quantitative methods, including regression models, VAR, GARCH, and risk-adjusted metrics, evaluate REITs' sensitivity to these risks.

The findings reveal significant regional disparities. While US and European REITs demonstrate resilience, regions like Canada, Australia, and China exhibit heightened sensitivity to geopolitical volatility. Interaction effects indicate that physical risks amplify geopolitical impacts, especially in areas prone to extreme weather events. The COVID-19 pandemic exacerbated these dynamics, with geopolitical risks intensifying the adverse effects on REIT returns globally, particularly in Canada, Australia, and China.

The results highlight REITs' potential as diversification tools, especially in developed markets, while cautioning against higher volatility in emerging markets. These insights contribute to portfolio diversification strategies and emphasize the importance of institutional resilience and climate risk mitigation. This research advances the understanding of REITs' performance under compounded crises, addressing a critical gap in the literature on alternative hedging mechanisms.

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Sumário:

Este estudo analisa o potencial dos fundos de investimento imobiliário (REIT) como instrumentos de cobertura contra riscos geopolíticos e físicos, centrando-se no seu desempenho durante a pandemia do COVID-19. Usando um conjunto de dados abrangente de junho de 2014 a maio de 2024, a análise incorpora dados diários sobre índices REIT em sete regiões, juntamente com proxies para riscos geopolíticos (COVOL e GPR) e riscos climáticos físicos. Métodos quantitativos, incluindo modelos de regressão, VAR, GARCH e métricas ajustadas ao risco, avaliam a sensibilidade dos REITs a estes riscos.

Os resultados revelam disparidades regionais significativas. Embora os REIT dos EUA e da Europa demonstrem resiliência, regiões como o Canadá, a Austrália e a China apresentam uma maior sensibilidade à volatilidade geopolítica. Os efeitos de interação indicam que os riscos físicos amplificam os impactos geopolíticos, especialmente em áreas propensas a eventos climáticos extremos. A pandemia de COVID-19 exacerbou esta dinâmica, com os riscos geopolíticos a intensificarem os efeitos adversos nos retornos dos REIT a nível mundial, em particular no Canadá, Austrália e China.

Os resultados destacam o potencial dos REITs como ferramentas de diversificação, especialmente nos mercados desenvolvidos, enquanto alertam para uma maior volatilidade nos mercados emergentes. Estes conhecimentos contribuem para as estratégias de diversificação de carteiras e sublinham a importância da resiliência institucional e da mitigação dos riscos climáticos.

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Palavras-chave: Investimentos Imobiliários; REITs; Riscos Geopolíticos; Riscos Físicos; Pandemia COVID-19; Volatilidade Comum Global; Índice de Risco Geopolítico

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Introduction

1. Background of the study

In an interconnected global economy, the financial markets can be directly affected by geopolitical and physical climate risks. Different events such as international conflicts (wars), tariff battles, pandemics (such as the COVID-19) and natural disasters have shown their impact on financial market stability and performance. The search for hedging mechanisms by investors to protect against those risks has become one of their main concerns; even though the conventional hedge mechanisms, such as gold and government bonds, are still used in many cases, the search for new instruments has significantly increased in recent years.

Real Estate Investment Trusts (REITs) are described as a hybrid asset class since it combines fixed income and equity, due to represent a stable income source with regular income distribution (required by law in most jurisdictions) while also experiencing appreciation based on the value of the underlying assets (Real Estate properties) which makes it an inflation hedging mechanism and one of the instruments earning most significant attention. REITs have thus emerged as one of the possible instruments to hedge against geopolitical risks, in response to the rising need to evaluate if those mechanisms can effectively hedge during periods of high geopolitical volatility.

2. Problem Statement

Geopolitical risks, measured by indices such as the geopolitical risk index (GPR)¹ developed by Caldara and Iacoviello (2018) or the global common volatility (COVOL)² of Engle and Campos-Martins (2023), show significant impact on global financial markets while influencing returns across several assets and increasing markets volatility. While there are several detailed studies on traditional safe-heaven assets and mechanisms, the capacity of hedging geopolitical risks by REITs is still unclear. As a case study, the COVID-19 pandemic can be seen as a geopolitical event since it created direct health impact and supply chain disruptions whilst at the same time precipitated tensions between nations creating an economic downturn and a shift in global power dynamics. Understanding how REITs perform under such geopolitical events

¹ The Caldara and Iacoviello GPR index reflects automated text-search results of the electronic archives of 10 newspapers: Chicago Tribune, the Daily Telegraph, Financial Times, The Globe and Mail, The Guardian, the Los Angeles Times, The New York Times, USA Today, The Wall Street Journal, and The Washington Post. Caldara and Iacoviello calculate the index by counting the number of articles related to adverse geopolitical events in each newspaper for each month (as a share of the total number of news articles).

² Global common volatility (COVOL) is a statistical measure of the magnitude of such shocks that helps explain large unexpected financial outcomes and why they are often common to a wide range of financial asset prices. The global COVOL model of Engle and Campos-Martins (2023) is simple, the estimation and testing are easy to implement and can capture complex shocks with global impact that make financial asset prices worldwide move unexpectedly at the same time.

has important implications for investors looking for diversification and stability of their portfolios.

Although the existing literature highlights the performance of REITs, there is still a gap in research regarding their capacity to hedge during economic and financial crises, more so during major global disruptions such as pandemics. This research seeks to fill this gap by analysing the impact of geopolitical tension across different regions and the effects of COVID-19 on several REITs returns.

3. Research Objective

The main goal of this research is to evaluate the efficacy of REITs as hedging instruments against geopolitical risks. In detail, this study is intended to:

- Evaluate the relationship between geopolitical risks (proxied by GPR and COVOL) and REITs returns across different regions of the world.
- Analyse the impact of physical climate risks, such as extreme temperatures, global warming, and hurricanes/floods on REITs performance.
- Study the performance of REITs during the COVID-19 pandemic, by checking their resilience and hedging potential in a high-risk environment.

4. Research Questions and Hypotheses

The study focuses on the following research questions:

- How do geopolitical risks, as measured by GPR and COVOL, influence REITs returns across regions?
- To what extent do physical climate risks amplify the effects of geopolitical risks on REITs performance?
- Do REITs demonstrate hedging potential during major geopolitical events and is this heterogenous across regions? Evidence from the COVID-19 pandemic.

To answer these questions, we test the following hypotheses:

- H1: REITs act as effective hedging instruments against geopolitical risks, with positive or resilient returns during periods of increased geopolitical volatility.
- H2: The compounded effects of geopolitical and physical climate risks significantly influence REITs returns, with variations across regions.
- H3: REITs provide consistent hedging potential during the COVID-19 pandemic, showing hedging potential for periods of heightened risk.

5. Significance of the study

The main goal of the study is to improve the research on alternative hedging strategies when we face a paradigm of increased geopolitical risks. Using REITs, we aim to search for signs of mitigation of market volatility during geopolitical and systemic crises using Real Estate investments. It also aims to understand the interaction between geopolitical and physical climate risks, providing a comprehensive analysis of the actual financial and political landscape.

Practically speaking, this study intends to show investors, portfolio managers and policymakers about the potential of REITs as a diversification mechanism for investment portfolios, particularly in regions with increased vulnerability to geopolitical and physical climate risks. Furthermore, the analysis focusses on COVID-19 pandemic, as a case study, to investigate the potential impact of future crisis where global common risks coincide with geopolitical uncertainty.

Literature Review

Geopolitical risks originate in political events, like wars, terrorism, policy uncertainties and tensions between nations which may affect the global financial markets and economies. The GPR index, for instance, was developed by Caldara and Iacoviello (2022) to help researchers and policymakers quantify these risks and measure their impact on the economy and macroeconomic stability.

These risks gained more importance during recent years with the Russia-Ukraine war, the US vs China tensions, and the COVID-19 pandemic. The events amplified worldwide volatility which directly affected major assets performance (Lang et al., 2024). The COVID-19 pandemic, for example, created a new compounded effect that shutdown supply chains and accentuated international tensions while amplifying pre-existing vulnerabilities.

1. Geopolitical Risks and Financial Markets

Several studies show that geopolitical risks have a significant influence on financial markets. Those risks often have a strong influence on market volatility, which may affect several asset sectors, from equities, bonds and commodities (Engle and Campos Martins, 2023). Lang et al. (2024) also identify the transmission of volatility as a critical phenomenon during geopolitical crises in which systemic risks are transmitted all over the world.

Measures like COVOL (short for common volatility) by Engle and Campos Martins (2023) can be used to effectively measure and analyse those global risks. The authors highlight how COVOL, alongside the GPR index, identifies periods of extreme volatility and their cross-market effects and state that for emerging markets, the impact of geopolitical risks can be more pronounced due to weaker institutional resilience (Engle and Campos-Martins, 2023).

Assets like gold, US Treasury bonds and specific currencies, known as the tradition safe-haven assets, have outperformed most of the other assets during periods of geopolitical instability. As proposed by Baur and Smales (2020), those assets give investors some protective characteristics against the increase in volatility. Nonetheless, Będowska-Sójka et al. (2022) showed several mechanisms which can be used as alternative hedges, like the REITs, that can provide some diversification benefits during times of increased geopolitical risk.

2. The Role of Real Estate Investment Trusts (REITs) in mitigating geopolitical risks

Real estate investments, specifically through real estate investment trusts (REITs), can have some distinctive characteristics that make them a promising investment for periods of heightened geopolitical risks. Their dual nature as income-generating assets and tangible real estate gives them a distinct risk-return profile and enables them to act as a hedge against geopolitical uncertainty.

As stated by Salisu et al. (2020), REITs consistently delivered stable returns, which led them to outperform some other asset classes during times of increased geopolitical risk. Nevertheless, REITs' performance is quite geographically dependent, with REITs in emerging markets showing higher volatility justified by their larger exposure to other external shocks. Furthermore, as Salisu et al. (2020) noted, REITs also exhibit inflation-hedging benefits, adding to their value as strategic assets during turbulent periods.

However, it's important to note that the REIT sector itself also demonstrates variability, with the residential REITs often outperforming during periods of crisis, justified by their relatively inelastic demand. In contrast, the commercial and retail REITs tend to underperform since there are more sensitive to macroeconomic downturns (Salisu et al., 2024).

3. Interaction Between Geopolitical and Physical Climate Risks

Physical climate risks, like extreme weather events or sea level rise, tend to exacerbate the effects of geopolitical risks. Physical weather events can have a harmful impact on real estate markets, particularly in exposed regions like coastal zones or more urbanized areas. This

emphasizes the need to quantify these physical risks and their interactions with geopolitical risks using frameworks like the media climate change concerns (MCCC) index of Ardia et al. (2022).

In particular, the intersection of health, geopolitical, and climate risks during the COVID-19 pandemic presented unique challenges for markets in general (Hanif et al., 2023) and policymakers, which may reveal that compounded effects of geopolitical and physical risks amplify volatility and lead to differential impacts on asset classes, including REITs.

4. COVID-19: A Case Study

The COVID-19 pandemic provides an excellent example on how compounded effects of both geopolitical and physical climate risks can affect the overall market dynamics with several geographic differences emerging. While the more developed markets such as the US and Europe have shown more efficient and fast recovery paths, emerging markets take more time, reflecting the role of institutional resilience in mitigating compounded risks (Hanif et al., 2023).

In addition, the pandemic aggravated the consequences of volatility and uncertainty on global financial markets, which emphasises the importance of metrics such as COVOL in quickly capturing geopolitical risks (Campos-Martins and Hendry, 2023, Karagozolu et al., 2022).

5. Risk-Adjusted Returns: Sharpe and Sortino Ratios

Several risk-adjusted metrics, such as the Sharpe ratio and the Sortino ratio, can provide critical insights and measures of REIT performance during geopolitical and physical events. These metrics evaluate the returns in relation to the risk carried by the assets, in this case, real estate investments.

The Sharpe ratio calculates the return per unit of total risk, while the Sortino ratio focuses specifically on downside volatility, which makes it even more relevant during crises like the COVID-19 pandemic or following extreme physical events. Empirical evidence suggests that REITs maintain favourable risk-adjusted returns during geopolitical crises, further supporting their role as hedging tools (Hanif et al., 2023; Coën and Desfleurs, 2024).

6. Methodological Approaches in Geopolitical Risk Research

The methodologies for studying geopolitical risks have moved forward significantly in recent years. Some regression models, like linear, multivariate, and regressions using interaction terms, are commonly used to test and study the different effects of geopolitical and physical risks on REIT returns. Other approaches like de Difference-in-Differences (DiD) have seen

their use increase, especially for isolating effects of specific events like the COVID-19 pandemic on REIT performance.

Event studies have also gained importance in evaluating REIT responses to geopolitical events, such as the Russo-Ukrainian war and major policy changes (Będowska-Sójka et al., 2022). These methodologies enable nuanced insights into REITs performance under varying risk conditions.

7. Future Directions and Implications

Despite the significant advances on research and the existing evidence, we do not fully understand the relation between geopolitical risks, physical risks and real estate or the mechanisms by which important, complex events can trigger crises in the sector.

Hanif et al. (2023) emphasized the importance of focusing on emerging markets since geopolitical risks and institutional weaknesses often compound to exacerbate market vulnerabilities. Studying this heterogeneity across countries and regions of the world is yet to be done.

Lastly, by examining the role of REITs in more diversified portfolios that suffer from high-risk conditions can offer critical insights for investor decision-making, specifically in regions with consistent resilience during crises (Hanif et al., 2023; Coën and Desfleurs, 2024).

Theoretical Framework

The foundation behind this study aims to explore the connection between geopolitical risks, financial markets and real estate investments. Specifically, we focus on real estate investment trusts (REITs) to evaluate the role of REITs as potential hedging instrument against geopolitical risks by using finance theory and risk management principles.

1. Geopolitical Risks and Financial Markets

Geopolitical risks arise from political events such as wars, terrorism, trade disputes and policy uncertainties that disrupt market stability, increasing uncertainty and volatility in financial markets while reducing investor confidence.

The geopolitical risk index (GPR) of Caldara and Iacoviello (2022) is a text-based measure that quantifies these risks and is used as proxy for measuring geopolitical risks in the study. In addition, we also use the global common volatility (further stated as COVOL) of Campos-

Martins and Engle (2023), a statistical measure based on asset prices that aims to capture broad geopolitical risks and market-wide volatility across different asset classes.

