A First Look at the Impact of COVID19 on Commercial Real Estate Prices: Asset Level Evidence

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Abstract

This paper examines the impact of the COVID-19 pandemic on commercial real estate prices. We construct a novel measure of real estate investment trusts' (REITs') exposure to the growth in COVID-19 cases at the asset level. We document a negative relationship between this geographically weighted case growth and risk-adjusted returns. However, there is substantial variation across property types: retail and hospitality REITs react the most negatively while health care and technology REITs react positively to the exposure of their portfolios to growth in COVID-19 cases. Portfolios tilted toward properties in population-dense areas increases the negative impact of COVID-19 on stock returns. After conditioning on the property type focus of the REIT, days since the beginning of the portfolio's exposure to the outbreak, the weighted-average population density of the counties in which the REIT is invested, and the extent to which the REIT's portfolio is concentrated by property type and geography, other firm characteristics have little effect on the negative stock price impact of the pandemic. We argue that the effects of COVID-19 that we observe in highly liquid stock markets are indicative of the effects occurring in private CRE markets.

Keywords: COVID19, Commercial real estate, stock return, REITs, asset location

JEL classification: I10, G11, G14, D80, R10

1. Introduction

The COVID-19 pandemic is having a devastating impact on economic activity. This has produced a rapidly growing literature that examines its economic consequences, some of which focuses on how stock returns have responded to changes in investors' information and expectations (e.g., Alfaro, Chari, Greenland, and Schott, 2020; Gormsen and Koijen, 2020; Ramelli and Wagner, 2020). Most of these studies provide evidence at the index-level or firm-level. However, movements in a firm's stock price are largely driven by the perceived productivity of the firm's underlying assets; therefore, it is important to understand how the COVID-19 shock transmits to the equity markets from a firm's underlying assets. The goal of this paper is to help fill this gap in the literature.

Using index-level return data, Alfaro et al. (2020) find that large increases in predicted infection rates are associated with larger negative stock returns. Gormsen and Koijen (2020) examine the behavior of stock and bond markets to explore how different shocks are reflected in asset prices. Sinagl (2020) provides evidence that industries with higher cash-flow risk had lower excess returns, higher systematic risk, and lower risk-adjusted returns in the first quarter of 2020.

A number of studies have also examined the effects of COVID-19 at the firm level. Ramelli and Wagner (2020) focus on the exposure of firms' international supply chains to China. They find that the stock returns of companies with more China exposure have reacted more negatively. They also find that corporate debt and cash holdings are important determinants of stock price responses to COVID-19. Ding, Levine, Lin, and Xie (2020) provide global evidence on the relationship between various firm characteristics and stock price reactions to COVID-19 cases. They conclude that stock prices react less negatively when firms are financially strong, have less exposure to global supply chains and consumers, and have better corporate social responsibility and corporate governance. Hassan, van Lent, Hollander, and Tahoun (2020) develop measures of a firm's COVID-19 exposure from earnings-call transcripts for a global sample of more than 11,000 firms across 84 countries. They find that firms' primary concerns are a decline in product demand, increased uncertainty, and disruption in supply chains. Gerding, Martin, and Nagler (2020) examine firm-level stock returns across 100 countries and find that stocks react more negatively to the COVID-19 outbreak in countries with higher debt-to-GDP ratios, suggesting the importance of governments' perceived fiscal capacity to help mitigate the pandemic's effects.

The COVID-19 crisis is undeniably causing pain for many commercial property owners. Real-estate advisers, property managers, and lawyers are fielding inquiries from tenants, landlords, and lenders about strategies for rent and mortgage relief given the closures of nonessential stores and the resulting economic downturn. Various large retailers have stopped paying rent or warned they plan to withhold payments to conserve cash. As of April 17, 2020, approximately 50% of retail tenants had paid their April rent, compared with the 85% who had paid their March rent, according to data from real-estate business-intelligence company Datex Property Solutions (Al-Muslim, 2020). Many nonpaying tenants say they are excused from making rent payments under their leases because the pandemic is a force majeure—an event outside their control that prevents them from fulfilling contracts. According to CoStar Risk Analytics, the commercial real estate market can expect to see borrowers default on more than 13,000 loans totaling $148 billion in value (Heschmeyer, 2020).

We focus on the commercial real estate (CRE) assets owned by listed U.S. equity real estate investment trusts (REITs). This setting is advantageous to the study of the impact of COVID-19 at the asset level for several reasons. First, the perceived productivity of a firm's underlying assets is difficult to measure in conventional firms. However, it is relatively straightforward to measure in the REIT market because asset productivity is mainly a function of the rent-generating ability of the properties owned by the REIT. In addition, REITs are subject to a set of restrictive conditions that ensure that equity REITs invest primarily in income-producing real estate.[1] These real assets are relatively easier to locate and value than the tangible (e.g., plant and equipment) and intangible assets (e.g., intellectual property) owned by conventional firms. Finally, listed REITs typically acquire and dispose of income-producing real estate in an illiquid, highly segmented, parallel private market. Although the illiquidity and opaqueness of these private CRE markets limits our ability to detect rent and (especially) price movements in "real time," we argue that the effects of COVID-19 that we observe in highly liquid stock markets are indicative of the effects occurring in private CRE markets.

[1] A "qualified" REIT may deduct dividends paid from corporate taxable income if they satisfy a set of restrictive conditions on an ongoing basis. Fully 75% of the value of the REIT's assets must consist of real estate assets, cash and government securities. Moreover, at least 75% of the REIT's gross income must be derived from real estate assets.

Initial comparisons using index-level returns for the S&P 500, Russell 2000, and the FTSE-NAREIT All Equity REITs Index, as well as NAREIT sub-indices (office, industrial, retail, residential, health care, and lodging/resort) reveal an increasing co-movement between the broader stock market and NAREIT equity REIT index during the pandemic. In addition, returns varied substantially by the property-type focus of the REIT. However, property type indices might mask significant variation across REITs in the exposure of their commercial real estate portfolios to the COVID-19 pandemic. This motivates our study at the firm- and asset-level.

We continue our analysis by evaluating firm-level stock performance across property types. Using a sample of 11,210 firm-day observations for 198 equity REITs from January 21 through April 15, 2020, we calculate returns over 1-day, 2-day, and 3-day windows. These returns are risk-adjusted based on the S&P 500 Index and the FTSE-NAREIT All Equity REITs Index.

We find that technology, self-storage, and industrial warehouse REITs produced positive risk-adjusted returns during the early stages of the pandemic. The worst performers were hospitality and retail REITs due to canceled travel, imposed closures, and shelter-in-place orders in most cities and states. Although the portfolios of retail and health care REITs display a similar geographic pattern, the risk-adjusted returns we observe for these two property types are quite different.

To examine how the growth rates of COVID-19 cases affect firms differently through their asset holdings, we construct a novel measure of geographically weighted COVID-19 growth (*GeoCOVID*) that varies daily during our sample periods. This variable is the weighted average of the daily growth rates of COVID19 cases in counties in which the REIT owns properties. The weights are the percentages of a REIT's portfolio allocated to each county at the end of 2019Q4.

In our univariate analyses, we observe a large variation across property types in the correlation between risk-adjusted returns and *GeoCOVID*. The performance of retail, office, and residential REITs is negatively correlated with *GeoCOVID.* In contrast, health care and technology REITs display a positive correlation even though risk-adjusted returns for these property types are mostly negative.

In our multivariate analysis, we regress 1-day, 2-day, and 3-day risk-adjusted returns on each REIT's *GeoCOVID* on day t-1. To account for the fact that COVID-19 exposure starts at different times for different firms depending on the locations of their properties, we include

the number of days since the first reported COVID19 case in counties in which the REIT owns properties. We also construct a geographically weighted population density variable (*GeoDensity*) based on REITs' asset locations. Two additional asset-specific controls are included in the pooled, cross-sectional regressions: the extent to which the REIT's property portfolio is concentrated by (county) location or by property type. Lastly, we include a large set of firm characteristics as controls.

Our baseline results suggest that a one- standard- deviation increase in *GeoCOVID* is associated with a 0.24 percentage points decrease in risk-adjusted returns on the next day. In terms of economic magnitude, this return reduction is equivalent to 40% of the sample mean (-0.6 percentage points) of risk-adjusted returns. Comparing across different property types, we find that the negative effect of a one-standard-deviation increase in *GeoCOVID* is equivalent to a reduction in returns that is equal to 64% and 138% of the sample mean return for retail and residential REITs, respectively. In contract, among health care and technology REITs, a one standard deviation increase in *GeoCOVID* is associated with a 1-day return *increase* of 0.4 percentage points. This variation across property types is striking.

Next, we further investigate how geographic asset allocations affect investors' response to the pandemic. If all REITs tend to overweight areas most negatively affected by the pandemic (e.g., coastal cities), our geographic weighting of each firm's asset allocations would not contribute additional explanatory power to our analysis of risk-adjusted returns. To investigate this concern, we construct a dummy variable that is set equal to one if the firm's exposure to COVID19 growth rates is in the upper quartile of growth rates across all counties in which a REIT owns properties. This variable is constructed to identify firms that are heavily exposed to areas most impacted by the pandemic. By including the interaction of this dummy with an equally weighted COVID growth variable, we find that the interaction coefficients are negative and significant; however, the simple average of COVID growth itself does not help to explain risk-adjusted returns. This finding suggests that the geographic weighting of a REIT's portfolio explains the response of stock returns to the pandemic, supporting the importance of asset-level information.

Turning to other aspects of asset allocation, we next investigate the extent to which geographically weighted population densities, property type concentrations, and geographic concentrations affect the sensitivity of stock returns to the firm's exposure to COVID19 growth rates. We find that, for firms with more assets allocated to areas with high *GeoDensity*, the negative return reaction to *GeoCOVID* is increased by 2.3 to 10 percentage

points. However, property type and geographic portfolio concentrations have no effect on the sensitivity of stock returns to *GeoCOVID*.

Lastly, we further investigate the impact of various firm characteristics on returns, including leverage, cash holdings, Tobin's Q, return momentum, institutional ownership, investment, and EBITDA. After conditioning on firms' property type and geographic concentrations, days since the outbreak, and population density, only a firm's stock returns in the fourth quarter of 2019 are associated with stock market reaction to *GeoCOVID*.

Taken together, our findings highlight the importance of the asset-level attributes of a firm's portfolio on stock reactions in response to the pandemic. Specifically, the key drivers are the type of business activity (proxied by the property type on which the REIT is focused) and the geographic allocation of assets (proxied by *GeoCOVID* and *GeoDensity*).

We believe we are the first paper to examine how the COVID-19 pandemic has affected stock return through a firm's underlying assets. By constructing a geographically weighted COVID19 growth variable at the asset-level, our paper contributes to the rapidly growing literature that investigates the effect of the COVID-19 pandemic on financial markets.

To the best of our knowledge, there is currently no study that examines the outbreak of COVID19 in real estate markets. Ambrus et al. (2020) study a cholera epidemic in one neighborhood of nineteenth-century London. They find that geographically concentrated income has a long-run negative impact on rents and housing prices over the following 160 years. Francke and Korevaar (2020) study the plague in Amsterdam and cholera in Paris between the late 16th century and 1811. They document large reductions in rents and house prices within the affected areas during the first six months of an epidemic; however, these shocks were transitory. More recently, Wong (2008) examines how SARS infected the property market in Hong Kong and found a small house price decline of -1.5%. More broadly, our study is related to the large literature on the economic effects of pandemics, disease, and health shocks (e.g., Bleakley, 2007; Weil, 2007; Nunn and Qian, 2010; Correia et al., 2020; Ambrus et al., 2020; Francke and Korevaar, 2020).

Outside of the pandemic literature, our study contributes to the growing literature of the geography of assets and the extent to which "local" information about the productivity of a firm's assets is capitalized into stock prices (e.g., Parsons, Sabbatucci, and Titman, 2020; Garcia and Norli, 2012; Bernile et al., 2015; Dougal et al., 2015; Jannati et al., 2019; Smajlbegovic, 2019; Ling, Wang, and Zhou, 2019, 2020a, 2020b; Wang and Zhou, 2020).

The remainder of the paper proceeds as follows. In section 2, we examine the impact of COVID-19 on stock returns using index-level return data. Section 3 contains a description of our firm-level data set, while summary statistics and our regression results are presented and discussed in section 4. Section 5 provides a brief conclusion.

2. Index-Level Stock Market Performance During the Pandemic

Figure 1 plots daily indices for the S&P 500, Russell 2000, and the FTSE-NAREIT All Equity REITs Index from 2015 through April 23, 2020.[2] Each index is set equal to 100 at year-end 2014. The arithmetic annualized mean return on the S&P 500 from year-end 2014 through February 28, 2020, was 13.1%. The corresponding returns on equity REITs and the Russell 2000 were 9.7% and 7.7%, respectively. The correlation of Russell 2000 daily returns and S&P 500 returns during this period is 0.874; however, the correlation of the NAREIT index and the S&P 500 is just 0.581.

Starting from the end of February 2020, the U.S. stock market reaction to the COVID-19 pandemic has been dramatic. For example, from February 24 to March 24, 2020, the S&P 500 moved more than +/-2.5% in 18 out of 22 trading days, which is more than any other period in history with the same number of trading days (Baker et al. 2020). The average *daily* total return on the S&P 500 in March was -0.6%. The corresponding average daily returns on equity REITs and the Russell 2000 were -0.9% and -1.1%, respectively. Overall, the total return index on the S&P 500, equity REITs, and the Russell 2000 declined 16%, 23%, and 26%, respectively, during March, with a significant day-to-day variation. In addition, the co-movement of these stock indices increased sharply. More specifically, the daily rerun correlation among these three indices increased to at least 0.94 during March. Clearly, holding a broad-based basket of REIT stocks provided little portfolio diversification for a stock portfolio during this severe stock market downturn. Through April 23, the S&P 500 Index increased 8% in April; the corresponding increase in the equity REIT index was just 2%. According to Real Capital Analytics, transaction activity in CRE markets dropped at a double-digit rate in March as the financial and economic implications of the COVID-19 pandemic started to unfold.[3]

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[2] Equity REITs own income-producing real estate and obtain most of their revenues from rents. Mortgage REITs invest in mortgages or mortgage-backed securities. According to the FTSE-NAREIT Index, the equity REITs in their index as of February 29, 2020 had a total equity market capitalization of $1.2 trillion.

[3] Real Capital Analytics, *RCA Insights*, April 22, 2020.

Figure 2 plots daily returns for office, industrial, retail, residential, health care, and lodging/resort REITs from 2015 through April 23, 2020.[4] Even prior to the onset of the pandemic, Figure 2 reveals that returns varied substantially by the property type focus of the REIT. For example, the arithmetic annualized mean return on office REITs was 5.4% from year-end 2014 through February 28, 2020. The corresponding returns on industrial, retail, residential, health care, and lodging/resort equity REITs were 22.3%, -1.6%, 14.8%, 5.9%, ad 7.0%, respectively. This variation in returns across property types highlights a significant limitation associated with the use of aggregate-level return data.

The average daily return on the six REIT property types highlighted above ranged from -0.2% (industrial) to -2.5% (retail) during March of 2020. As the potential implications of the COVID-19 pandemic began to be reflected in share prices, the cumulative total return index for retail REITs declined by a staggering 49%. This March decline was closely followed by lodging/resort REITs (-44%) and health care REITs (-41%); again, with significant day-to-day variation. The lockdown on "non-essential" retail in virtually all parts of the country has been, and continues to be, destructive. Moreover, according to Green Street Advisors, about 50 percent of the 1,000 department stores in U.S. malls are vulnerable to permanent closure by the end of 2021, If struggling department store anchors go out of business as a result of the COVID-19 pandemic, other troubled tenants at those shopping centers likely will activate lease clauses to shutter their stores, as well (Boswell 2020).