By using these proxies, we are in line with the efficient markets hypothesis (EMH) which states that the markets react almost instantly to new information, arising for instance from geopolitical events, and which will have an impact on asset prices. Nevertheless, under increase uncertainty, some discrepancy from market efficiency may occur, which motivates for the creation of hedging strategies.

2. REITs as hybrid assets and risk mitigation tools

Real estate investment trusts have characteristics of both equities and fixed income instruments. These assets provide a regular fixed income (with dividends) whilst they can also appreciate over time (real estate properties). This hybrid classification places them as a different asset class, possessing both diversification and inflation-hedging potential. The REITs capacity in mitigating several risks can be explained by the following theoretical principles:

- **Modern portfolio theory (MPT):** Proposed by Markowitz (1952), points the importance of diversifying portfolios to reduce risks. REITs, as an unconventional asset class, can help to diversify portfolios by offering a low correlation with different asset classes, especially during geopolitical crisis.
- **Asset pricing models:** The **capital asset pricing model (CAPM)** aims to explain how market (or systematic) risks (including geopolitical risks) can influence asset returns. We employ a CAPM-based methodology to examine the correlation between REIT returns and geopolitical risks (using proxies like GPR and COVOL) to calculate hedge ratios, which helps to test if REITS can mitigate those risks.
- **Safe-haven theory:** During periods of increased risk, traditional safe-haven assets, like gold or the US Treasury bonds are searched for due to their capability of preserving value. Our analysis aims to discover if REITs can show similar properties by keeping steady returns or decreased volatility during geopolitical and physical risk periods.

3. Compounding Effects of Geopolitical and Physical Risks

The interaction between geopolitical risks and physical risks, like extreme weather events, natural disasters, and climate change, increases the complexity of the dynamic of risk-return of REITs. The **MCCC index** is a text-based measure that can capture physical climate risks, which we use to analyse their compounded effects with geopolitical risks on REITs performance.

The idea is to analyse how interconnected risks can increase volatility and disrupt global markets. The inclusion of interaction terms (e.g., $GPR \times \text{Physical Risks}$ or $COVOL \times \text{Physical Risks}$) in the regression models offers a more comprehensive analysis of how REITs respond simultaneously to multiple risk factors.

4. Volatility Modelling and Risk-Adjusted Performance

Understanding volatility is important to assess the resilience of REITs during periods of geopolitical uncertainty. To study the influence of geopolitical risks on REIT returns and volatility, we assume a factor model with **generalized autoregressive conditional heteroskedastic (GARCH)** errors. In this setting, innovations to returns can exhibit the stylized feature of **volatility clustering where** large changes in asset prices are often followed by large changes, regardless of the direction of change.

To provide even more theoretical support for evaluating REITs hedging capabilities, some risk-adjusted performance metrics, such as the **Sharpe ratio** and **Sortino ratio** are also used. These metrics help balance returns against downside risks while offering a nuanced perspective on the different trade-offs associated with investing in this specific asset (REITs) during more volatile periods.

5. Regional Perspectives

Another layer of complexity is introduced with the geographical variability of the REITs. Regional disparities in the exposure to geopolitical risks and institutional resilience can influence the REITs performance. For example, developed markets with robust legal frameworks may exhibit lower volatility compared to emerging markets, where geopolitical shocks are more pronounced.

This study uses different key financial and risk management theories to understand the role of REITs as hedging mechanisms for geopolitical risks. By using theoretical concepts such as portfolio diversification, safe-haven properties, and volatility dynamics, this study aims to create a robust framework that analyses the relations between REITs' performance, geopolitical risks, and physical climate risks, contributing to fulfil a critical gap in understanding the hedging potential of REITs in an era of increased global uncertainties.

Methodology

1. Research Design:

This study uses quantitative methods with the main goal of evaluating the role of real estate investment trusts (REITs) as a hedging mechanism, specifically against geopolitical and physical climate risks. By using econometric models, this research aims to study and identify the relations between REITs returns and some proxies used for geopolitical and physical risks over a 10-year time span from June 2014 to May 2024. The daily frequency of data enables a detailed examination of both short-term dynamics and long-term trends, especially during times of increased global risks like the COVID-19 pandemic. To better understand the hedging potential and the risk-adjusted performance of the REITs, the study makes use of regression analysis, event studies, and volatility analysis.

2. Data Collection Methods:

REITs prices were retrieved from DataStream, with a focus on S&P REIT indices to ensure consistency and representativeness. These indices include Global, the US, Canada, Europe, Australia, Latin America, and China. The global common volatility (COVOL) index was provided by V-Lab (at the Volatility and Risk Institute, New York University Stern School of Business), while the geopolitical risk (GPR) index came from Matteo Iacoviello's database. Physical risk (text-based) factors, such as extreme temperatures, global warming, and hurricanes/floods, were obtained from MCCC Sentometrics³, a measure that quantifies the level of public concern about climate change based on the frequency and sentiment of media coverage. It captures variations in media attention to climate change issues, serving as an indicator of public awareness and potential policy focus over time. To establish market benchmarks, daily S&P 500 prices were collected and converted into log returns. Risk-free rates were sourced from Kenneth French's data library. Furthermore, a COVID-19 dummy variable was created to represent the period from February to March 2020, which marks the main period of the pandemic. The final dataset includes more than 2000 daily observations for each variable.

3. Sample Selection and Size:

The sample is representative since it includes daily observations for risk proxies and REITs indices across a ten-year period from June 2014 to May 2024. This period is chosen to cover a variety of systemic hazards and geopolitical events, including trade disputes, the COVID-19 pandemic, and shocks connected to climate change. It successfully captures both global and

³ Media Climate Change Concerns Index: <https://sentometrics-research.com/download/mccc/>

regional dynamics by combining seven REITs indices from different locations, enabling comparisons of REITs performance in diverse risk situations.

4. Description of Variables:

In this analysis we divided the variables into 4 types:

The **dependent variables** include the log-returns of REITs indices, calculated as:

$$R_{i,t}^{\text{REIT}} = \ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right) * 100,$$

where, $R_{i,t}^{\text{REIT}}$ represents the daily log-return of the i^{th} REIT, $P_{i,t}$ is the price of the REIT i at time t and $P_{i,t-1}$ is the price of the same series at time $t-1$. This calculation ensures static and interpretable percentages changes.

The **independent variables** include 1. the COVOL⁴ (short for global common volatility) that aims to capture geopolitical market volatility using financial asset prices, was treated by $(COVOL)^2 - 1$ which isolates unexpected variations in systemic risk beyond the baseline, enhancing its explanatory power for financial market analysis. 2. the GPR⁵ (geopolitical risk index) that measures geopolitical tensions using text-based analysis and their impact on the markets that was treated by $\ln(GPR_t) - \ln(GPR_{t-1})$ to capture the relative change in geopolitical risk over time, emphasizing its dynamic fluctuations rather than absolute levels and 3. the text-based proxies of physical climate risks, in particular media-based concerns about extreme temperatures, global warming, and hurricanes/floods.

As the **control variables**, we use the COVID-19 dummy, interaction terms between independent variables for compounded effects, and lagged variables for robustness checks. Lastly, as **complementary variables, we include** the S&P 500 logged returns and the risk-free rate to enhance the event study and the risk-adjusted return analysis.

5. Correlation Analysis:

We start by providing a simple statistical measure of the association between REITs returns and geopolitical risks. Using the Pearson correlation coefficient gives some insight on whether REITs returns are positively or negatively associated with those risks. A strong positive correlation indicates that REITs returns tend to rise and fall alongside global and geopolitical risk levels, whereas a negative or minimal correlation suggests that REITs could serve as effective hedging tools. This analysis is of high-level importance since it can help to identify

⁴ Global Common Volatility: <https://vlab.stern.nyu.edu/docs/covol/COVOL>

⁵ Geopolitical Risk Index: <https://www.matteoiacoviello.com/gpr.htm>

whether REITs are sensitive to geopolitical risk proxies or if they provide stability and security during uncertain times. For example, if there are low correlations with COVOL during high-risk periods, it could suggest that REITs are a good option for diversifying portfolios.

6. Basic Linear Regression:

To assess the direct effects of COVOL and GPR on the different REITs returns, we use a basic linear regression using the following equation:

$$R_{i,t}^{\text{REIT}} = \alpha_i + \beta_{1,i} * COVOL_t + \beta_{2,i} * GPR_t + \epsilon_{i,t},$$

where $\beta_{1,i}$ and $\beta_{2,i}$ are used to test the sensitivity of the i^{th} REIT log-returns to changes in geopolitical risks. Positive coefficients imply that REITs tend to perform well or maintain stability in these situations, whereas negative coefficients point to potential weaknesses. This analysis provides a foundational understanding of the risk-return dynamics, assisting investors in evaluating whether REITs can provide stability amid geopolitical unrest. For instance, a positive correlation with GPR may underscore the resilience of REITs during political conflicts, which can be beneficial for portfolio construction strategies.

7. Multivariate Regression:

To improve the linear regression, the multivariate regression aims to incorporate physical risk factors, such as extreme temperatures, global warming, and hurricanes/floods. The regression has the form (although models are different, we keep the same notation for simplicity):

$$R_{i,t}^{\text{REIT}} = \alpha_i + \beta_{1,i} * COVOL_t + \beta_{2,i} * GPR_t + \beta_{3,i} * PHYSICAL_t + \epsilon_{i,t}.$$

This regression tries to test whether physical climate risks either independently or jointly have some influence on REITs returns side by side with geopolitical risks. In case of significant coefficients for the physical risk variables, this highlights the exposure of REITs to climate-related risks, which emphasizes the compounded nature of geopolitical risks. For example, if extreme temperatures have a significant effect on REITs returns in Latin America but not in the US, this information can guide regional investment strategies and highlight geographic weaknesses.

8. Multivariate Regression with Interaction Terms:

To understand the compounded effects of geopolitical and physical risks on the REITs returns, we expand the multivariate regression to incorporate interaction terms between geopolitical

risks (using the proxies COVOL and GPR) and physical risks (extreme temperatures, global warming, and hurricanes/floods). In this setting, the regression being estimated becomes

$$R_{i,t}^{\text{REIT}} = \alpha_i + \beta_{1,i} * COVOL_t + \beta_{2,i} * GPR_t + \beta_{3,i} * PHYSICAL_t \\ + \beta_{4,i} * (COVOL_t * PHYSICAL_t) + \beta_{5,i} * (GPR_t * PHYSICAL_t) + \epsilon_{i,t}.$$

With the use of the interaction terms, the analysis aims to better understand how physical risks increase or decrease the influence of geopolitical risks on REITs returns. For example, a significant positive $\beta_{4,i}$ would suggest that physical risks intensify the negative effects of geopolitical volatility on REITs performance.

9. Difference-in-Differences (DiD) Analysis:

The DiD analysis is focused on measuring the impact of the COVID-19 pandemic (dummy variable $I_{\text{COVID},t}$) on REITs returns, using COVOL as a metric for these risks:

$$R_{i,t}^{\text{REIT}} = \alpha_i + \beta_{1,i} * I_{\text{COVID},t} + \beta_{2,i} * COVOL_t + \beta_{3,i} * (I_{\text{COVID},t} * COVOL_t) + \epsilon_{i,t}$$

The interaction term $I_{\text{COVID},t} * COVOL_t$ aims to test the compounded effect of geopolitical risks during the COVID-19 pandemic. A significant $\beta_{3,i}$ may indicate the COVID-19 increased or decreased the influence of geopolitical risks on REITs returns, depending on the sign of the coefficient. For example, a higher impact on REITs return during the pandemic may indicate an increased sensitivity to global and geopolitical risks.

10. Lagged Variable Analysis:

To better understand our results and address any potential endogeneity, lagged variables for COVOL, GPR and physical risks are used as follows:

$$R_{i,t}^{\text{REIT}} = \alpha_i + \beta_{1,i} * COVOL_{t-1} + \beta_{2,i} * GPR_{t-1} + \beta_{3,i} * PHYSICAL_{t-1} + \epsilon_{i,t}$$

These lagged variables are introduced to ensure that the previous values of geopolitical risk (COVOL/GPR) do not disproportionately affect the actual REITs returns.

11. Risk-Adjusted Return Analysis:

To evaluate REITs performance during higher risk periods, this analysis uses Sharpe and Sortino ratios:

- $\text{Sharpe Ratio} = \frac{\text{Mean Excess Returns}}{\text{Standard Deviation of Returns}}$
- $\text{Sortino Ratio} = \frac{\text{Mean Excess Returns}}{\text{Downside Deviation of Returns}}$

When these two ratios present a high value during volatile periods, identified by the higher 10% values of COVOL, it indicates favourable risk-adjusted returns, which may demonstrate REITs resilience. For example, a high Sortino ratio can demonstrate REITs' ability to minimize losses during recessions, making them attractive to risk-averse investors. This analysis quantifies the stability of REITs in relation to their risks, which helps in the portfolio optimization.

12. Event Study Analysis:

To assess the market's reaction on March 11, 2020, the day that COVID-19 was declared a pandemic by the World Health Organization, we proceed with an event study that estimates the expected returns as

$$E(R_{i,t}^{\text{REIT}}) = \alpha_i + \beta_i * R_{i,t}^{\text{S\&P500}},$$

and the abnormal returns calculated as:

$$A(R_{i,t}^{\text{REIT}}) = R_{i,t}^{\text{REIT}} - E(R_{i,t}^{\text{REIT}})$$

The cumulative abnormal return (CAR) result from aggregating the abnormal returns over the event window to measure the total impact of the event. To determine whether CARs present market sensitivity (significantly different from zero) some statistical tests are carried out. For instance, significant CARs during the event window suggest that REITs were notably impacted by the declaration of the pandemic, highlighting their response to global and geopolitical shocks.

13. Hedge Ratio Analysis:

To estimate hedge ratios, we use the CAPM and VAR models. The CAPM regression is given by

$$R_{i,t}^{\text{REIT}} = \alpha_i + \beta_i * RISK_t + \epsilon_{i,t}$$

where *RISK* is the risk proxy i.e., either COVOL or GPR, the coefficient β_i represents the hedge ratio, measuring how well REITs offset risks. For dynamic interactions, the VAR model examines how shocks in COVOL and GPR affect REIT returns over time. This analysis informs investors on the optimal allocation to REITs for mitigating geopolitical risks.