Travel restrictions and social distancing guidelines have resulted in the travel and tourism industry coming to a standstill. Generally, in a recession, healthcare real estate looks relatively stable and profitable, and healthcare REITs are generally considered to be well-positioned to withstand the current economic downturn. Although health care real estate is not immune to the impact of coronavirus, the various types of healthcare real estate—including hospitals, medical offices, and senior housing—have all been affected and are faring differently (Bass 2020). For example, Healthcare Realty Trust, a health care REIT that specializes in medical offices, experienced a small average daily (3-day) risk-adjusted returns of -0.16% (-0.39%) during our sample period. On the other hand, one of its worst-performing

[4] As of February 29, 2020, the FTSE-NAREIT All Equity REITs Index contained 18 office, 13 industrial, 33 retail, 21 residential, 17 health care, and 15 lodging/resort REITs. See *REIT Watch*, March 2020 (www.nareit.com). Retail REITs include firms that invest in shopping centers, regional malls, and free-standing properties. Residential REITs include listed companies that invest in apartments, manufactured housing, and single-family (rental) homes.

peers, Capital Senior Living Corporation, was down by more than 1.7% per day (or -5.2% over three days), on average.

The total return indices for office and residential REITs also declined sharply in March 2020: 25% and 26%, respectively. Although the longer-term nature of office leases may be providing some protection for office property owners, evidence is appearing that corporations of all sizes plan to use less real estate after the pandemic subsides.[5] Residential REITs would seem to have an advantage over many other REITs because everybody must live somewhere. A survey by the National Multifamily Housing Council found that 89 percent of apartment tenants had made full or partial rent payments by April 19 this year. However, the extent to which the payment situation will worsen as more Americans lose their jobs is creating significant uncertainty. Moreover, tenant groups and nonprofits in multiple cities are encouraging rent strikes designed to persuade the government to halt rent and mortgage payments (Lang 2020).

Of the six major types included in Figure 2, the best performing during this bear period was industrial (primarily warehouses), which suffered a decline in its total return index of just 10%. Before the coronavirus pandemic, the e-commerce explosion was already boosting industrial REITs. Short-term and long-term growth in e-commerce spurred by coronavirus-stimulated changes in shopping behavior should further benefit industrial REITs. The looming permanent closure of thousands of stores across the country also promises to lift industrial REITs, with more shoppers likely to be seeking e-commerce alternatives. The total return index for industrial REITs recovered a modest 3% during April of 2020 (through April 23). In contrast, the returns on office, retail, health care, and lodging/resort REITs continued to decline in April.

Although not displayed in Figure 2, infrastructure REITs and data center REITs, although small in number, were the best performing property types during the period of March 1 to April 23. The total return index for infrastructure REITs and data center REITs *increased* 5% and 15%, respectively. Two developments have protected the stocks of publicly-traded data center REITs during the early stages of the pandemic: more e-commerce activity amid the clampdown on bricks-and-mortar shopping and increased telecommuting and

[5] Sixty-nine percent of corporate real estate professionals said their company will take up less real estate after observing the feasibility of employees working from home according to a CoreNet Global survey conducted between April 22 and April 27, 2020. A survey from the research firm Gartner released April 3 revealed that 74% of the 314 chief financial officers they surveyed said they planned to downsize the number of people that came into the office each day.

distance learning as a result of widespread stay-at-home orders, triggering more video and data traffic. In addition, telemedicine has seen a surge in use as health care providers try to limit in-person visits. Millions of Americans have also increasingly relied on their cellphones to stay connected during the coronavirus pandemic (Egan 2020). Thus, REITs that own cell towers should benefit from most schools being shut down for the rest of this academic year and many people sticking to social distancing guidelines.

Although the use of property type indices is a substantial improvement over the use of an aggregate, industry-level index, these property type indices still mask significant variation across REITs in the exposure of their commercial real estate portfolios to the COVID-19 pandemic. Because the number of reported COVID-19 cases varies substantially by regions, we next describe the dataset that allows us to measure the exposure of a firm's real estate portfolio to the growth in reported COVID-19 cases.

3. Data

The initial sample of publicly traded U.S. equity REITs is obtained from the S&P Global Real Estate Properties (formerly SNL Real Estate) database. We require non-missing values for the following items for each REIT at the end of each day from January 1, 2019, to April 15, 2020: REIT identifier (SNL Institution Key), total return, stock price, property type, and stock market capitalization. The initial sample includes 224 unique equity REITs traded on NYSE, Amex, and Nasdaq in 2019Q4. According to S&P Global and NAREIT, REITs are classified into twelve major property types, including office, industrial, retail, residential, diversified, hospitality (lodging/resorts), health care, self-storage, specialty, timber, data center, and infrastructure. Due to a small number of firms, we include timber REITs in the specialty category and combine infrastructure and data center REITs into a "technology" category.[6] Appendix 2 summarizes property type descriptions. Quarterly accounting data and daily total returns on individual REITs and on our broad-based market indices are obtained from the S&P Global Companies database. The 30-day U.S. Treasury rate is downloaded from the Federal Reserve System website.[7]

[6] The FTSE-NAREIT All Equity REITs Index contained only four timber REITs, five infrastructure (primarily cell tower) REITs and five data center REITs as of February 29, 2020. See *REIT Watch*, March 2020 (www.nareit.com).

[7] See https://www.federalreserve.gov/releases/h15/

To measure time-varying, firm-level exposure to the growth in confirmed COVID-19 cases in each county, we collect the following data from the S&P Global Real Estate Properties for each property held by a listed equity REIT at the end of 2019Q4: property owner (institution name), property type, geographic (county) location, book value, initial cost and historic cost. This produces a REIT property-level data set containing 73,406 property observations for 201 unique REITs. We first calculate, for each REIT *i*, the percentage of its property portfolio, based on depreciated book values, invested in each county at the end of 2019.[8] We then match these portfolio allocations with the daily growth rates of county-level COVID-19 confirmed cases, which is obtained from the Coronavirus COVID-19 Global Cases database at Johns Hopkins University.[9] These daily growth rates are available for the period between Tuesday, January 21, 2020, and Wednesday, April 15, 2020, which dictates the start and end of our analysis period. These county-level growth rates are then value-weighted by the percentage of the REIT's portfolio invested in each county. This produces an estimated daily COVID-19 exposure of each REIT's underlying property portfolio (*GeoCOVID*). This merge leaves us with 198 equity REITs and 12,338 firm-day observations (excluding weekends).

We estimate daily risk-adjusted returns following Rehse et al. (2019). We obtain return sensitivities for each firm using a simple market model for the time period January 1, 2019 to January 20, 2020. We use two stock market indices: the S&P 500 Index and the FTSE-NAREIT All Equity REITs Index. Next, we use the firm-level return sensitivities estimated in the first step to compute daily risk-adjusted returns for the baseline period between Tuesday, January 21, 2020 and Wednesday, April 15, 2020. Daily risk-adjusted returns are calculated as the difference between REIT returns in excess of risk-free rate and the product of returns on the market index and the corresponding return sensitivity.[10]

We first use *GeoCOVID* reported on day t-1 to predict stock returns on day t. However, because the news contained in the number of new cases of COVID19 reported on day t-1 may take more than the subsequent day to be fully incorporated into stock prices, we also use

[8] The use of book values in place of unobservable true market values may understate (overstate) the value-weighted percentage of the REIT portfolio invested in regions that have recently experienced a relatively high (low) rate of price appreciation.

[9] https://github.com/CSSEGISandData/COVID-19

[10] Share price changes, and therefore total returns, are dependent on how much debt a company employs. Therefore, unlevered returns may provide a more accurate picture of how investors repriced the different property sectors, and individual REITs, during the early stages of the pandemic (Green Street Advisors, 2020). In the future, we plan to redo our analysis using unlevered returns as a robustness check.

GeoCOVID reported on day t-1 to predict cumulative returns over the subsequent two days (day t and day t+1). Finally, because investors may be able to partially predict reported *COVID19 Growth* using epidemiological models, we use *GeoCOVID* reported on day t-1 to predict aggregate stock returns over a three-day window: day *t-1,* day *t,* and day *t*+1. These multiple-day return measures are constructed using non-overlapping windows (days) so that each observation of the dependent variable is independent of the prior and subsequent observation (Harri and Brorsen, 1998).