14. GARCH Analysis:

These models are used to assess the volatility dynamics of REITs returns:

$$\sigma_{i,t}^2 = \alpha_i + \beta_{i,1} * \epsilon_{i,t-1}^2 + \beta_{i,2} * \sigma_{i,t-1}^2,$$

where σ_t^2 presents the conditional variance of REIT i . By adding COVOL, GPR and the physical risk proxies to the model builds up and helps to evaluate their influence on volatility. If, for example, there is an outstanding impact of GPR over $\sigma_{i,t}^2$ it shows up as the REIT's sensitivity to geopolitical risks. To identify periods of increased risk, we visualize predicted volatilities, which can directly help in risk management and strategic allocation decisions.

Data Analysis and Results:

1. Correlation Analysis

Table 1: Correlation Analysis - Result

Region	REITs - Log Return (%)	
	COVOL-REIT Correlation	GPR-REIT Correlation
Global	-0,027	-0,001
USA	-0,011	0,006
Canada	-0,060	-0,015
Europe	-0,019	-0,001
Australia	-0,059	-0,008
Latin America	-0,019	-0,015
China	-0,076	-0,034

The correlations shown in Table 1 highlight the diversified sensitivity of REITs to the global and geopolitical risk proxies and key findings across regions. Global REITs demonstrate weak negative correlations with COVOL (-0,027) and GPR (-0,001) suggesting that geopolitical risks have nearly zero effect on REITs returns, making them a stable option for diversification. In parallel, European REITs also show very low correlations (-0.019 for COVOL and -0.001 for GPR) which confirms their resilience and hedging potential.

The US REIT also demonstrates minimal sensitivity to COVOL (-0,011) however it shows a slightly positive correlation with GPR (0,006). This might indicate that a robust market like US can remain stable under periods of increased volatility which may reflect strong investor confidence. Nevertheless, it is important to note that GPR is computed based on US newspapers and so it might be the case that US investors are quicker at responding to geopolitical events than investors in other countries. The correlations for Canada highlight their vulnerability to

geopolitical risks by showing a stronger negative correlation with COVOL (-0,06) and a weakly negative relation with GPR (-0,015).

In relation to Australia, its REIT shows a moderate sensitivity to COVOL (-0,059) however a minimal exposure to GPR (-0,008), probably justified by their economic positioning. Latin America demonstrates similar weak negative correlation with both COVOL and GPR (-0,019 and -0,015, respectively), likely explained by its not well-developed REITs market and institutional vulnerabilities that can make the region more exposed to global shocks. Chinese REITs show the highest negative correlation (-0,076 for COVOL and -0,034 for GPR), showing a significant sensitivity to geopolitical risks, reflecting the region increased exposure for these global shocks.

In summary, more developed markets like the US and Europe show greater resilience whereas emerging markets demonstrate higher sensitivity. This analysis underscores the importance of regional diversification while creating a portfolio to better manage exposure against geopolitical risks.

2. Basic Linear Regression:

Table 2: Basic Linear Regressions - Results

REIT Name	COVOL Coefficient	COVOL P-Value	GPR Coefficient	GPR P-Value	R-squared	Adj. R-Squared
Global REIT	-0.022214	0.175	-0.0036518	0.933	0.0007	-0.0001
USA REIT	-0.0116241	0.569	0.01584	0.770	0.002	-0.0006
Canada REIT	-0.0607952	0.002	-0.0417379	0.431	0.0039	0.0031
Europe REIT	-0.0205871	0.352	-0.0030536	0.958	0.0003	-0.0005
Australia REIT	-0.0660325	0.003	-0.025878	0.663	0.0035	0.0027
Latin America REIT	-0.0180966	0.324	-0.0371502	0.444	0.0006	-0.0002
China REIT	-0.0508181	0.000	-0.061576	0.078	0.0070	0.0062

Our regression analysis is intended to measure the sensitivity of REITs returns to geopolitical risks, as measured by COVOL and GPR. The results across the different regions show outstanding trends and divergences, showing regional heterogeneity of risk exposure.

For the Global REIT, both COVOL and GPR have negative coefficients (-0.022 and -0.0036, respectively) but neither is statistically significant suggesting that, on a global scale, REITs returns are not influenced by geopolitical risks. Comparably, for the US the coefficients for COVOL and GPR are also insignificant, showing no impact of these risks on REITs returns.

This result can indicate that the US market is considerably resilient to periods of higher volatility, likely due to their market development and stability.

For Canada, we see a different pattern. COVOL presents a significant negative coefficient (-0.060, p-value = 0.002), indicating that geopolitical risks can have an adverse impact on its REITs returns implying that Canada REIT's market is quite sensitive to these risks, probably justified by their exposure to external shocks.

When analysing Europe, neither COVOL nor GPR demonstrates to have a statistically significant impact, showing that the European market has limited sensitivity to global and geopolitical risks. This may reflect a good diversification level on the market that helps to mitigate the impact of heightened volatility.

Australian REITs show a significant negative relationship with COVOL (-0.066, p-value = 0.003), suggesting that geopolitical risks can impact the country's REIT returns, potentially explained by their integration with global markets.

The Latin America REIT shows no significant relationship with either of the geopolitical risk proxies, reflecting a possibly higher level of market inefficiency. Lastly, China REIT reveals some sensitivity to COVOL (-0.050, p-value = 0.000) and a significant relationship with GPR (-0.061, p-value = 0.078) considering a 10% significance level. This result may indicate that Chinese REITs are particularly vulnerable to geopolitical risks, reflecting the increased economic uncertainty in the region.

In sum, we conclude that there are regional disparities in the REITs sensitivity to geopolitical risks. Canadian, Australian and Chinese markets show a stronger relationship with geopolitical risks suggesting that these markets have a big exposure to volatility while others may benefit from protection against global disruptions. This information can be of high value for investors aiming to understand the regional vulnerabilities with respect to global and geopolitical risks, and for policymakers aiming to improve market resilience.

3. Multivariate Regression Analysis:

Table 3: Multivariate Regression Analysis - Results

REIT Name	COVOL Coefficient	COVOL P-Value	GPR Coefficient	GPR P-Value	Extreme Temperatures Coeff.	Extreme Temperatures P-Value	Global Warming Coeff.	Global Warming P-Value	Hurricanes & Floods Coeff.	Hurricanes & Floods P-Value	R-Squared	Adj R-Squared
Global REIT	-0.0220727	0.179	-0.0047346	0.913	0.0206583	0.389	-0.0261475	0.423	0.0001444	0.994	0.0012	-0.0007
USA REIT	-0.0112338	0.583	0.0142302	0.793	0.0335077	0.263	-0.0431492	0.246	0.0026344	0.917	0.0011	-0.0009
Canada REIT	-0.0613266	0.002	-0.0436178	0.411	0.0215133	0.463	-0.0363958	0.318	-0.0034977	0.888	0.0044	0.0024
Europe REIT	-0.0205189	0.356	-0.0032959	0.955	0.0067143	0.836	-0.0004961	0.993	-0.0038831	0.887	0.0004	-0.0016
Australia REIT	-0.0648948	0.004	-0.023913	0.687	-0.0184076	0.575	0.0034099	0.933	0.0261041	0.347	0.0039	0.0019
Latin America REIT	-0.020363	0.268	-0.0371416	0.445	-0.0383232	0.154	0.0415827	0.213	-0.0216434	0.473	0.0028	0.0008
China REIT	-0.051122	0.000	-0.0617296	0.078	0.0012006	0.951	0.0259428	0.108	-0.0195512	0.231	0.0078	0.0058

In the multivariate regression analysis, we also incorporate physical risk variables, namely the media climate change concerns index relating to extreme temperature, global warming and hurricanes/floods, in addition to the geopolitical risk proxies to evaluate their combined effect on REITs returns in different regions.

The Global REIT shows no statistically significant relationships for any of the variables, which might suggest increased resilience and weak sensitivity to geopolitical and physical climate risks. For the US, none of the coefficients is significant. This indicates that physical climate risks can have some influence on REITs returns but their impact is not sufficient to systematically explain variation in the returns.

Canada REITs still present a significant negative coefficient for COVOL (-0.0613, p-value = 0.002), however GPR and physical risks remain insignificant, which indicates a stronger sensitivity to global volatility. Europe REITs show no significant relationships with any of the variables that could indicate region protection from physical and geopolitical risk due to a diversified economy and resilient institutions.

In relation to the Australia REIT, it shows significant sensitivity to COVOL (-0.0649, p-value = 0.004), showing vulnerabilities to geopolitical risks, however this is insignificant for physical risks, showing a higher impact of geopolitical risks compared to physical ones. Latin America REITs show no significant relationship for all the variables justified by weak institutions and increased volatility in the region. For China, we find a notable robust significant impact for geopolitical risks, but no significance for physical risks, highlighting the vulnerability to external geopolitical shocks.

These findings reveal some robust heterogeneity in REITs sensitivity to risks. Canada, Australia and China show robust significant negative relations with COVOL which indicates some kind of vulnerability while for the Global, US, Europe, and Latin America, they appear to be more resilient. Our results also indicate that physical risks have no measurable impact on REITs

returns. Recall that the physical climate proxies are text-based and constructed from major US newspapers, which may explain the weak relation between most REITs, other than US.

4. Regression with Interaction Terms

Table 4: Regression w/ Interaction Terms - Results

REIT Name	Variable	Coefficient	Std. Error	t-statistic	P-Value	95% CI Lower	95% CI Upper
Globo IREIT	COVOL	-0.0380473	0.0266757	-1.43	0.154	-0.0903561	0.0142615
	GPR	0.1284467	0.0828987	1.55	0.121	-0.0341103	0.2910036
	ExtremeTemperatures	0.1526988	0.0416537	3.67	0.000	0.0710196	0.2343779
	GlobalWarming	0.188614	0.0578366	3.26	0.001	0.0752016	0.3020264
	HurricanesFloods	-0.3206296	0.0444537	-7.21	0.000	-0.4077992	-0.2334599
	Inter_COVOL_ET	0.179938	0.0514754	3.49	0.000	0.0789994	0.2808767
	Inter_COVOL_GW	0.3043901	0.0746595	4.08	0.000	0.1579895	0.4507907
	Inter_COVOL_HF	-0.4617666	0.0572567	-8.06	0.000	-0.5740359	-0.3494973
	Inter_GPR_ET	-0.1736983	0.1154954	-1.50	0.135	-0.4001745	0.0527779
	Inter_GPR_GW	-0.1255741	0.1524533	-0.82	0.413	-0.4245215	0.1733733
	Inter_GPR_HF	0.0681698	0.1031943	0.66	0.509	-0.1342343	0.2705739
	COVOL	-0.0378085	0.0332756	-1.11	0.265	-0.1023311	0.0281701
	GPR	0.1610074	0.1034088	1.56	0.120	-0.0417681	0.3637829
	ExtremeTemperatures	0.1638043	0.0519953	3.15	0.002	0.0619167	0.2656918
USA REIT	GlobalWarming	0.2579227	0.072146	3.58	0.000	0.1164507	0.3993946
	HurricanesFloods	-0.3879545	0.0554582	-7.00	0.000	-0.496691	-0.279218
	Inter_COVOL_ET	0.1723356	0.064211	2.68	0.007	0.0464236	0.2982477
	Inter_COVOL_GW	0.4290351	0.0935114	4.59	0.000	0.2461432	0.611927
	Inter_COVOL_HF	-0.5592957	0.0762552	-7.33	0.000	-0.6993492	-0.4192422
	Inter_GPR_ET	-0.202312	0.1440703	-1.40	0.162	-0.4848211	0.0801972
	Inter_GPR_GW	-0.191234	0.1901721	-1.01	0.315	-0.5641446	0.1816765
	Inter_GPR_HF	0.1329464	0.1287571	1.03	0.303	-0.1195349	0.3854278
	COVOL	-0.0705442	0.032521	-2.17	0.030	-0.134315	-0.0067734
	GPR	0.1201547	0.1010636	1.19	0.235	-0.0780221	0.3183316
	ExtremeTemperatures	0.232344	0.0507809	4.58	0.000	0.1327671	0.3319209
	GlobalWarming	0.1758562	0.070599	2.49	0.013	0.0375926	0.3141198
	HurricanesFloods	-0.4129691	0.0541945	-7.62	0.000	-0.5192396	-0.3066986
	Inter_COVOL_ET	0.2964221	0.0627548	4.72	0.000	0.1733655	0.4194787
Inter_COVOL_GW	0.3013075	0.0910913	3.31	0.001	0.1228272	0.4797878	
Inter_COVOL_HF	-0.5954472	0.0752553	-7.92	0.000	-0.7323245	-0.4585699	
Inter_GPR_ET	-0.2120859	0.1480083	-1.43	0.132	-0.4881882	0.0640163	
Inter_GPR_GW	0.0497635	0.1858593	0.27	0.787	-0.3146335	0.4141605	
Inter_GPR_HF	-0.0606947	0.1258371	-0.48	0.632	-0.2536971	0.1323077	
Canada REIT	COVOL	0.0222323	0.0364976	0.61	0.542	-0.0493363	0.0938009
	GPR	0.0815371	0.1134216	0.72	0.472	-0.1408727	0.3039468
	ExtremeTemperatures	0.1159553	0.0569904	2.03	0.042	0.0042022	0.2277084
	GlobalWarming	-0.0588141	0.0791317	-0.74	0.457	-0.2139845	0.0963562
	HurricanesFloods	-0.1228603	0.0608213	-2.02	0.043	-0.2421255	-0.0035951
	Inter_COVOL_ET	0.1618995	0.0704284	2.30	0.022	0.0237956	0.3000033
	Inter_COVOL_GW	-0.0996131	0.1021488	-0.98	0.326	-0.2999178	0.1006916
	Inter_COVOL_HF	-0.1786088	0.0738333	-2.42	0.015	-0.3232233	-0.0249943
	Inter_GPR_ET	-0.0361171	0.1508023	-0.24	0.810	-0.3316068	0.2593726
	Inter_GPR_GW	0.0007755	0.208856	0.00	0.997	-0.4082431	0.4097941
	Inter_GPR_HF	-0.1025245	0.1412244	-0.73	0.468	-0.3794171	0.1743681
	COVOL	-0.0884487	0.036736	-2.41	0.016	-0.1604848	-0.0164126
	GPR	0.0748797	0.1141828	0.66	0.512	-0.1490227	0.2987822
	ExtremeTemperatures	0.2309251	0.0573626	4.03	0.000	0.1184421	0.3434082
GlobalWarming	0.0519027	0.0796547	0.65	0.515	-0.1042931	0.2080985	
HurricanesFloods	-0.232484	0.0612188	-3.80	0.000	-0.3525287	-0.1124393	
Inter_COVOL_ET	0.3642314	0.0708885	5.14	0.000	0.2252253	0.5032374	
Inter_COVOL_GW	0.0755083	0.1028165	0.73	0.463	-0.1261057	0.2771223	
Inter_COVOL_HF	-0.3828559	0.0793443	-4.83	0.000	-0.5374474	-0.2282643	
Inter_GPR_ET	-0.2077974	0.1599523	-1.30	0.192	-0.519865	0.1042702	
Inter_GPR_GW	0.1542371	0.2096069	0.74	0.457	-0.2574894	0.5659635	
Inter_GPR_HF	0.0869812	0.142147	0.61	0.543	-0.1927569	0.3667194	
Australia REIT	COVOL	-0.0255841	0.0301512	-0.85	0.396	-0.0847079	0.0335398
	GPR	0.0687206	0.0936992	0.73	0.463	-0.1150152	0.2524564
	ExtremeTemperatures	0.1138205	0.0470806	2.42	0.016	0.0214997	0.2061413
	GlobalWarming	0.0192074	0.0653719	0.29	0.769	-0.108981	0.1473958
	HurricanesFloods	-0.1359765	0.0502453	-2.71	0.007	-0.2345032	-0.0374499
	Inter_COVOL_ET	0.214762	0.0581819	3.69	0.000	0.1006724	0.3288515
	Inter_COVOL_GW	-0.0310853	0.0843866	-0.37	0.713	-0.1965599	0.1343893
	Inter_COVOL_HF	-0.1685521	0.0642661	-2.62	0.009	-0.2954525	-0.0416518
	Inter_GPR_ET	-0.2210614	0.1305428	-1.69	0.092	-0.4769993	0.0348765
	Inter_GPR_GW	0.1045442	0.1723158	0.61	0.544	-0.2333518	0.4424403
	Inter_GPR_HF	-0.0478711	0.1166747	-0.41	0.680	-0.2764655	0.1807233
	COVOL	-0.0213812	0.0215277	-0.99	0.321	-0.0635951	0.0208327
	GPR	0.0398469	0.0669004	0.60	0.551	-0.0913388	0.1710327
	ExtremeTemperatures	0.1619181	0.0336151	4.82	0.000	0.0960019	0.2278344
GlobalWarming	0.0399813	0.0466749	0.86	0.392	-0.0515441	0.1315068	
HurricanesFloods	-0.2406636	0.0358747	-6.71	0.000	-0.3109534	-0.1702591	
Inter_COVOL_ET	0.2292265	0.0415413	5.52	0.000	0.1477676	0.3106854	
Inter_COVOL_GW	-0.00149	0.0602512	-0.02	0.980	-0.1196373	0.1166573	
Inter_COVOL_HF	-0.3163929	0.039164	-8.08	0.000	-0.407002	-0.2257852	
Inter_GPR_ET	-0.1585108	0.0903463	-1.75	0.080	-0.3350217	0.0180001	
Inter_GPR_GW	-0.1260444	0.1203319	-1.05	0.292	-0.3627291	0.1156404	
Inter_GPR_HF	0.0896916	0.0839295	1.07	0.285	-0.0746693	0.2540525	