Wheaton and Thompson (2020) propose a power function that measures the cumulative number of confirmed COVID-19 cases across the major U.S. counties from January 21, 2020 to the end of March 2020. They calibrate the power parameters using a log-linear regression equation. Among the parameters, days since the onset of the pandemic in that county and the population density of the county predict the cumulative number of confirmed cases. Similar to Wheaton and Thompson (2020), we define *Days since outbreak* as the number of days since a COVID19 case was reported in any county in which the REIT owns property. To account for the expected non-linearity in the growth rate of COVID-19 cases, we also include the quadratic term of *Days since outbreak*, or *Days since outbreak*^{2}, in our analysis.

Greater population density in a geographic area complicates social distancing and therefore increases the likelihood the virus will spread. To test this conjecture, we construct a measure of the average population density of the counties in which the REIT owns properties. *GeoDensity* is the average of county-level population densities per square mile in 2019, weighted by the percentage of the REIT's portfolio invested in the corresponding county at the end of 2019Q4. County-level population densities are downloaded from the S&P Global Geographic Intelligence database.

Our final dataset for regression analysis consists of 11,210 firm-day (198 REITs) observations. Our control variables include determinants of the daily stock returns identified in the prior literature. These variables are all measured as of the end of 2019. *GeoHHI* and *PropHHI* capture the degree to which the firm concentrates its property portfolio within geographic regions or by property type. *Leverage* is the total book value of debt divided by the book value of total assets, *Cash* is the sum of cash and equivalents divided by lagged total assets, *Size* is the reported book value of total assets, and *Tobin's Q* is the market value of equity, plus the book value of debt, divided by the book value of assets. *LAG3MRET* is defined as the firm's cumulative return during 2019Q4, *InstOwn* is a REIT's institutional ownership

percentage, *Investment* is defined as the growth rate in non-cash assets over the fourth quarter of 2019, and *EBITDA/AT* is EBITDA divided by the book value of assets.[11] The appendix summarizes variable definitions and data sources.

4. Results

4.1 Summary Statistics

Table 1 reports summary statistics for our 11,210 firm-day risk-adjusted return observations. During our sample period from January 21, 2020 to April 15, 2020, the average 1-day risk-adjusted return based on the S&P 500 (FTSE-NAREIT All Equity REITs Index) is -0.6% (-0.8%). The mean 2-day risk-adjusted return is -1.3% (-1.5%). The number of observations in our 2-day return sample is approximately half of the 1-day sample because of the non-overlapping estimation windows. The mean 3-day risk-adjusted return is -1.9% (-2.2%). The standard deviation of 1-day risk-adjusted returns for both the S&P 500 and the FTSE-NAREIT All Equity REITs benchmarks are about ten times their means, reflecting the extreme stock market volatility during the early stages of the pandemic. The 25th percentiles are approximately three times more negative than the mean, while the 75th percentiles are all positive and of large magnitudes relative to the corresponding means.

Firm-level, geographically weighted COVID19 growth averaged 6.6% per day with a standard deviation of 9.4% during our sample period. Because we track firms' portfolio exposures since the first reported U.S. case on January 21, 2020, more than 25% of our stock-day observations are associated with no growth in reported cases, as shown by the 25th percentile. The geographically weighted growth rate in firms' exposure also varies substantially; for example, more than 25% of firms experienced daily growth in COVID19 cases of more than 11.7%. The mean (and median) *Days since outbreak*, as of April 15, 2020, is 33 days.

Geographically weighted population density, *GeoDensity*, averaged 4,887 persons per square miles. The 25th percentile was 1,180; the 75th percentile was 4,165. The summary statistics for other control variables (measured as of the end of 2019Q4) are comparable to prior studies. The average REIT in our sample has a property concentration (Herfindahl Index) of 0.788, a geographic concentration of 0.119 (measured using county data), a leverage ratio of 49%, cash holding of 3.7%, a book value of assets equal to $6.6 billion, and a Tobin's

[11] EBITDA is earnings before interest, taxes, depreciation, and amortization expenses.

Q of 1.5. The percentage of stock owned by institutional investors averages 81%. The 25th percentile of institutional ownership is 69%; the 75th percentile is 88%. The percentage growth rate in non-cash assets during 2019Q4 (*Investment*) averaged 9.2% but varied substantially across firms. The ratio of EBITDA to the book value of total assets has a mean of 2.1%. Nineteen percent of REITs focus on retail properties, 14% on hospitality properties, and 11% on office assets and healthcare properties.[12] The means of the ten property type dummies are in line with the constituents by property type discussed in Appendix 2.

4.2 Stock Performance across Property Types

Figure 3 depicts the means and 95% confidence intervals of risk-adjusted returns across property types for our sample period from Tuesday, January 21, 2020, through Wednesday, April 15, 2020. We observe similar patterns for different return horizons (1-day, 2-day, and 3-day), and for the S&P500 and equity REIT market models (Panel A and B, respectively). The best performing property types were technology, self-storage, and warehouses. These industries likely recorded positive risk-adjusted return because cell towers that transmit data communications and high-tech facilities that host Cloud servers are in high demand because many people are working remotely from home. The worst performers were hospitality and retail REITs due to canceled travel, imposed closures, and shelter-in-place orders in most cities and states. Diversified REITs also underperformed as a sector because many hold retail and multi-use properties. Owners of specialty REITs (e.g., casinos, golf courses, timber, and agriculture) were also negatively affected by reduced demand. Office and residential properties were less negatively affected over our sample period, perhaps because of longer-term leases and relatively inelastic demand. The results are little changed when the FTSE-NAREIT All Equity REITs Index is used as our market benchmark instead of the S&P 500.

Figure 4, Panel A, shows a heat map of average daily COVID-19 growth at the county level during our January 21 to April 15, 2020 sample period. In Panels B-D, we show the geographic distribution of REIT property holdings as of 2019Q4. These geographic patterns are shown in terms of percentiles. COVID-19 growth is highly correlated with REIT property

[12] The disaggregation of REITs by major property may mask some variation across sub-property types. For example, Green Street Advisors (2020) disaggregate "residential" properties into apartments, student housings, single-family rental, and manufactured home parks. They calculate, for example, that from February 21 through April 27, student housing REITs suffered an average total return of -33%. In contrast, REITs focused on manufactured home parks experienced an average total return of -19%.

holdings, and there is some variation across property types (comparing Panel C and D).[13] Although retail and health care REITs display a similar geographic pattern, these two sectors performed quite differently, as shown in Figure 1. This suggests that some REIT property types might continue to perform better as the Pandemic continues to unfold.

The importance of geographic asset allocation can be illustrated with the following example. Consider two REITs with similar characteristics in terms of property type focus and size. One REIT's portfolio is heavily concentrated in areas severely affected by the COVID-19 Pandemic, while the other REIT's portfolio is mostly concentrated in less affected counties. How does the difference in asset location and geographic weights affect stock reactions during the pandemic?

We plot the pre-pandemic asset allocations for two residential REITs, BRT Apartments Corp. and Investors Real Estate Trust, in Panel E and F of Figure 4, respectively. For the two maps on the left-hand side of the panel, solid circles indicate that the growth rates of COVID-19 cases in the corresponding counties are above 9.2%, which is the median daily growth rates across all the U.S. counties over our sample period. Hollow circles indicate growth rates below the median. The size of the circles indicates the magnitude of growth rate deviation from the median. For the ease of comparison, we plot the heat map of COVID-19 growth rates for counties in which the firm holds properties (from Panel A) on the right-hand-side of the panel.

Compared with BRT Apartments Corp., Investors Real Estate Trust's property portfolio has a much lower correlation with the geography pattern of growth in COVID-19 cases. The large hollow circles in Panel F suggest that a large percentage of Investors Real Estate Trust's portfolio is located in less affected areas. In terms of return differences, the median of 1-day, 2-day, and 3-day risk-adjusted returns ranges +0.03% to +0.6% for Investors Real Estate Trust, compared with a range of -0.05% to -1% for BRT Apartments Corp. As a benchmark, the sample medians for all residential REITs are -0.4%, 0.9%, -1.4%, respectively. Clearly, firms holding more properties in less affected areas are therefore more resilient to the pandemic. Although this example does not provide a definitive answer to our question, it reveals the importance of geographic asset allocations during the pandemic.