The estimation results in Table 4 includes the interaction terms. This regression intends to evaluate the combined effects of geopolitical with physical risks on REITs returns across several regions.

On Global REITs, extreme temperatures and global warming show significant positive effects, while hurricanes and floods and its interaction with COVOL show higher negative relations, suggesting that physical risks, especially hurricanes and floods can negatively influence returns, and geopolitical risks amplify this effect. US REITs face extreme temperatures and global warming with positive significant values; however, hurricanes and floods show a stronger negative effect with interaction with COVOL increasing those effects indicating that geopolitical risks amplify the impact of physical climate concerns.

On Canada REITs, COVOL shows a significant negative effect, while physical risks present positive significant values, with the interactions with COVOL worsening their impacts, showing that geopolitical risks aggravate the physical risks impact.

For European REITs only extreme temperatures (0.1159, p-value = 0.042) and hurricanes/floods (-0.1228, p-value = 0.043) have a significant effect on returns, which indicates weak combined effects.

Australia REITs present significant negative values for COVOL (-0.0884, p-value = 0.016), with extreme temperatures and hurricanes/floods showing strong effects that are intensified when COVOL is high, leading us to conclude that geopolitical risks have a bigger impact and worsen physical risks impact. Latin America presents significant values for extreme temperatures (0.1138, p-value = 0.016) and hurricanes/floods (-0.1359, p-value = 0.007) with the interaction with COVOL increasing the geopolitical volatility impact. Finally, China REITs, have positive and significant extreme temperature values, while hurricanes/floods have a negative coefficient, with both interaction with COVOL being highly significant which might suggest that geopolitical volatility amplifies physical risks as well.

To summarise, we conclude that physical risks can have an impact on REITs returns across the different regions, especially hurricanes/floods. Moreover, by including its interaction with COVOL, we observe that global and geopolitical risks amplify these effects.

5. Difference-in-difference Regression for COVID-19:

REIT Name	Variable	Coefficient	Std. Error	t-statistic	P-Value	95% CI Lower	95% CI Upper
GlobalREIT	Covid_Dummy	-0.2154515	0.0697002	-3.09	0.002	-0.3521271	-0.0787759
GlobalREIT	COVOL	0.0658039	0.031026	2.20	0.028	0.0073185	0.1296893
GlobalREIT	Interaction_Covid	-0.0966704	0.0391282	-2.47	0.014	-0.1733972	-0.0199436
USAREIT	Covid_Dummy	-0.2193521	0.0869934	-2.52	0.012	-0.3899381	-0.048766
USAREIT	COVOL	0.0791009	0.0389442	2.03	0.042	0.0072348	0.1554669
USAREIT	Interaction_Covid	-0.096066	0.0488362	-1.97	0.049	-0.1918294	-0.0003026
CanadaREIT	Covid_Dummy	-0.1923056	0.0851466	-2.26	0.024	-0.3592702	-0.025341
CanadaREIT	COVOL	0.0662475	0.0381175	1.74	0.082	-0.0084973	0.1409924
CanadaREIT	Interaction_Covid	-0.1581109	0.0477995	-3.31	0.001	-0.2518413	-0.0643805
EuropeREIT	Covid_Dummy	-0.2849396	0.0943609	-3.02	0.003	-0.4699728	-0.0999064
EuropeREIT	COVOL	0.0528237	0.0422424	1.25	0.211	-0.0300098	0.1356573
EuropeREIT	Interaction_Covid	-0.0548538	0.0529722	-1.04	0.301	-0.1587275	0.04902
AustraliaREIT	Covid_Dummy	-0.1414905	0.0953931	-1.48	0.138	-0.3285477	0.0455667
AustraliaREIT	COVOL	0.0848449	0.042705	1.99	0.047	0.0011042	0.1685856
AustraliaREIT	Interaction_Covid	-0.2063912	0.0535519	-3.85	0.000	-0.3114015	-0.1013808
LatinAmericaREIT	Covid_Dummy	-0.0830429	0.0782154	-1.06	0.288	-0.2364162	0.0703304
LatinAmericaREIT	COVOL	0.0589338	0.0350146	1.68	0.092	-0.0079267	0.1275942
LatinAmericaREIT	Interaction_Covid	-0.1028336	0.0439085	-2.34	0.019	-0.1889341	-0.0167331
ChinaREIT	Covid_Dummy	-0.054375	0.0562853	-0.97	0.334	-0.1647453	0.0559953
ChinaREIT	COVOL	0.0224541	0.0251972	0.89	0.373	-0.0269552	0.0718634
ChinaREIT	Interaction_Covid	-0.102738	0.0315974	-3.25	0.001	-0.1646976	-0.0407784

Table 5: DiD Regression for COVID-19 - Results

The DiD regression allows us to study the impact of the recent pandemic on REITs returns by using a dummy for the period of the COVID-19 pandemic, from February to March 2020, and its interaction with COVOL.

For Global REITs, the COVID dummy has a significant negative effect (-0.2155, p-value = 0.002), highlighting a decline in returns during the pandemic onset. While COVOL exhibits a considerable positive impact (0.0685, p-value = 0.028), the interaction term (-0.0967, p-value = 0.014) indicates that geopolitical risks can amplify the adverse effects of COVID-19 on global returns. This suggests that geopolitical volatility can exacerbate market downturns.

For US REITs, similar patterns emerge, with the COVID dummy showing a significant negative coefficient (-0.2193, p-value = 0.012), reflecting initial market shocks. COVOL has a significant positive coefficient (0.0791, p-value = 0.042), while the interaction term (-0.0961, p-value = 0.049) confirms that geopolitical risk seems to worsen COVID-19's adverse effects. In Canada, the COVID dummy has also a negative and significant (-0.1923, p-value = 0.024) effect on REITs, but the interaction term (-0.1581, p-value = 0.001) indicates a much stronger amplification effect from geopolitical risk. This emphasizes Canada REITs sensitivity to global volatility during the crisis.

For Europe, the COVID dummy is significant and negative (-0.2849, p-value = 0.003), suggesting a sharper decline compared to other regions. However, the interaction term is

insignificant (-0.0549, p-value = 0.301), indicating a limited role of geopolitical risk in amplifying COVID-19 effects in Europe. In Australia, the interaction term (-0.2064, p-value = 0.000) is highly significant, showing geopolitical risk considerably intensified the pandemic's negative impact on REITs, even though the COVID dummy itself is statistically insignificant (-0.1415, p-value = 0.138).

For Latin America, the interaction term (-0.1028, p-value = 0.019) is significant, pointing to geopolitical risk exacerbating COVID-19 shocks to REITs. Finally, China REITs display a notable interaction effect (-0.1027, p-value = 0.001), suggesting geopolitical risk worsens the damaging impacts of the pandemic despite the insignificant coefficient associated with the COVID dummy. These findings emphasize regional variations, with geopolitical risk consistently amplifying the adverse effects of COVID-19 on REITs returns, particularly in Canada, Australia, and China. At the same time, Europe experienced a less pronounced geopolitically induced exacerbation of the impacts.

6. Lagged variables analysis:

REIT Name	Variable	Coefficient	R-squared	Adj. R-squared	P-Value	95% CI Lower	95% CI Upper
GlobalREIT	L_COVOL	0.0489253	0.0051	0.0026	0.005	0.0146307	0.0832198
	L_GPR	-0.0392601	0.0051	0.0026	0.389	-0.1286626	0.0501425
	L_ExtremeTemperatures	0.0091727	0.0051	0.0026	0.719	-0.0408554	0.0592008
	L_GlobalWarming	-0.0311152	0.0051	0.0026	0.329	-0.0935869	0.0313564
	L_HurricanesFloods	-0.0018933	0.0051	0.0026	0.931	-0.0447758	0.0409891
USAREIT	L_COVOL	0.0667569	0.0057	0.0032	0.002	0.0243423	0.1091714
	L_GPR	-0.0554612	0.0057	0.0032	0.325	-0.1660318	0.0551094
	L_ExtremeTemperatures	-0.0026845	0.0057	0.0032	0.933	-0.0645578	0.0591888
	L_GlobalWarming	-0.0245738	0.0057	0.0032	0.533	-0.1018373	0.0526894
	L_HurricanesFloods	0.0052796	0.0057	0.0032	0.845	-0.0477562	0.0583155
CanadaREIT	L_COVOL	0.0771733	0.0082	0.0057	0.0	0.0351904	0.1191561
	L_GPR	-0.0866457	0.0082	0.0057	0.121	-0.1960091	0.0227996
	L_ExtremeTemperatures	-0.0016911	0.0082	0.0057	0.957	-0.0629347	0.0595526
	L_GlobalWarming	-0.0173831	0.0082	0.0057	0.656	-0.0938569	0.0590938
	L_HurricanesFloods	0.0060825	0.0082	0.0057	0.98	-0.0511835	0.0531786
EuropeREIT	L_COVOL	0.0650839	0.0057	0.0032	0.009	0.0161024	0.1140654
	L_GPR	-0.0656952	0.0057	0.0032	0.313	-0.1933852	0.0619947
	L_ExtremeTemperatures	0.0055925	0.0057	0.0032	0.878	-0.0658605	0.0770455
	L_GlobalWarming	-0.0576877	0.0057	0.0032	0.205	-0.1469133	0.031538
	L_HurricanesFloods	-0.0104136	0.0057	0.0032	0.739	-0.0716608	0.0508336
AustraliaREIT	L_COVOL	0.0114202	0.003	0.0005	0.65	-0.0378823	0.0607226
	L_GPR	-0.0513463	0.003	0.0005	0.434	-0.1798934	0.0772008
	L_ExtremeTemperatures	0.0424094	0.003	0.0005	0.248	-0.029522	0.1143409
	L_GlobalWarming	-0.096666	0.003	0.0005	0.035	-0.1864698	-0.0068451
	L_HurricanesFloods	-0.0006076	0.003	0.0005	0.985	-0.0610537	0.0598385
LatinAmericaREIT	L_COVOL	0.0245578	0.0011	-0.0014	0.229	-0.0154485	0.0645642
	L_GPR	0.0036221	0.0011	-0.0014	0.946	-0.1006705	0.1079148
	L_ExtremeTemperatures	-0.0061367	0.0011	-0.0014	0.837	-0.0644497	0.0522263
	L_GlobalWarming	0.0194177	0.0011	-0.0014	0.601	-0.0534587	0.0922941
	L_HurricanesFloods	-0.0143937	0.0011	-0.0014	0.558	-0.0649616	0.0358036
ChinaREIT	L_COVOL	0.0396655	0.005	0.0025	0.007	0.0109669	0.0683641
	L_GPR	0.0373931	0.005	0.0025	0.327	-0.0374212	0.1122074
	L_ExtremeTemperatures	0.016809	0.005	0.0025	0.431	-0.0250558	0.0586737
	L_GlobalWarming	-0.0089856	0.005	0.0025	0.736	-0.0612634	0.0432922
	L_HurricanesFloods	-0.0164478	0.005	0.0025	0.369	-0.0523329	0.0194373

Table 6: Lagged Variable Analysis - Results

As robustness checks, we incorporate lagged variables of the geopolitical risk proxies (L_COVOL and L_GPR), and of physical climate risks (L_extreme_temperatures, L_global_warming, L_hurricanes/floods) to validate our findings. For Global REITs, lagged COVOL is significant (0.0489, p-value = 0.005), indicating some predictability of the impact of geopolitical risk, while the lagged physical risks remain insignificant. This contrasts with the multivariate results, suggesting a delayed impact of geopolitical risk on Global REITs.