To gain further insight, we next plot correlations between risk-adjusted returns and geographically weighted COVID-19 growth by property types. As displayed in Figure 5, the

[13] http://www.reitsacrossamerica.com/#/map (Last access: February 23, 2018).

correlations are mostly negative, suggesting a firm's exposure to COVID19 is negatively correlated with its stock performance. The correlation pattern across property types is different from the return pattern displayed in Figure 1. For example, health care and technology REITs display a positive correlation even though risk-adjusted returns for these property types are mostly negative. Overall, these correlations suggest that both property location and property type focus affect the vulnerability of a REIT's portfolio to the COVID-19 Pandemic.

4.3 Baseline Results - Risk-adjusted returns and geographic-weighted COVID19 growth

We begin our multivariate analysis by estimating the relation between the daily growth rate in reported COVID19 cases and risk-adjusted REIT returns, *Ret*. The one-day risk-adjusted return for firm *i* on day *t* is calculated by first regressing the firm's daily stock return in excess of the U.S. Treasury yield on the contemporaneous total return on the S&P 500 Index or the NAREIT Equity Index.[14] This regression is estimated for each firm using daily data from January 1, 2019 through January 20, 2020. The results of this regression are then used to calculate *Ret* for each REIT over our sample period. These 1-day "market model" results are reported in columns (1) to (3) of Table 2, panel A. The results for the 2-day market model (estimated using day *t* and day *t*+1 returns) are reported in columns (4) to (6). Finally, the 3-day model (estimated using days *t-1*, *t*, and *t*+1 returns) are reported in columns (7) to (9). Our main test variable is geographically weighted COVID19 growth (*GeoCOVID*). During the COVID-19 outbreak, *GeoCOVID* on day *t*-1 is used to predict subsequent risk-adjusted returns.

As an initial baseline, we first regress 1-day risk-adjusted returns on *GeoCOVID19*. Property type fixed effects are included in this pooled, cross-sectional regression with 11,210 observations. Standard errors are clustered at the firm level. In Column (1), the estimated coefficient on *GeoCOVID* is negative and highly significant, indicating that an increase in a firm's portfolio exposure to COVID19 cases on day *t*-1 is associated with significantly lower risk-adjusted returns on day *t*.

To our baseline specification, we next add *Days since outbreak* and *Days since outbreak*^{2}. To control for variation in the population density of counties in which the REIT

[14] Daily Fama-French factors were not available for our sample period. We will test the robustness of our results using Fama-French factors when they become available.

owns properties, we also include *GeoDensity* in the specification. Finally, we include our set of firm-level control variables defined above. Property type fixed effects are retained to control for the firm's property type focus. The results from estimating this expanded regression are reported in column (2) of Table 2, panel A. The estimated coefficient on *GeoCOVID* remains negative and highly significant. Economically, a one-standard-deviation increase in *GeoCOVID* on day *t*-1 is associated with a 0.24 percentage points decrease (=-0.026*0.094 (the sample mean)) in risk-adjusted returns on day *t*. This economic magnitude is equivalent to more than 40% of the sample mean decrease (-0.6 percentage points).

The estimated coefficient on *Days since outbreak* is negative and highly significant (t-stat=-7.01). This suggests that 1-day risk-adjusted returns are significantly related to the duration of the firms' exposure to COVID-19 cases. However, the estimated coefficient on *Days since outbreak*^{2} is positive and highly significant (t-stat-8.73). This estimated non-linear effect of *Days since outbreak* suggests that risk-adjusted returns decline as the pandemic worsens, but the rate of decline decreases over time as REIT investors understand the concept of "flattening the curve."[15] The estimated coefficient on *GeoDensity* is positive and highly significant, suggesting that REITs holding properties in dense population areas perform better, controlling for COVID-19 growth rates and days since the outbreak.

Among the firm-level control variables, the estimated coefficient on *Leverage* is negative and significant at the 1% level, suggesting investors expect firms that employ more financial leverage to underperform during the market downturn. Although a repeat of the credit crisis that occurred during the Global Financial Crisis is unlikely, the probability that more highly leveraged REITs will experience financial distress surely increased during the early stages of the pandemic. The estimated coefficient on *LAG3MRET* is positive and highly significant (t-stat=20.05). This indicates that the firm's stock returns during the fourth quarter of 2019 are predictive of risk-adjusted returns in March and April of 2020. We also find weak evidence that *Ret* is negatively related to the extent to which a firm concentrates its portfolio by property type (*PropHHI*) and geography (*GeoHHI*).

We next estimate our 1-day risk-adjusted return regression using firm fixed effects in place of our set of firm-level explanatory variables. These results are reported in column (3) of Panel A. The estimated coefficients on *GeoCOVID* and *Days since outbreak* remain

[15] In epidemiology, the flattening of the curve refers to the expectation that the number of people infected over a period of time will increase at a decreasing rate.

negative and highly significant and the coefficient on *Days since outbreak*^{2} remains positive and highly significant (t-stat=8.24). These results suggest that the large and significant coefficient estimates we observe for *GeoCOVID* are not being driven by an omitted firm characteristic.

The results from the estimation of our 2-day market model are reported in columns (4) to (6). Although this two-day return window decreases the number of independent return observations from 11,210 to 5,510, the magnitude and significance of the estimated coefficients on *GeoCOVID* are larger in all three specifications than in the corresponding one-day regression model. Moreover, the estimated coefficient on *Days since outbreak* remains negative and highly significant, and the estimated coefficient on *Days since outbreak*^{2} is positive and highly significant. The coefficients on *GeoDensity*, *Leverage*, and *LAG3MRET* remain highly significant using two-day return windows, and we continue to find some weak evidence *Ret* is negatively related to property type and geographic concentrations. Finally, our 3-day market model results are reported in columns (7) to (9). Overall, this further widening of the risk-adjusted return window has little effect on our coefficient estimates or conclusions about the impact of *GeoCOVID* on the pricing of REIT stocks and their underlying commercial real estate portfolios.

To examine the performance of equity REITs relative to other equity REITs during the COVID-19 outbreak, we redo the analysis reported in Table 2, panel A using the total returns on the FTSE-NAREIT All Equity REITs Index in place of the S&P 500. This requires, among other things, regressing each firm's excess stock returns on the contemporaneous total return on the equity REIT index using daily data from Tuesday, January 1, 2019 through Monday, January 20, 2020. This equation is then used to calculate daily risk-adjusted returns over the sample period. These results are reported in panel B of Table 2. Inspection of the panel reveals that using the FTSE-NAREIT All Equity REITs Index as our benchmark in place of the S&P 500 has little effect on the magnitude or statistical significance of the estimated coefficients on *GeoCOVID*, *Days since outbreak*, *Days since outbreak*^{2}, or *GeoDensity*. The lack of sensitivity of our results to the change in the market benchmark is at least partially attributable to the high correlation (0.94) of daily returns on the FTSE-NAREIT All Equity REITs Index and the S&P 500 Index during March and April of 2020.

4.4 Risk-adjusted returns and geographic-weighted COVID19 growth across Property Types

Given the strong negative relation between risk-adjusted returns and geographically weighted COVID-19 growth we uncover, we next investigate how this relationship varies across property types. As discussed earlier, different property sectors face different COVID19 exposures and show a striking variation in terms of risk-adjusted returns (Figure 3) and correlations between returns and COVID19 growth (Figure 5). We therefore augment the regressions reported in Table 2 with interactions between *GeoCOVID* and our property type dummies. We suppress the intercept and saturate the model with all combinations of property type dummies and *GeoCOVID* interactions. The estimated coefficients on the interaction terms can therefore be interpreted as the property-type specific effects of *GeoCOVID*. As before, we include our full set of firm-level controls.