For US REITs, lagged COVOL remains significant (0.0667, p-value = 0.002), reinforcing sensitivity to geopolitical risk, while all other variables, including physical risks, remain insignificant. This aligns with the multivariate results, where extreme temperatures and hurricanes/floods showed weak influence, confirming their limited explanatory power.

In Canada REITs, lagged COVOL shows a highly significant positive effect (0.0771, p-value = 0.000), consistent with the prior findings of significant, but also persistent geopolitical risk sensitivity. Lagged GPR and physical risks remain insignificant, supporting the conclusion that Canada's REITs are primarily affected by global common volatility rather than physical risks.

For Europe REITs, lagged COVOL is again significant (0.0650, p-value = 0.009), while the remaining variables are insignificant. This contradicts the findings from the multivariate analysis, where Europe appeared to be protected from geopolitical and physical risks, suggesting that geopolitical risk effects may be delayed rather than contemporaneous.

Australia REITs show no significant relationships for lagged COVOL or physical risks, a departure from the findings above where COVOL had a significant negative coefficient. This highlights that geopolitical volatility's impact on Australian REITs might be immediate rather than lagged. Latin America REITs present no significant relationships with any of the variables, which is consistent with the multivariate results. Lastly, China REITs have a significant positive relation with lagged COVOL (0.0397, p-value = 0.007), which supports the findings from multivariate regression of vulnerability to geopolitical risks, however lagged physical risks remain insignificant, which suggests limited impact on REIT return.

Concluding, this robustness check analysis helps to justify the multivariate regression conclusions. Where Global, US, Canada, and China REITs remain sensitive to more geopolitical risks, particularly COVOL, while physical risks continue to show limited significance. Europe's lagged geopolitical sensitivity might indicate delayed impact which is in contrast with earlier finding. These results confirm the heterogeneous nature of REIT sensitivity across regions, with some geopolitical risks playing a dominant role.

7. Risk-Adjusted Return Analysis:

	Sharpe ratio	Sortino Ratio
Global	0.0319	0.0291
USA	0.0384	0.0364
Canada	0.0395	0.0362
Europe	0.0058	0.0064
Australia	0.0384	0.0375
Latin America	0.0208	0.0313
China	0.0063	0.0066

Table 7: Sharpe and Sortino Ratio

The Risk-Adjusted return analysis, where we use the Sharpe and Sortino ratios, aims to analyze impactful variations across regions, to check differences in reward-to-risk efficiency.

The Global REITs show a relatively low Sharpe ratio (0,0319) and Sortino ratio (0,0291), which might indicate average returns in relation to both overall volatility and downside risk, being in line with previous findings of weak sensitivity to geopolitical and physical risks. In the US REITs, both the Sharpe and Sortino rate present higher values (0,0384 and 0,0364, respectively), suggesting a better risk-adjusted performance and resilience, aligning with previous analysis where geopolitical and physical risks had limited influence.

Comparably, Canada REITs show the highest Sharpe ratio (0,0395) and a strong Sortino ratio (0,0362) which may suggest an ability to generate superior returns relative to risk despite the increased sensitivity to geopolitical risks (COVOL) seen in previous analysis. The Europe REITs have the lowest Sharp ratio (0,0058) and Sortino ratio (0,0064), indicating poor risk-adjusted performance, this conclusion is in line with previous findings where Europe seemed to be somehow protected by geopolitical and physical risks however lacking strong returns.

In Australia REITs both ratios are relatively strong, with a Sharpe ratio value of 0,0384 and a Sortino ratio of 0,0375, which reflects positive risk-adjusted returns, consistent with previous regression where COVOL had a considerable impact, but Australia presented a robust performance. Latin America REITs show a comparably low Sharpe ratio (0,0208) but a relatively higher Sortino ratio (0,0313) which indicates a better downside risk management, also in line with previous findings where Latin America presents signs of weak institutional framework. Finally, China REITs present the lower Sharpe and Sortino ratio (0,0063 and

0,0066, respectively), which highlights poor risk-adjusted return reflecting vulnerability to Geopolitical risks.

In conclusion, Canada, the US and Australia markets show more risk adjusted returns, justified by higher Sharpe and Sortino ratios, while Europe and China underperformed significantly. These results indicate that geopolitical risks, especially global common volatility, dominate in some markets, however risk-adjusted returns remain regionally heterogeneous.

8. Event Study Analysis:

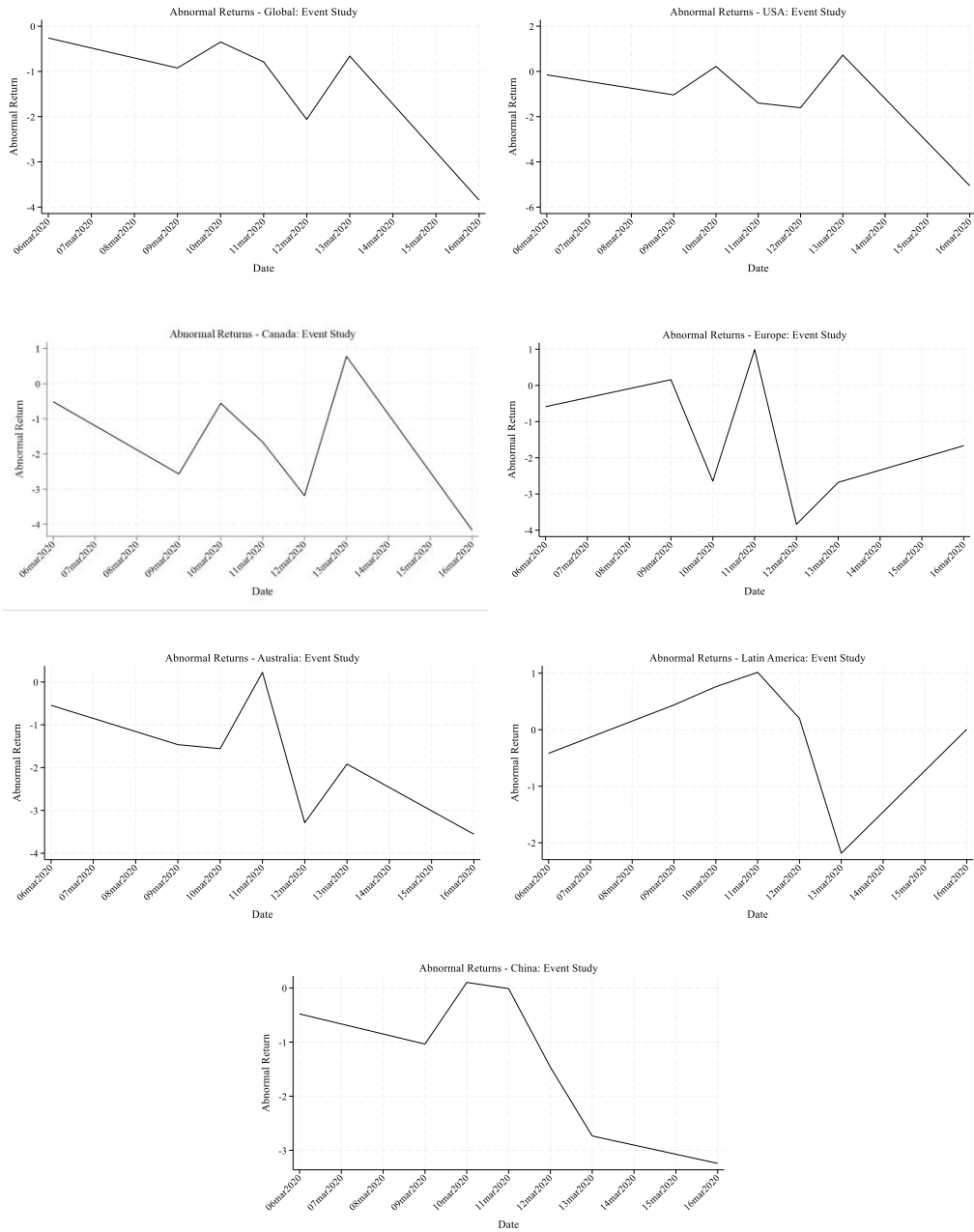


Figure 1: Event Study - Abnormal returns

This analysis intends to evaluate how REIT returns reacted to the declaration of COVID-19 as a pandemic by the World Health Organization, on March 11, 2020.

For Global REITs it shows a negative reaction, which might indicate that the market understood the declaration as a signal of increased volatility and uncertainty. Even though the magnitude of the impact is moderate, it shows some caution sentiment on the global market. US REITs also show a negative response to the declaration, however with a lower magnitude when compared to other regions, suggesting that the first market reaction was smoother possibly justified by confidence in the market ability to mitigate the shock.

The Canada REITs present a pronounced reaction, where significant negative returns are recorded. A sharper decline on returns that might reflect Canada sensitivity to geopolitical risks, aligning with its market dependence in some sectors. Relatively to Europe REITs, it shows a mix of positive and negative reaction to the periods close to the declaration, with a more pronounced shock on the event date, but with positive moves on the days after, suggesting some degrees of resilience justified by diversified economies and faster institutional responses.

Australia REITs experience a significant negative reaction, highlighting the market's vulnerabilities to global geopolitical shocks. The global event amplified pre-existing volatility in Australia, leading to a sharper market correction. Latin America REITs record a considerable decline, reflecting the region's structural weaknesses and heightened vulnerability to external shocks. The combination of weaker institutions and economic uncertainty likely exacerbates the impact. China REITs exhibit one of the sharpest negative reactions, contradicting earlier perceptions of resilience. The WHO declaration likely triggered renewed concerns about global spillovers, as China remained sensitive to global and geopolitical risks.

In summary, the event study analysis shows heterogeneous reactions across regions. Sharper declines were experienced in Australia and China, while the US, Canada and Europe presented sensitivity to global and geopolitical risks. Structural weaknesses accentuated negative spillovers in Latin America. Market sentiment was predominantly negative for all economies, reflecting the heightened uncertainty from the WHO's pandemic declaration.

9. Hedge Ratios – VAR and CAPM

REIT Name	Model	Variable	Lag (L1/L2)	Coefficient	P-Value
GlobalREIT	VAR	COVOL	L1	-0.3219482	0.019
			L2	0.2956487	0.029
		GPR	L1	-0.0731907	0.277
			L2	0.0037295	0.946
	CAPM	COVOL	-	-0.022189	0.175
		GPR	-	-0.0025864	0.952
USAREIT	VAR	COVOL	L1	-0.3925888	0.021
			L2	0.3916262	0.020
		GPR	L1	-0.1033708	0.223
			L2	-0.0190765	0.782
	CAPM	COVOL	-	-0.0117324	0.565
		GPR	-	0.0163975	0.762
CanadaREIT	VAR	COVOL	L1	-0.4987084	0.004
			L2	0.5011184	0.003
		GPR	L1	-0.0575932	0.497
			L2	0.0856710	0.215
	CAPM	COVOL	-	-0.0605100	0.002
		GPR	-	-0.0388220	0.464
EuropeREIT	VAR	COVOL	L1	0.0268753	0.889
			L2	-0.0261684	0.889
		GPR	L1	-0.0430705	0.656
			L2	0.1224744	0.120
	CAPM	COVOL	-	-0.0205663	0.353
		GPR	-	-0.0020062	0.972
AustraliaREIT	VAR	COVOL	L1	-0.8247939	0.000
			L2	0.7659407	0.000
		GPR	L1	-0.1171485	0.233
			L2	0.0952188	0.234
	CAPM	COVOL	-	-0.065856	0.003
		GPR	-	-0.0227159	0.702
LatinAmericaREIT	VAR	COVOL	L1	-0.2928882	0.051
			L2	0.2714012	0.067
		GPR	L1	-0.0750615	0.329
			L2	-0.0593434	0.343
	CAPM	COVOL	-	-0.0178427	0.330
		GPR	-	-0.0362823	0.455
ChinaREIT	VAR	COVOL	L1	-0.1451523	0.208
			L2	0.1306448	0.251
		GPR	L1	0.0127532	0.820
			L2	0.0009356	0.984
	CAPM	COVOL	-	-0.0503974	0.000
		GPR	-	-0.0591387	0.091

Table 8: VAR & CAPM - Results

The hedge ratio analysis using CAPM-style regressions and VAR models reveals regional variations in sensitivity to geopolitical risks (proxied by COVOL or GPR).

For Global REITs, the CAPM regression shows that COVOL has a coefficient of -0.022 (with a p-value of 0.175) and for GPR this is 0.0026 (p-value = 0.952), which shows an insignificant sensitivity to geopolitical risks. For the VAR Model, lagged COVOL (L1) has a significant negative coefficient of -0.3219 (p-value = 0.019), while L2 is positive at 0.2956 (p-value = 0.029), highlighting short-term vulnerability to risks with a partial turnaround over time. For GPR, the coefficients appear to be insignificant, indicating limited sensitivity. On the US REITs, the CAPM regression presents insignificant coefficients for COVOL and GPR with a p-value of 0.565 and 0.762, respectively, suggesting no clear signals of sensitivity to geopolitical risks. In the VAR model, lagged COVOL (L1) is significant and negative at -0.3926 (p-value = 0.021), while L2 reverses to 0.3913 (p-value = 0.020). Indicating an immediate negative impact of geopolitical risks followed by partial recovery. GPR coefficients remain insignificant, reflecting weak sensitivity.