The results of these tests are displayed in Table 3, where we report the coefficient estimates on the interaction terms and their t-statistics. The mean coefficient estimates and the corresponding 95% confidence interval are displayed in Figure 6. We continue to find a negative relation between *GeoCOVID* and risk-adjusted returns for most of the property types. In terms of economic magnitude, retail and residential REITs experienced the largest negative risk-adjusted returns, followed by office and hospitality REITs. For retail REITs, a one-standard-deviation increase in *GeoCOVID* is associated with a reduction in 1-day risk-adjusted returns of 0.69 percentage points (=-0.073*0.094), which represents 64% of the mean risk-adjusted return for retail REITs (=0.69%/1.08%). The cumulative 2-day and 3-day effects for retail properties are even larger, ranging from 1.72 to 2.15 percentage points. For residential REITs, a one-standard-deviation increase in *GeoCOVID* corresponds to a return reduction of 0.62 to 1.57 percentage points, depending on the return window and risk adjustment methods. Given the mean value of risk-adjusted return for residential is -0.45, the impact of a one-standard-deviation increase in *GeoCOVID* corresponds to 138% to 349% of the mean. Hospitality REITs also experienced a large impact: a one-standard-deviation increase in *GeoCOVID* corresponds to a return reduction of 0.24 to 1.88 percentage points, representing 22% to 171% of the mean (-1.09 percentage points). Overall, the magnitudes of these negative returns are striking in industries most impacted by the pandemic.

In contrast, the estimated *GeoCOVID* interactions for specialty REITs cannot be distinguished from zero in any of the six regression specifications, and the interaction term for industrial REITs is negative and significant in the 2-day return specifications, but otherwise indistinguishable from zero. However, REITs focused on health care and

technology properties display positive (or zero) coefficients on the interaction terms. Using risk-adjusted returns based on the S&P 500, a one-standard-deviation increase in *GeoCOVID* is associated with a 0.4 percentage point increase in 1-day returns in both of these sectors.

4.5 The Importance of Asset Allocation

The results reported in Table 2 demonstrate that greater exposure to high-COVID-19-growth areas predicts lower future risk-adjusted returns. However, one might argue that our findings are the result of a high correlation between the geography of REITs' underlying properties and the geography of COVID-19 growth (Figure 4). If REITs tend to overweight areas that subsequently suffered the most from the pandemic (e.g., coastal cities), the geographic weighting on asset allocation would not contribute additional explanatory power to our analysis.

To further examine the importance of our geographically weight COVID-19 growth variable, we construct an arithmetic average of daily growth across all counties in which a REIT owns any property at the end of 2019Q4 (*AvgCOVID*). Next, we create a dummy variable, *HighGeoCOVID,* which equals one if the geographically weighted COVID-19 growth (*GeoCOVID*) for REIT *i* on day *t* is in the upper quartile of the growth rates across all counties in which the REIT owns any property on day *t*, and zero otherwise. Finally, we interact *HighGeoCOVID* with *AvgCOVID*. If the geographic weighting on asset allocation does not explain investors' reaction, this interaction term should have no explanatory power.

In Table 4, we find all the coefficient estimates on the interaction term, *HighGeoCOVID* × *AvgCOVID*, are negative and statistically significant. In contrast, *AvgCOVID* itself does not explain the cross-section of risk-adjusted returns. This finding supports the importance of asset allocation in explaining stock market reactions to the pandemic. The results are robust to various model specifications and controls, as well as to different return windows and market model benchmarks.

Next, we investigate how population densities, property type concentrations, and geographic concentrations of REIT portfolios affect the sensitivity of stock returns to *GeoCOVID*. Wheaton and Thompson (2020) study the determinants of how rapidly the virus grows once it has been seeded within an MSA or a county. They conclude that population density predicts the growth rate of COVID19 cases. Also, prior literature (e.g., Hartzell et al., 2014; Ling et al., 2019) highlights the importance of property type concentrations and geographic concentrations in determining REIT performance and returns.

For each of the three asset allocation variables, we create a dummy variable for above-median values and interact it with *GeoCOVID*. We also include *GeoCOVID* in the estimation; thus, the interaction term measures whether, for example, population density augments or mutes the negative impact of *GeoCOVID* on returns. In all model specifications, we include our full set of control variables (except the variable of interest itself) and property type fixed effects. As shown in Table 5, above-average population density is associated with higher 1-day, 2-day, and 3-day risk-adjusted returns. However, the coefficient estimate on the interaction term is negative and significant at the 5% level or higher in all three return windows, suggesting returns are more negatively affected if the firm allocates more assets to areas with high population density. The economic magnitude of this effect is large: asset allocation in areas with above-median population density intensifies the negative reaction to COVID19 by 2.3 to 10 percentage points.

In contrast, high property type and geographic concentrations are not associated with risk-adjusted returns; moreover, they have no impact on the sensitivity of returns to *GeoCOVID*. Because listed REITs tend to own properties in population-dense metropolitan areas, we should expect population density and geographic concentration to have similar effects on return responses to *GeoCOVID*. However, our results suggest it is not the case. During the early stages of the pandemic, only population density is associated with greater sensitivity of stock returns to the degree to which firms have high COVID19 exposure.

4.6 The Impact of Firm Characteristics

Next, we further examine the extent to which different firm characteristics affect the impact of *GeoCOVID* on risk-adjusted returns. Similar to our Table 5 results, we create dummy variables for above-median values of *Size*, *Leverage*, *Cash*, *Tobin's Q*, *LAG3MRET*, *InstOwn*, *Investment*, and *EBITDA/AT*. We then interact these dummies with *GeoCOVID*. We include our full set of control variables (except the variable of interest itself) and property type fixed effects in all model specifications. The regression results are summarized in Table 6, and the coefficient estimates and 95% confidence intervals are displayed in Figure 7.

Return momentum has a significant effect on both risk-adjusted returns and the sensitivity of returns to *GeoCOVID*; that is, firms that previously experienced high return growth were more resilient during the early stages of the pandemic. More specifically, firms with strong returns in the fourth quarter of 2019 produced returns that are 3.8 percentage points less sensitive to COVID-19 growth rates (as shown in Panel A). There is evidence in

the 3-day results that firms with high growth potential (*Tobin's Q*) also reacted less negatively to their exposure to *GeoCOVID*. Table 6 and Figure 7 also suggests that firm size, leverage, and the degree of institutional ownership increase return sensitivity. However, these coefficients are largely statistically insignificant. Overall, we conclude that, after conditioning on the firm's property type focus, with the exception of return momentum, firm characteristics have a modest impact on stock price reactions to *GeoCOVID*.

5. Conclusion

How does the shock of COVID-19 transmit to the equity markets from a firm's underlying assets? To answer this question, we employ asset-level data from the commercial real estate market and construct a novel measure of geographically weighted exposure to COVID-19 growth (*GeoCOVID*) using a sample of equity REITs during the early stages of the pandemic from January 21, 2020, to April 15, 2020.

We first document a large variation in performance across property types. Different sectors face different exposures to the pandemic, and REIT returns reflect those differences. Technology, self-storage, and industrial warehouse REITs produced positive risk-adjusted returns while hospitality and retail REITs performed the worst. Examining the correlation between return and *GeoCOVID* across property types, we find the returns for REITs specialized in retail, office, and residential (health care and technology) are negatively (positively) correlated with *GeoCOVID.*

Using different benchmark for risk adjustment, different return windows, and different model specifications, we find a negative relationship between risk-adjusted returns and *GeoCOVID*. Specifically, firms in retail and residential react more negatively among all sectors. In contrast, the performance of health care and technology REITs correlates positively to *GeoCOVID*.

Our results are not driven by a similar geographic pattern of the growth rates of COVID-19 cases and REITs' property holdings because cross-sectional geographic weighting explains firms' stock returns respond to the pandemic. Furthermore, we find that firms with more assets allocated to areas with higher population density react more negatively to the pandemic. However, neither property type nor geographic concentration explains the negative return reaction to the pandemic. Finally, by investigating a variety of firm characteristics, we find only a firm's stock returns in the fourth quarter of 2019 are associated

with stock market reaction to *GeoCOVID* after conditioning on firms' property type and geographic concentrations, days since the outbreak, and population density.