For Canada REITs, CAPM regression presented a significant COVOL with a negative coefficient of -0.0605 (p-value = 0.002) showing a high sensitivity. GPR is insignificant indicating limited impact. In the VAR model, lagged COVOL (L1) has a significant negative coefficient of -0.4987 (p-value = 0.004), while L2 reverses to 0.5011 (p-value = 0.003), indicating an immediate negative effect followed by partial recovery. GPR coefficients remain insignificant, reflecting minimal sensitivity to geopolitical risks. Regarding Europe REITs, from the CAPM regression we observe insignificant effects from both COVOL and GPR, showing weak sensitivity to geopolitical risks. For the VAR model, lagged COVOL coefficients are insignificant at 0.0268 (L1) and -0.0261 (L2), showing no indicative effect. Similarly, GPR is insignificant across both lags. These results confirm Europe REITs' superior protection from geopolitical shocks.

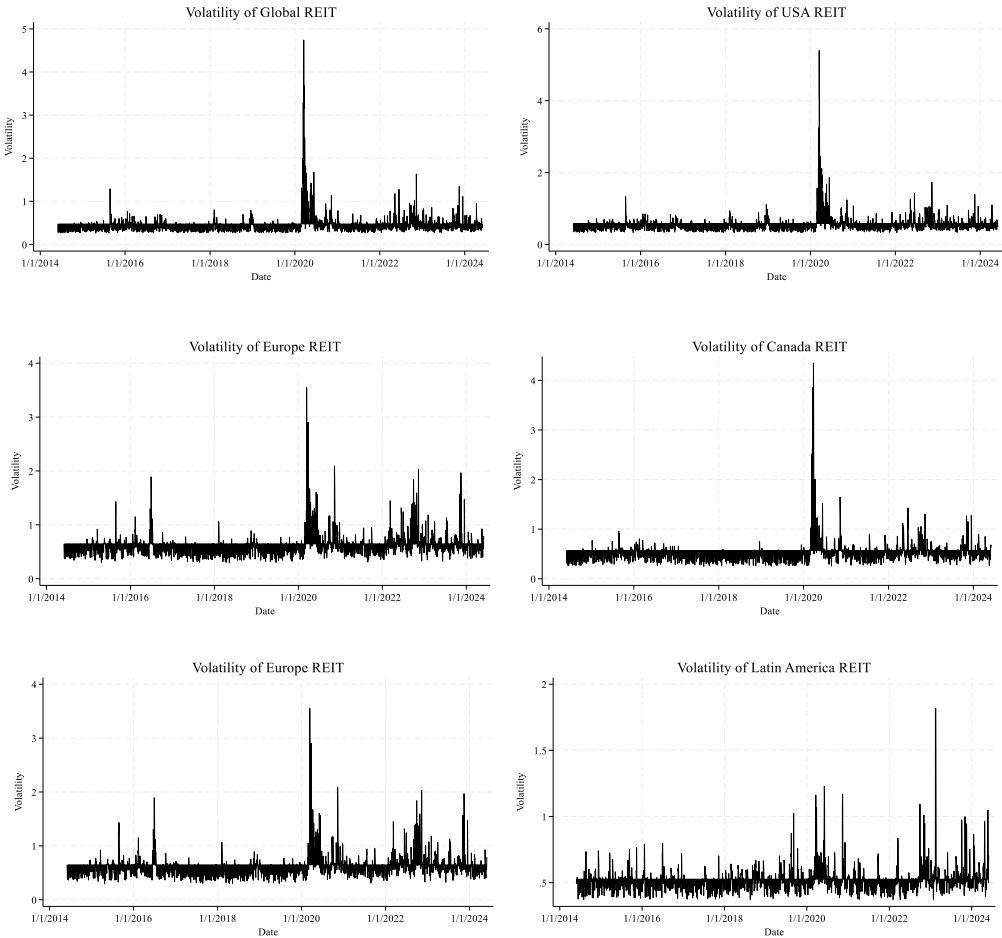
Australia REITs, on the CAPM regression the COVOL has a significant negative coefficient of 0.0659 (p-value = 0.003), reflecting strong sensitivity to this proxy of risk while GPR is insignificant at -0.0227 (p-value = 0.702). For the VAR model, lagged COVOL (L1) has a significant negative effect of -0.8247 (p-value = 0.000), while L2 reverses to 0.7659 (p-value = 0.000). This indicates an immediate negative shock followed by partial correction, in relation to GPR it remains insignificant across lags. Highlighting that COVOL can better capture the effects of broader, material geopolitical risks than GPR. For Latin America REITs, in the CAPM analysis both COVOL and GPR showed no significant values (-0.0178 (p-value = 0.330) and -0.0368 (p-value = 0.455), respectively), suggesting a weak sensitivity to these risks. In the VAR model, lagged COVOL (L1) shows a marginally significant negative coefficient of -0.2929 (p-

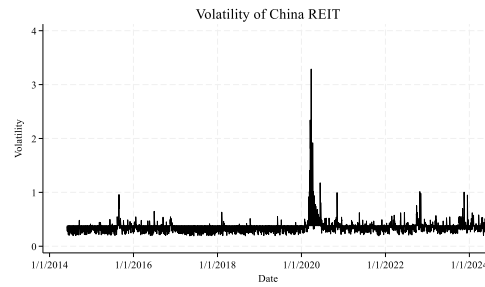
value = 0.051), suggesting mild short-term sensitivity to geopolitical risks. L2 reverses direction to 0.2714 (p-value = 0.067), indicating partial correction over time. GPR coefficients are consistently insignificant, reflecting minimal impact.

Finally, China REITs, in the CAPM regression, COVOL showed a significant negative coefficient of -0.0504, while GPR is marginally insignificant at -0.0591 (p-value = 0.092), reflecting some negative impact from geopolitical risks. The VAR model presented insignificant values for both lagged COVOL L1 and L2 (although L1 presented a negative coefficient and L2 a positive one). GPR remained insignificant across both lags.

In summary, both Canada, Australia and China show high sensitivity to COVOL, justified by significant negative hedge ratios in both CAPM and VAR model. On the other side, Europe REITs remain largely insulated from geopolitical risks, showing minimal hedge ratios and insignificant effects over time.

10. GARCH Models





Figures 2: GARCH Model - Volatility

The GARCH model analysis intends to study the volatility clustering of REITs returns across regions to examine the conditional heteroscedasticity in the data. This model identifies whether returns exhibit periods of persistent volatility, driven by geopolitical and physical risks.

The GARCH analysis for Global REITs shows significant volatility persistence being strongly associated with COVOL (0.0329, p-value = 0.000). Adding physical risks reveals climate weather events have an insignificant impact, while COVOL remains robust. Volatility spikes significantly during COVID-19, reaching 4.74, highlighting the market's sensitivity to geopolitical shocks and strong ARCH (0.4158) effects.

In the baseline GARCH model for US REITs, COVOL and GPR coefficients are negative but insignificant at 5% significance, indicating no clear volatility linkage. The ARCH (0.3451) and GARCH (0.5248) terms are statistically significant, reflecting strong shock persistence.

When physical risks are added, coefficients for COVOL (-0.0118) and GPR (-0.0316) remain insignificant, as do extreme temperatures (0.0122), global warming (-0.0142), and hurricanes and floods (0.0203). The persistence of volatility remains significant through ARCH (0.3521) and GARCH (0.5136), suggesting that shocks in the system persist over time.

The volatility plot confirms a spike during COVID-19, with volatility showing a maximum of 5.39 while the mean volatility is 0.5446, indicating pronounced volatility clustering around the pandemic period.

For Canada REITs, the GARCH model highlights significant volatility. In the baseline model, COVOL is highly significant (coefficient = -0.176, p-value < 0.01), indicating sensitivity to global volatility. GPR remains insignificant. The ARCH effect (= 0.237) and GARCH persistence (= 0.786) confirm high volatility clustering. Adding physical risks does not improve explanatory power, as none of these variables are significant. Volatility spikes, notably during COVID-19, emphasize heightened market uncertainty, as seen in an average volatility of 0.517, reaching a max of 4.35.

For the European REITs, the GARCH model reveals no significant coefficient but when the analysis is done with physical risks it shows that COVOL has a weakly significant negative impact on REITs returns (coefficient: -0.0216, p-value=0.046) while GPR and physical risks are statistically insignificant. Volatility spikes significantly during global shocks, notably in early 2020 (COVID-19). The mean conditional variance is 0.4296, with volatility peaking at 3.55. The high GARCH term (0.8082) indicates persistent volatility clustering, consistent with market instability periods.

The first GARCH model for Australia REITs returns reveals a significant negative impact of COVOL (-0.0374, $p < 0.001$), while GPR is insignificant. Volatility shows persistence, with ARCH (0.2646) and GARCH (0.6138) terms confirming lasting shocks.

In the second model, adding physical risks, COVOL remains significant (-0.0359, p-value < 0.001), but extreme temperatures, global warming, and hurricanes are all insignificant. Mean volatility is 0.5957, peaking at 4.49, with COVID-19 driving volatility spikes.

In the first GARCH model for Latin America REITs, COVOL and GPR are insignificant, with p-values above 0.10, suggesting no direct impact on returns with volatility showing strong persistence, with ARCH = 0.126 and GARCH = 1.013, confirming significant volatility clustering. When including physical risks, all coefficients remain insignificant. The conditional variance averages 0.2796, while volatility peaks notably post COVID-19, which can be explained by heightened market uncertainty and sustained volatility persistence beyond the initial COVID-19 shock or other types of geopolitical shocks affecting the region.

For China REITs, the first GARCH model shows COVOL with a small negative impact on returns (coefficient = -0.0998, $p < 0.01$), while GPR remains insignificant. Volatility persistence is evident, with ARCH = 0.311 and GARCH = 0.648, confirming clustering.

When physical risks are added, COVOL retains significance, while hurricanes and floods appear to show some influence. Conditional variance averages 0.146, with volatility peaking sharply during early 2020 (3.28), reflecting elevated uncertainty during the pandemic period.

Discussion:

1. Relating results to Research Questions / Hypothesis

This research aims to study the potential of REITs as a hedging mechanism for periods of heightened geopolitical and physical risks and at the same time evaluate the different REITs

performance during the COVID-19 pandemic. For that purpose, our analysis addressed three key research questions.

1. ***How do geopolitical risks, measured by COVOL and GPR, influence REITs returns across regions?*** Results show heterogeneous responses across regions. While COVOL, a proxy for global and geopolitical volatility notably impacts REITs returns in Canada, Australia, Latin America and China, with negative coefficients showing vulnerability to global shocks. For the US, Europe and Global REITs results show nearly no impact, suggesting greater resilience to global and geopolitical risks. GPR, the other proxy for geopolitical risks, showed insignificant values for most regions proving that REITs returns are more responsive to global/geopolitical risks (COVOL) than to isolated geopolitical tensions, and that COVOL is a better proxy to study the impact of geopolitical risks on REITs returns.

2. ***To what extent do physical risks amplify the effects of geopolitical risks on REITs performance?*** Using interaction terms between physical risks (extreme temperatures, global warming, and hurricanes/floods) and COVOL, results show that physical risks alone do not have a measurable impact on REITs returns. However they are able to exacerbate the impact of geopolitical risks. Australia, Latin America and China are the locations that show higher amplification effects, with hurricanes and floods being the physical risk with bigger impact. For Europe and the US, they seem relatively unaffected which might reflect stronger resilience and diversification in these economies. Results also indicate that physical risks by themselves do not have a significant impact, however when interacting with geopolitical risks they are able to amplify the shock, particularly in emerging or resource-dependent markets.

3. ***Do REITs demonstrate hedging potential during the COVID-19 pandemic, and how does this vary by region?*** The COVID-19 period triggered substantial volatility across all REITs markets, with declines in returns observed in all the REITs analysed. The Difference-in-Differences (DiD) analysis shows that geopolitical volatility (COVOL) amplified the pandemic's adverse effects on returns, particularly in Canada (-0.1581), Australia (-0.2064), and China (-0.1027). Europe exhibits resilience, with the interaction term remaining insignificant, highlighting investor confidence in the market.

2. Implications of the results:

Our results have important implications for developing investment strategies as they highlight the importance of regional diversification for REITs investors. While the US and Europe offer more stability during heightened geopolitical risk periods, Canada and Australia provide higher

returns with higher volatility. For investors targeting emerging markets like Latin America, or China, it is important to be aware of the increased volatility justified by weaker institutional resilience and exposure to other risks.

In relation to the role of physical risks, the interaction between physical and geopolitical risks calls investors' attention to climate risk mitigation strategies and compounded effects when having market exposure, particularly in regions with extreme weather events. Regarding the COVID-19 and possibly future crises, the pandemic demonstrates that geopolitical risks can significantly amplify crisis negative effects. The returns on the REITs market suggests that these geopolitical risks exacerbate market correction during periods of heightened uncertainty proving that higher institutional frameworks and diversified economies in regions like Europe can help to mitigate such shocks. For policymakers, especially in countries like those in Latin America and China, they must prioritize institutional strengthening and adaptation to climate risk shocks to reduce market vulnerabilities. Implementing measures to enhance the REITs market efficiency can help stabilize returns and attract investors during crises.

This research extends the literature by providing supporting evidence of the compounded effects of physical and geopolitical risks on REITs markets. The findings are also in line with the Modern Portfolio Theory (Markowitz, 1952) and Safe-Haven Theory, demonstrating that REITs can serve as diversification tools during crises, particularly in developed markets. Additionally, the volatility clustering observed in GARCH models validates the persistence of market shocks, aligning with the volatility clustering stylized fact of daily financial returns.

Our results also give some practical insights for investors, first regarding the importance of diversification where investors can use US and European REITs as hedging instruments to stabilize portfolios, especially during geopolitical crisis. The existence of high-risk, high-reward markets, with Canada and Australia REITs offering more attractive returns but requiring risk-adjusted strategies to control increased volatility. Caution is needed though in emerging markets, like Latin America and China, since they are more sensitive to geopolitical and physical risks. Lastly, we highlight the importance of crisis preparation since investors should be aware of geopolitical volatility indices like COVOL to anticipate market correction during compounded crises.

Conclusion:

1. Summary of key findings:

We explore the potential of real estate investment trusts (REITs) to be used as hedging mechanisms against geopolitical risks, with a special focus on their performance during the COVID-19 pandemic.

The results indicate significant regional disparities of REITs sensitivity to geopolitical risks as measured by COVOL (global common volatility) and GPR (the geopolitical risk index). COVOL appears to be more effective compared to GPR when analysing several relationships across regions. Canada, Australia, Latin America and China show heightened vulnerability to global and geopolitical risks, while the US and Europe show more resilience to these risks.