Together, our results highlight the importance of asset-level attributes in explaining investors' reactions to the pandemic. In future updates to this paper, we plan to investigate the role of asset allocation in explaining how trading behavior (such as volatility, bid-ask spread, trading volume) changes in response to the pandemic as well as the impact of lease structure and stay-at-home orders.

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Figure 1: Total Return Indices: S&P 500, Russell 2000, NAREIT

This figure depicts daily indices for the S&P 500, Russell 2000, and the FTSE-NAREIT All Equity REITs (FNER) Index from 2015 through April 23, 2020. Each index is set equal to 100 at year-end 2014.

Figure 2: Total Return Indices: REIT Property Types

This figure depicts daily indices for the FTSE-NAREIT Equity REITs indices for office, industrial, retail, residential, health care, and lodging/resort REITs from 2015 through April 23, 2020.

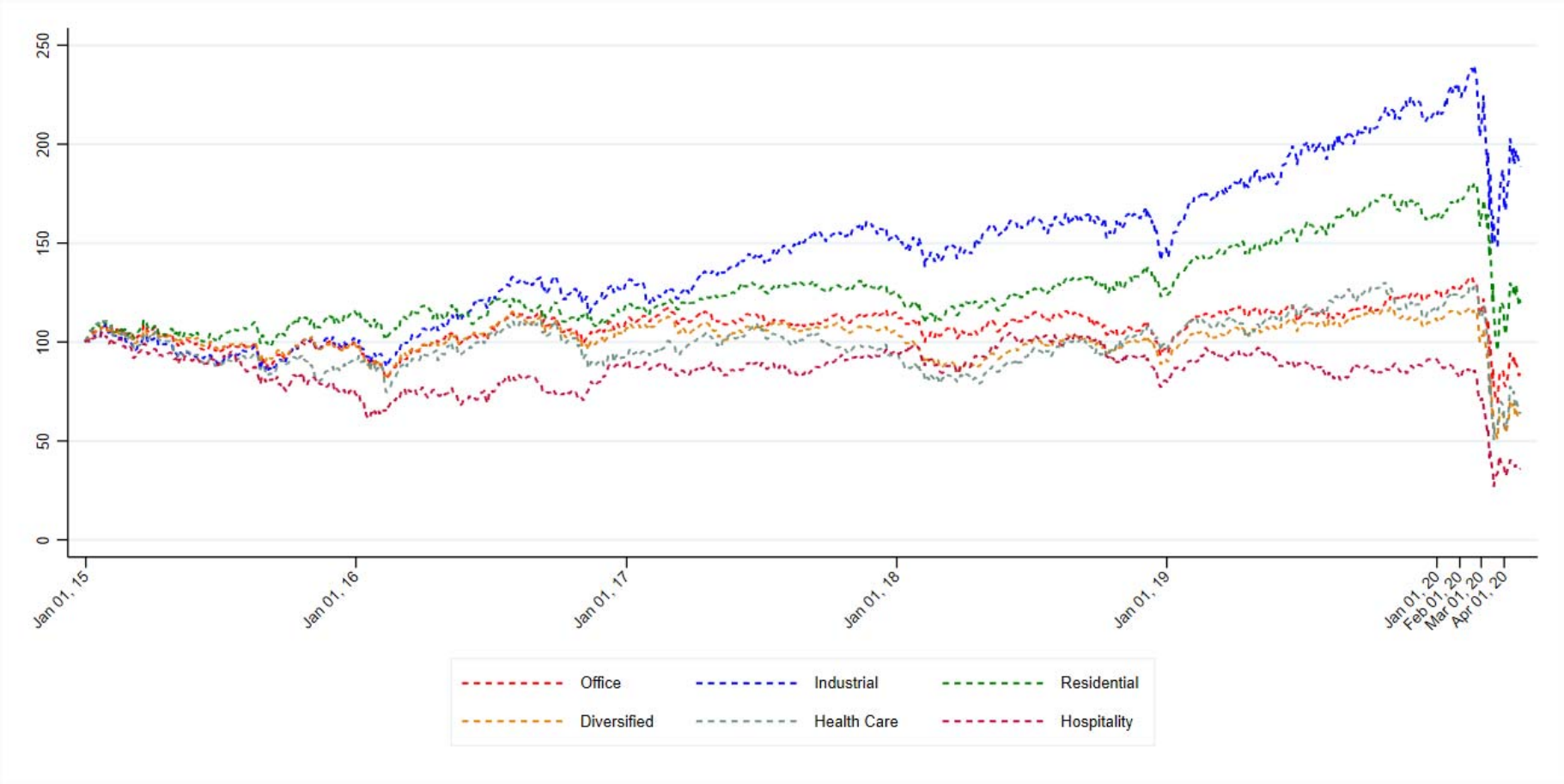
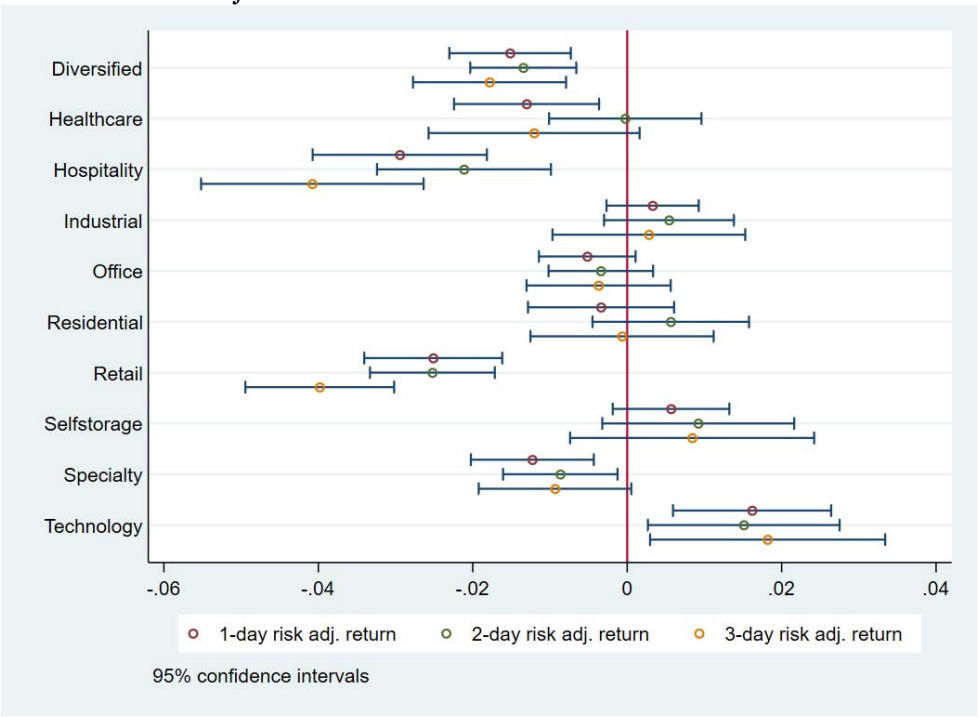


Figure 3: Risk-Adjusted Return by Property Types

This figure shows the means and 95% confidence intervals of risk-adjusted returns across property types for the period from Tuesday, January 21, 2020, through Wednesday, April 15, 2020. *1-day risk adj. returns* are calculated as $R_{i,d} - \beta_i M_d$. β_i is estimated from the market model for firm *i* from the beginning of 2019 to Monday, January 20, 2020. $R_{i,d}$ denotes stock returns for firm *i* on day *d*. M_d denotes daily returns on either the S&P 500 index (Panel A) or the NAREIT Equity Index (Panel B). *2-day (3-day) risk adj. returns* are the non-overlapping cumulative risk-adjusted returns from day *d* (*d-1*) to day *d+1*. See Appendix 1 for variable descriptions and Appendix 2 for descriptions of property types.