Regarding the inclusion of physical risks, particularly hurricanes and floods show compounded effects of geopolitical risks in the generality of the regions, while the physical risks alone show minimal impact on REITs returns.

From the COVID-19 analysis, the pandemic reveals that these shocks can amplify the adverse impact on REITs performance, with countries like Australia, China and those in Latin America being particularly affected, while in Europe they show higher resilience.

These findings align with Modern Portfolio Theory (Markowitz, 1952) and Safe-Haven Theory, reinforcing REITs' potential as strategic diversification assets during periods of geopolitical uncertainty.

2. Limitations of the study and Recommendation for future research:

Relative to data frequency, the study utilizes daily data, which, while comprehensive, may introduce noise. Employing weekly or monthly data could yield more precise trends and reduce volatility spikes. Using a different data frequency could offer a clearer perspective on long-term trends and volatility dynamics.

Regarding the proxies, by focusing on COVOL and GPR, the study excludes other important geopolitical and economic indicators of uncertainty, such as the economic policy uncertainty (EPU) index of Baker, Bloom and Davis (2016), that could provide additional insights and help to go deeper into several conclusions. Future studies should incorporate the EPU index to capture a broader spectrum of risks and uncertainties affecting REITs performance and establish a more robust framework for understanding REITs sensitivity to geopolitical risks.

The analysis focuses on regional perspectives, excluding sector-specific insights. Various REITs sectors, such as residential and commercial, may react uniquely to geopolitical risks, adding value to the study. Exploring the performance of specific REITs sectors could yield more granular insights and guide sector-specific investment strategies.

The study could be further developed to help construct an optimal portfolio to determine the ideal REITs allocation for hedging purposes, increasing the utility of the research for portfolio managers seeking diversification strategies. The methodology could also be used to evaluate the ideal percentage of REITs to minimize portfolio sensitivity while maximizing returns.

3. Practical Implications:

The study's results can provide valuable guidance for investors, policymakers and portfolio managers, since it can help with diversification strategies, with the US and European REITs demonstrating strong resilience and making them suitable hedging instruments during periods of heightened geopolitical risk. For emerging markets, these should be approached with caution, as these markets exhibit heightened sensitivity to geopolitical risks due to weaker institutional frameworks.

The analysis also calls attention for the importance of addressing climate risks, since physical and geopolitical risks have a compounded negative impact on REITs returns, especially in regions with more extreme weather events, concluding that those regions integrate comprehensive climate risk mitigation strategies. This integration can be crucial for fostering resilience in these markets and mitigating long-term vulnerabilities.

Moreover, the increased impact of geopolitical risks during periods like the COVID-19 pandemic highlights the necessity of robust institutional frameworks and market resilience measures. For countries and regions like Latin America and China, which experienced increased adverse effects, the focus should be on strengthening their institutional resilience to buffer against future crises.

Finally, the study emphasizes the selection of effective risk proxies. COVOL's demonstrates superiority over GPR indicating its primacy as a tool for evaluating REITs performance under geopolitical risks. Policymakers and analysts should consider prioritizing volatility metrics for a more accurate assessment of market dynamics under geopolitical uncertainty.

References

- Baur, D. G., & Smales, L. A. (2020). Hedging geopolitical risk with precious metals. *Journal of Banking and Finance*, 105823. <https://doi.org/10.1016/j.jbankfin.2020.105823>
- Będowska-Sójka, B., Demir, E., & Zaremba, A. (2022). Hedging geopolitical risks with different asset classes: A focus on the Russian invasion of Ukraine. *Finance Research Letters*, 103192. <https://doi.org/10.1016/j.frl.2022.103192>
- Bondarenko, Y., Lewis, V., Rottner, M., & Schüller, Y. (2024). Geopolitical risk perceptions. *Journal of International Economics*, 104005. <https://doi.org/10.1016/j.jinteco.2024.104005>
- Campos-Martins, S., & Hendry, D. F. (2024). Common volatility shocks driven by the global carbon transition. *Journal of Econometrics*, 105472. <https://doi.org/10.1016/j.jeconom.2023.05.008>
- Engle, R. F., & Campos-Martins, S. (2020). Measuring and hedging geopolitical risk. *Working Paper*, National Funds of the FCT. <https://ssrn.com/abstract=3685213>
- Engle, R. F., & Campos-Martins, S. (2023). What are the events that shake our world? Measuring and hedging global COVOL. *Journal of Financial Economics*, <https://doi.org/10.1016/j.jfineco.2022.09.009>
- Hanif, W., Andraz, J. M., Gubareva, M., & Teplova, T. (2024). Are REITs hedge or safe haven against oil price fall? *International Review of Economics and Finance*, <https://doi.org/10.1016/j.iref.2023.07.052>
- Karagozoglu, A. K., Wang, N., & Zhou, T. (2022). Comparing geopolitical risk measures. *The Journal of Portfolio Management*, 48(10), 226–257. <https://doi.org/10.3905/jpm.2022.1.415>
- Lang, C., Xu, D., Corbet, S., Hu, Y., & Goodell, J. W. (2024). Global financial risk and market connectedness: An empirical analysis of COVOL and major financial markets. *International Review of Financial Analysis*, 103152. <https://doi.org/10.1016/j.irfa.2024.103152>
- Salisu, A. A., Akinsomi, O., Ametefe, F. K., & Hammed, Y. S. (2024). Gold market volatility and REITs' returns during tranquil and turbulent episodes. *International Review of Financial Analysis*, 103348. <https://doi.org/10.1016/j.irfa.2024.103348>

- Salisu, A. A., Raheem, I. D., & Ndako, U. B. (2020). The inflation hedging properties of gold, stocks and real estate: A comparative analysis. *Resources Policy*, 101605. <https://doi.org/10.1016/j.resourpol.2020.101605>
- Coën, A., & Desfleurs, A. (2024). Geopolitical risk and the dynamics of REITs returns. *Finance Research Letters*, 105437. <https://doi.org/10.1016/j.frl.2024.105437>
- Ma, T., & Zhou, X. (2024). Geopolitical risk hedging or timing: Evidence from hedge fund strategies. *North American Journal of Economics and Finance*, 102240. <https://doi.org/10.1016/j.najef.2024.102240>

Appendix:

1. Event Study Analysis

Estimating expected returns; summarizing CAR and performing statistical test

. reg GlobalREIT_SP500LogReturn if Estimation_Period

Source	SS	df	MS	Number of obs =	74
Model	4.4011973	1	4.4011973	F(1, 72)	= 48.58
Residual	6.52348601	72	.090603972	Prob > F	= 0.0000
				R-squared	= 0.4029
				Adj R-squared	= 0.3946
Total	10.9246833	73	.149653196	Root MSE	= .301

GlobalREIT_	Coefficient	Std. err.	t	P> t	[95% conf. interval]
SP500LogReturn	.589697	.0846091	6.97	0.000	.4210318 .7583622
_cons	-.0269152	.0350592	-0.77	0.445	-.0968044 .042974

. summarize CAR if Within_Window

Variable	Obs	Mean	Std. dev.	Min	Max
CAR	7	-3.376005	2.977968	-8.890413	-.261648

. ttest Abnormal_Return == 0 if Within_Window

One-sample t test

Variable	Obs	Mean	Std. err.	Std. dev.	[95% conf. interval]
Abnorm-n	7	-1.270059	.4837523	1.279888	-2.453758 -.0863597

mean = mean(Abnormal_Return) t = -2.6254
H0: mean = 0 Degrees of freedom = 6

Ha: mean < 0 Ha: mean != 0 Ha: mean > 0
Pr(T < t) = 0.0196 Pr(|T| > |t|) = 0.0393 Pr(T > t) = 0.9804

. reg USAREIT_SP500LogReturn if Estimation_Period

Source	SS	df	MS	Number of obs =	74
Model	6.64734265	1	6.64734265	F(1, 72)	= 46.53
Residual	10.2850152	72	.142847433	Prob > F	= 0.0000
				R-squared	= 0.3926
				Adj R-squared	= 0.3841
Total	16.9323578	73	.231950107	Root MSE	= .37795

USAREIT_	Coefficient	Std. err.	t	P> t	[95% conf. interval]
SP500LogReturn	.7247155	.106238	6.82	0.000	.512934 .936497
_cons	-.0231001	.0440214	-0.52	0.601	-.1108552 .064655

. summarize CAR if Within_Window

Variable	Obs	Mean	Std. dev.	Min	Max
CAR	7	-2.886169	2.736525	-8.301466	-.1520065

. ttest CAR == 0 if Within_Window

One-sample t test

Variable	Obs	Mean	Std. err.	Std. dev.	[95% conf. interval]
CAR	7	-2.886169	1.034309	2.736525	-5.417033 -.355306

mean = mean(CAR) t = -2.7904
H0: mean = 0 Degrees of freedom = 6

Ha: mean < 0 Ha: mean != 0 Ha: mean > 0
Pr(T < t) = 0.0158 Pr(|T| > |t|) = 0.0316 Pr(T > t) = 0.9842

. reg EuropeREIT_SP500LogReturn if Estimation_Period

Source	SS	df	MS	Number of obs =	74
Model	3.89091589	1	3.89091589	F(1, 72)	= 24.58
Residual	11.3992885	72	.158323451	Prob > F	= 0.0000
				R-squared	= 0.2545
				Adj R-squared	= 0.2441
Total	15.2902044	73	.209454854	Root MSE	= .3979

EuropeREIT_	Coefficient	Std. err.	t	P> t	[95% conf. interval]
SP500LogReturn	.554459	.1118449	4.96	0.000	.3315003 .7774177
_cons	-.0284674	.0463447	-0.61	0.541	-.120854 .0639192

. summarize CAR if Within_Window

Variable	Obs	Mean	Std. dev.	Min	Max
CAR	7	-4.427938	3.91387	-10.27382	-.4310805

. ttest Abnormal_Return == 0 if Within_Window

One-sample t test

Variable	Obs	Mean	Std. err.	Std. dev.	[95% conf. interval]
Abnorm-n	7	-1.467689	.6539838	1.730279	-3.06793 .1325519

mean = mean(Abnormal_Return) t = -2.2442
H0: mean = 0 Degrees of freedom = 6

Ha: mean < 0 Ha: mean != 0 Ha: mean > 0
Pr(T < t) = 0.0330 Pr(|T| > |t|) = 0.0660 Pr(T > t) = 0.9670

. reg AustraliaREIT_SP500LogReturn if Estimation_Period

Source	SS	df	MS	Number of obs =	74
Model	1.44605122	1	1.44605122	F(1, 72)	= 7.23
Residual	14.4087025	72	.200120868	Prob > F	= 0.0089
				R-squared	= 0.0912
				Adj R-squared	= 0.0786
Total	15.8547537	73	.217188407	Root MSE	= .44735

AustraliaREIT_	Coefficient	Std. err.	t	P> t	[95% conf. interval]
SP500LogReturn	.3380145	.1257447	2.69	0.009	.087347 .588682
_cons	-.0418558	.0521044	-0.80	0.424	-.1457239 .0620124

. reg LatinAmericaREIT_SP500LogReturn if Estimation_Period

Source	SS	df	MS	Number of obs =	74
Model	.766917173	1	.766917173	F(1, 72)	= 4.11
Residual	13.4513768	72	.186824678	Prob > F	= 0.0465
				R-squared	= 0.0539
				Adj R-squared	= 0.0408
Total	14.218294	73	.19477115	Root MSE	= .43223

LatinAmerica_	Coefficient	Std. err.	t	P> t	[95% conf. interval]
SP500LogReturn	.2461601	.1214956	2.03	0.046	.003963 .4883572
_cons	-.0590283	.0503437	-1.17	0.245	-.1593866 .04133

. summarize CAR if Within_Window

Variable	Obs	Mean	Std. dev.	Min	Max
CAR	7	-5.246873	4.057931	-12.09928	-.5443482

. ttest Abnormal_Return == 0 if Within_Window

One-sample t test

Variable	Obs	Mean	Std. err.	Std. dev.	[95% conf. interval]
Abnorm~n	7	-1.728468	.5146516	1.36164	-2.987775 - .4691611

mean = mean(Abnormal_Return) t = -3.3585
 H0: mean = 0 Degrees of freedom = 6

Ha: mean < 0 Pr(T < t) = 0.0076
 Ha: mean != 0 Pr(|T| > |t|) = 0.0153
 Ha: mean > 0 Pr(T > t) = 0.9924

. summarize CAR if Within_Window

Variable	Obs	Mean	Std. dev.	Min	Max
CAR	7	.543874	.9999955	-.4180843	1.996425

. ttest Abnormal_Return == 0 if Within_Window

One-sample t test

Variable	Obs	Mean	Std. err.	Std. dev.	[95% conf. interval]
Abnorm~n	7	-.0259761	.4020214	1.063649	-1.009687 .9577349

mean = mean(Abnormal_Return) t = -0.0646
 H0: mean = 0 Degrees of freedom = 6

Ha: mean < 0 Pr(T < t) = 0.4753
 Ha: mean != 0 Pr(|T| > |t|) = 0.9506
 Ha: mean > 0 Pr(T > t) = 0.5247

. reg ChinaREIT_ SP500LogReturn if Estimation_Period

Source	SS	df	MS	Number of obs	F(1, 72)
Model	.79550615	1	.79550615		8.31
Residual	6.891227	72	.095711486		0.0052
Total	7.68673315	73	.105297714		0.1035

ChinaREIT_	Coefficient	Std. err.	t	P> t	[95% conf. interval]
SP500LogReturn	.2507063	.0869612	2.88	0.005	.0773523 .4240603
_cons	.0134868	.0360338	0.37	0.709	-.0583453 .0853188

. summarize CAR if Within_Window

Variable	Obs	Mean	Std. dev.	Min	Max
CAR	7	-3.173055	3.017019	-8.863567	-.4793473

. ttest Abnormal_Return == 0 if Within_Window

One-sample t test

Variable	Obs	Mean	Std. err.	Std. dev.	[95% conf. interval]
Abnorm~n	7	-1.266224	.4929623	1.304256	-2.472459 -.0599886

mean = mean(Abnormal_Return) t = -2.5686
 H0: mean = 0 Degrees of freedom = 6

Ha: mean < 0 Pr(T < t) = 0.0212
 Ha: mean != 0 Pr(|T| > |t|) = 0.0424
 Ha: mean > 0 Pr(T > t) = 0.9788

2. ARCH/GARCH Model

ARCH family regression

Sample: 02jun2014 thru 31may2024, but with gaps

Number of obs = 2517
 Wald chi2(2) = 38.14
 Prob > chi2 = 0.0000
 Log likelihood = -1394.913

GlobalREIT_	Coefficient	std. err.	z	P> z	[95% conf. interval]
GlobalREIT_					
COVOL	.0329149	.005425	6.07	0.000	.0222822 .0435477
GPR	-.0490354	.0355322	-1.38	0.168	-.1186772 .0206064
_cons	.0362421	.0073318	4.94	0.000	.0218721 .0506122
ARCH					
arch					
L1.	.4012354	.024769	16.20	0.000	.3526891 .4497817
garch					
L1.	.4524231	.0511173	8.85	0.000	.352235 .5526111
_cons	.0342142	.0073947	4.63	0.000	.0197208 .0487077

ARCH family regression

Sample: 02jun2014 thru 31may2024, but with gaps

Number of obs = 2517
 Wald chi2(5) = 51.48
 Prob > chi2 = 0.0000
 Log likelihood = -1393.783

GlobalREIT_	Coefficient	std. err.	z	P> z	[95% conf. interval]
GlobalREIT_					
COVOL	.0379687	.005704	6.66	0.000	.0267891 .0491483
GPR	-.0473773	.0373772	-1.27	0.205	-.1206353 .0258808
ExtremeTemperatures	.0091013	.0192986	0.47	0.637	-.0287232 .0469258
GlobalWarming	-.0114595	.0229224	-0.50	0.617	-.0563866 .0334677
HurricanesFloods	.0166056	.0153475	1.08	0.279	-.0134749 .046686
_cons	.0296145	.0123093	2.41	0.016	.0054887 .0537403
ARCH					
arch					
L1.	.415781	.0242402	17.15	0.000	.368271 .463291
garch					
L1.	.4343703	.0501794	8.66	0.000	.3360206 .5327201
_cons	.0359326	.0073776	4.87	0.000	.0214727 .0503925

ARCH family regression

Sample: 02jun2014 thru 31may2024, but with gaps

Number of obs = 2517
Wald chi2(2) = 3.44
Prob > chi2 = 0.1789

Log likelihood = -1974.545

USAREIT_	OPG				
	Coefficient	std. err.	z	P> z	[95% conf. interval]
USAREIT_					
COVOL	-.0142613	.0086938	-1.64	0.101	-.0313008 .0027782
GPR	-.0346231	.0448887	-0.77	0.441	-.1226034 .0533572
_cons	.0071378	.0099789	0.72	0.474	-.0124206 .0266962
ARCH					
arch L1.	.3451356	.0237317	14.54	0.000	.2986223 .3916489
garch L1.	.5248556	.0548209	9.57	0.000	.4174087 .6323026
_cons	.0415056	.0126725	3.28	0.001	.0166679 .0663432

ARCH family regression

Sample: 02jun2014 thru 31may2024, but with gaps

Number of obs = 2517
Wald chi2(5) = 6.81
Prob > chi2 = 0.2350

Log likelihood = -1973.367

USAREIT_	OPG				
	Coefficient	std. err.	z	P> z	[95% conf. interval]
USAREIT_					
COVOL	-.0118934	.0089303	-1.33	0.183	-.0293964 .0056096
GPR	-.0316024	.0469086	-0.67	0.501	-.1235415 .0603368
ExtremeTemperatures	-.0122372	.0251836	0.49	0.627	-.0371217 .0615961
GlobalWarming	-.0142436	.0285226	-0.50	0.618	-.070147 .0416597
HurricanesFloods	.0203132	.0194912	1.04	0.297	-.0178888 .0585153
_cons	-.0046241	.0171553	-0.27	0.788	-.0382478 .0289966
ARCH					
arch L1.	.3521324	.023865	14.76	0.000	.3053578 .398907
garch L1.	.5136771	.0557799	9.21	0.000	.4043505 .6230037
_cons	.0434176	.0132126	3.29	0.001	.0175214 .0693138

ARCH family regression

Sample: 02jun2014 thru 31may2024, but with gaps

Number of obs = 2517
Wald chi2(2) = 635.47
Prob > chi2 = 0.0000

Log likelihood = -1809.419

CanadaREIT_	OPG				
	Coefficient	std. err.	z	P> z	[95% conf. interval]
CanadaREIT_					
COVOL	-.176487	.0070366	-25.08	0.000	-.1902784 -.1626955
GPR	-.0314355	.0423859	-0.74	0.458	-.1145103 .0516393
_cons	-.1041525	.0091145	-11.43	0.000	-.1220166 -.0862884
ARCH					
arch L1.	.2370772	.0242355	9.78	0.000	.1895765 .2845779
garch L1.	.7864971	.0471351	16.69	0.000	.6941139 .8788802
_cons	-.0215034	.0097502	-2.21	0.027	-.0406134 -.0023934

ARCH family regression

Sample: 02jun2014 thru 31may2024, but with gaps

Number of obs = 2517
Wald chi2(5) = 647.50
Prob > chi2 = 0.0000

Log likelihood = -1808.497

CanadaREIT_	OPG				
	Coefficient	std. err.	z	P> z	[95% conf. interval]
CanadaREIT_					
COVOL	-.1778722	.0071263	-24.96	0.000	-.1918395 -.1639049
GPR	-.0327715	.0425394	-0.77	0.441	-.1161472 .0506043
ExtremeTemperatures	.0261967	.0231696	1.13	0.258	-.0192148 .0716082
GlobalWarming	-.0221789	.0288071	-0.77	0.441	-.0786398 .0342819
HurricanesFloods	-.0128004	.0193323	-0.66	0.508	-.0506911 .0250903
_cons	-.1004733	.0172115	-5.84	0.000	-.1342072 -.0667394
ARCH					
arch L1.	.2387445	.0246395	9.69	0.000	.1904521 .287037
garch L1.	.7844321	.0481646	16.29	0.000	.6900312 .8788331
_cons	-.021205	.0099444	-2.13	0.033	-.0406956 -.0017144

ARCH family regression

Sample: 02jun2014 thru 31may2024, but with gaps

Number of obs = 2517
Wald chi2(2) = 3.21
Prob > chi2 = 0.2088

Log likelihood = -2194.168

EuropeREIT_	OPG				
	Coefficient	std. err.	z	P> z	[95% conf. interval]
EuropeREIT_					
COVOL	-.0192462	.0107401	-1.79	0.073	-.0402963 .001804
GPR	.0056797	.0474533	0.12	0.905	-.087327 .0986864
_cons	-.0143602	.0112095	-1.28	0.200	-.0363304 .00761
ARCH					
arch L1.	.3035028	.0270942	11.20	0.000	.2503991 .3566065
garch L1.	.7911001	.0411435	19.23	0.000	.7104604 .8717398
_cons	-.0257993	.0103198	-2.50	0.012	-.0460258 -.0055728

ARCH family regression

Sample: 02jun2014 thru 31may2024, but with gaps

Number of obs = 2517
Wald chi2(5) = 7.85
Prob > chi2 = 0.1646

Log likelihood = -2192.368

EuropeREIT_	OPG				
	Coefficient	std. err.	z	P> z	[95% conf. interval]
EuropeREIT_					
COVOL	-.02163	.0108647	-1.99	0.046	-.0429244 -.0003356
GPR	.0041499	.0478156	0.09	0.931	-.0895669 .0978667
ExtremeTemperatures	-.0002759	.0249413	-0.01	0.991	-.0491599 .0486081
GlobalWarming	-.0193789	.0265492	0.73	0.464	-.0325445 .0713022
HurricanesFloods	-.0376642	.0237356	-1.59	0.113	-.0841852 .0088568
_cons	-.0015609	.0190102	-0.08	0.935	-.0388202 .0356985
ARCH					
arch L1.	.2998789	.0270216	11.10	0.000	.2469175 .3528403
garch L1.	.8080274	.0414242	19.51	0.000	.7268375 .8892172
_cons	-.0312534	.0104977	-2.98	0.003	-.0518286 -.0106782

ARCH family regression

Sample: 02jun2014 thru 31may2024, but with gaps

Number of obs = 2516
Wald chi2(2) = 16.52
Prob > chi2 = 0.0003

Log likelihood = -2187.277

AustraliaREIT_	OPG				
	Coefficient	std. err.	z	P> z	[95% conf. interval]
AustraliaREIT_					
COVOL	-.037411	.0092785	-4.03	0.000	-.0555965 -.0192255
GPR	.042315	.053199	0.80	0.426	-.061953 .1465831
_cons	-.0241112	.0117289	-2.06	0.040	-.0470995 -.0011229
ARCH					
arch L1.	.2646274	.0294068	9.00	0.000	.206991 .3222637
garch L1.	.6137679	.0529264	11.60	0.000	.510034 .7175018
_cons	.0384678	.0144227	2.67	0.008	.0101997 .0667358

ARCH family regression

Sample: 02jun2014 thru 31may2024, but with gaps

Number of obs = 2516
Wald chi2(5) = 16.06
Prob > chi2 = 0.0067

Log likelihood = -2186.977

AustraliaREIT_	OPG				
	Coefficient	std. err.	z	P> z	[95% conf. interval]
AustraliaREIT_					
COVOL	-.0358814	.0093614	-3.83	0.000	-.0542294 -.0175335
GPR	.0427322	.0534374	0.80	0.424	-.0620031 .1474675
ExtremeTemperatures	-.0072502	.0265622	-0.27	0.785	-.0593113 .0448108
GlobalWarming	.003955	.0313664	0.13	0.900	-.0575221 .0654321
HurricanesFloods	.0155027	.0239554	0.65	0.518	-.0314489 .0624544
_cons	-.0310037	.0199809	-1.55	0.121	-.0701655 .0081582
ARCH					
arch L1.	.2636706	.0294972	8.94	0.000	.2058572 .321484
garch L1.	.616378	.0534556	11.53	0.000	.511607 .721149
_cons	.0377129	.0145658	2.59	0.010	.0091644 .0662614

ARCH family regression						
Sample: 02jun2014 thru 31may2024, but with gaps						
Log likelihood = -1893.089						
Number of obs = 2517						
Wald chi2(2) = 2.97						
Prob > chi2 = 0.2265						
LatinAmericaREIT_	OPG					
Coefficient	std. err.	z	P> z	[95% conf. interval]		
LatinAmericaREIT_						
COVOL	-.0133774	.011882	-1.13	0.260	-.0366656	.0099109
GPR	-.0593511	.0450356	-1.32	0.188	-.1476192	.028917
_cons	.0036004	.0115146	0.31	0.755	-.0189679	.0261686
ARCH						
arch L1.	.1262076	.0203543	6.20	0.000	.0863139	.1661013
garch L1.	1.013344	.1062144	9.54	0.000	.805168	1.221521
_cons	-.0387355	.0251155	-1.54	0.123	-.0879609	.0104899

ARCH family regression						
Sample: 02jun2014 thru 31may2024, but with gaps						
Log likelihood = -1891.684						
Number of obs = 2517						
Wald chi2(5) = 6.72						
Prob > chi2 = 0.2425						
LatinAmericaREIT_	OPG					
Coefficient	std. err.	z	P> z	[95% conf. interval]		
LatinAmericaREIT_						
COVOL	-.0155962	.011916	-1.31	0.191	-.0389512	.0077587
GPR	-.0598519	.0450173	-1.33	0.184	-.1480843	.0283804
ExtremeTemperatures	-.0352183	.0216194	-1.63	0.103	-.0775915	.0071549
GlobalWarming	.0182617	.0312702	0.58	0.559	-.0430267	.0795501
HurricanesFloods	-.0026712	.0206662	-0.13	0.897	-.0431762	.0378338
_cons	.0157433	.0188132	0.84	0.403	-.02113	.0526166
ARCH						
arch L1.	.1251582	.0204431	6.12	0.000	.0850904	.165226
garch L1.	1.008415	.1077961	9.35	0.000	.7971382	1.219691
_cons	-.0371155	.0254959	-1.46	0.145	-.0870865	.0128555

ARCH family regression						
Sample: 02jun2014 thru 31may2024, but with gaps						
Log likelihood = -778.1019						
Number of obs = 2517						
Wald chi2(2) = 438.39						
Prob > chi2 = 0.0000						
ChinaREIT_	OPG					
Coefficient	std. err.	z	P> z	[95% conf. interval]		
ChinaREIT_						
COVOL	-.0998307	.0048025	-20.79	0.000	-.1092435	-.090418
GPR	-.0213975	.0292089	-0.73	0.464	-.078646	.035851
_cons	-.0575187	.006553	-8.78	0.000	-.0703622	-.0446751
ARCH						
arch L1.	.3114473	.0247808	12.57	0.000	.2628778	.3600167
garch L1.	.6475799	.0488741	13.25	0.000	.5517885	.7433713
_cons	.0052349	.004579	1.14	0.253	-.0037397	.0142096

ARCH family regression						
Sample: 02jun2014 thru 31may2024, but with gaps						
Log likelihood = -774.0544						
Number of obs = 2517						
Wald chi2(5) = 459.28						
Prob > chi2 = 0.0000						
ChinaREIT_	OPG					
Coefficient	std. err.	z	P> z	[95% conf. interval]		
ChinaREIT_						
COVOL	-.1019699	.0049017	-20.80	0.000	-.111577	-.0923628
GPR	-.0244927	.0301895	-0.81	0.417	-.0836631	.0346777
ExtremeTemperatures	.0039652	.0147215	0.27	0.788	-.0248883	.0328187
GlobalWarming	.0209903	.0160484	1.31	0.191	-.010464	.0524446
HurricanesFloods	-.0333245	.0133246	-2.50	0.012	-.0594402	-.0072089
_cons	-.0503523	.0101712	-4.95	0.000	-.0702874	-.0304171
ARCH						
arch L1.	.3131098	.0255351	12.26	0.000	.2630619	.3631578
garch L1.	.6568915	.0487804	13.47	0.000	.5612836	.7524994
_cons	.0038473	.0045123	0.85	0.394	-.0049967	.0126913