Panel A: Risk-Adjusted Returns based on S&P 500 Index



Panel B: Risk-Adjusted Returns based on NAREIT Equity Index

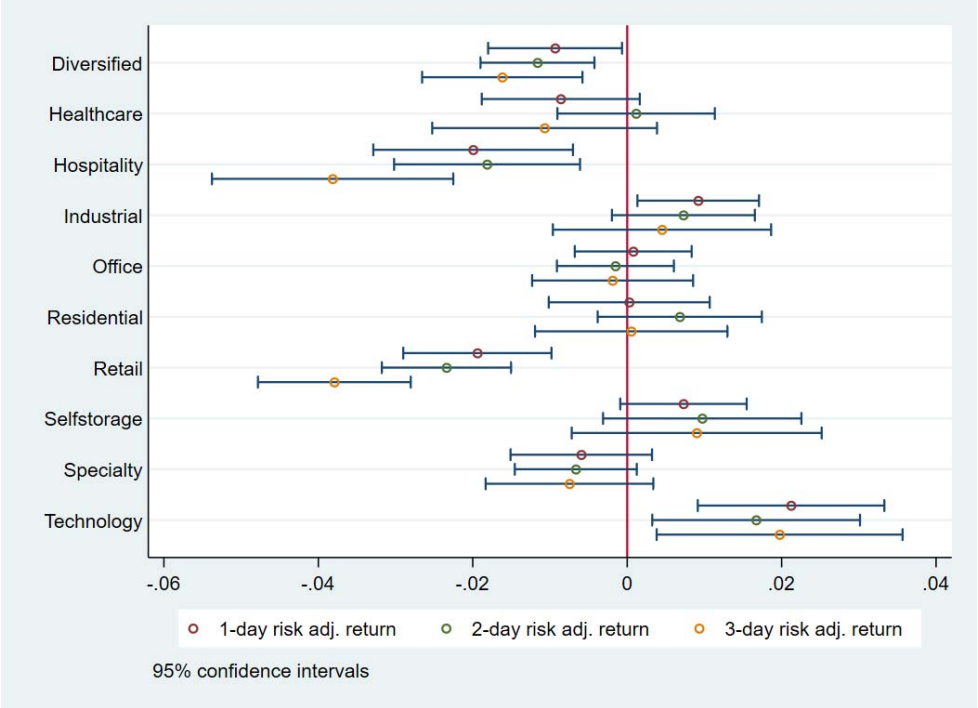
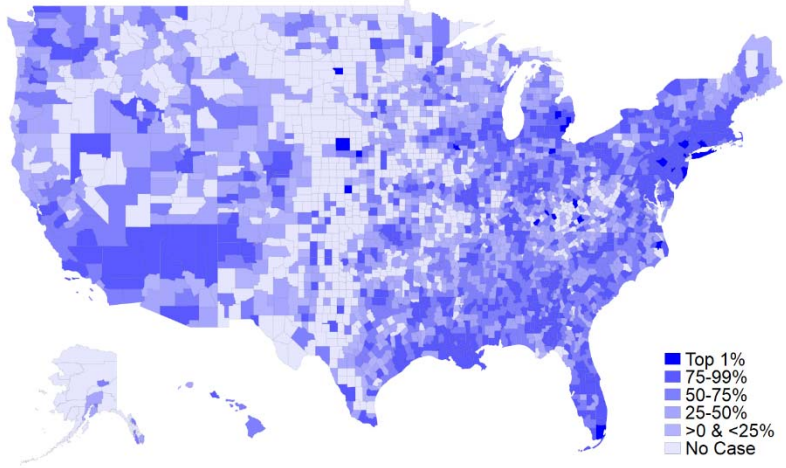


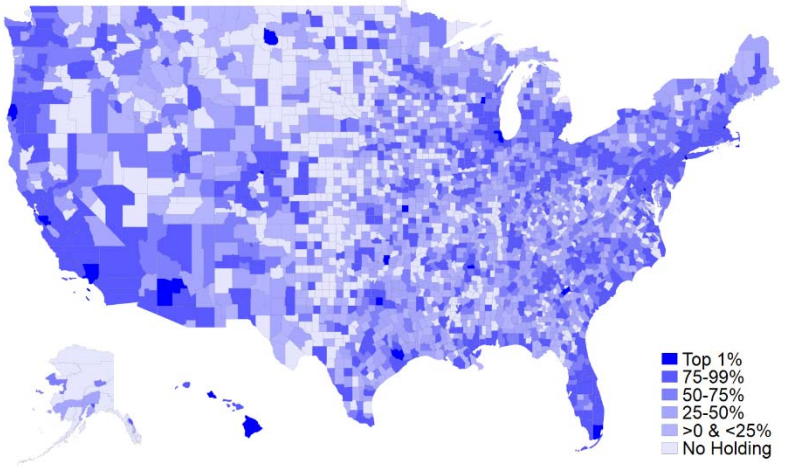
Figure 4: COVID-19 Growth and Property Holdings

Panel A shows geographic patterns of the average daily growth rates of COVID-19 confirmed cases in the U.S. counties for the period from Tuesday, January 21, 2020, through Wednesday, April 15, 2020. Panels B-D shows the geographic distribution of REIT property holdings as of 2019Q4. Geographic patterns are shown in terms of percentiles. Panel B is based on all property types. Panel C (D) is based on retail (health care). Panel E and F provide two examples of firm-level asset allocation on stock performance. See Appendix 1 for variable descriptions and Appendix 2 for descriptions of property types.

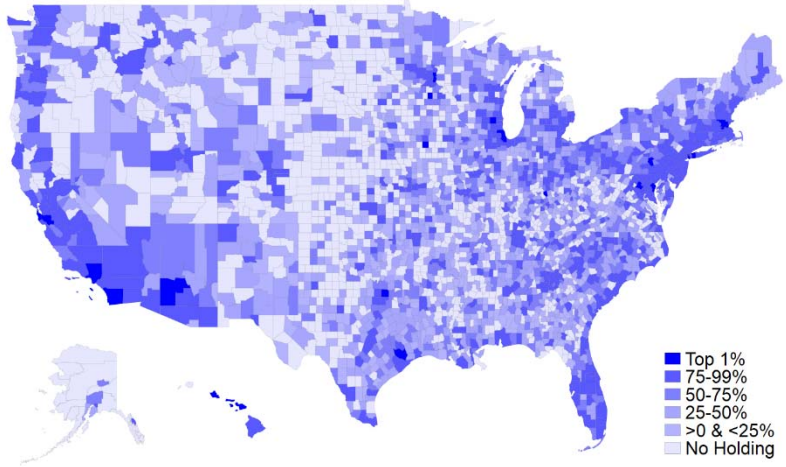
Panel A: COVID-19 Growth (County Level)



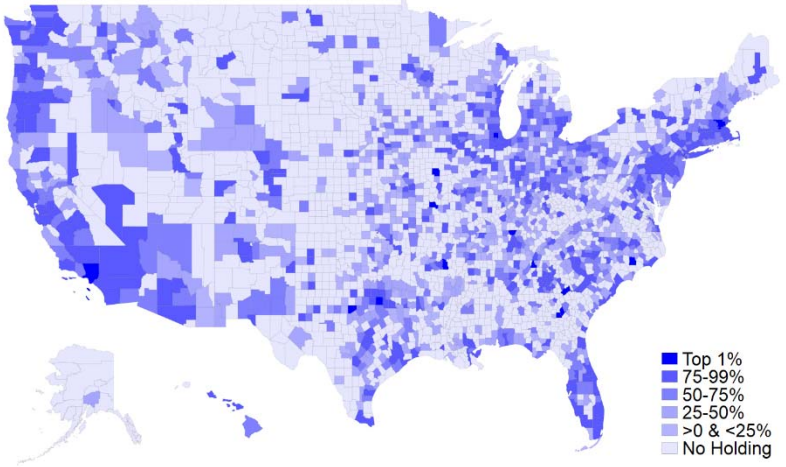
Panel B: Average Property Holdings (County Level)



Panel C: Average Property Holdings (County Level), Retail



Panel D: Average Property Holdings (County Level), Health Care



Panel E: An illustrative example of firm-level Asset Allocation, using BRT Apartments Corp.

Panel F: An illustrative example of firm-level Asset Allocation, using Investor Real Estate Trust

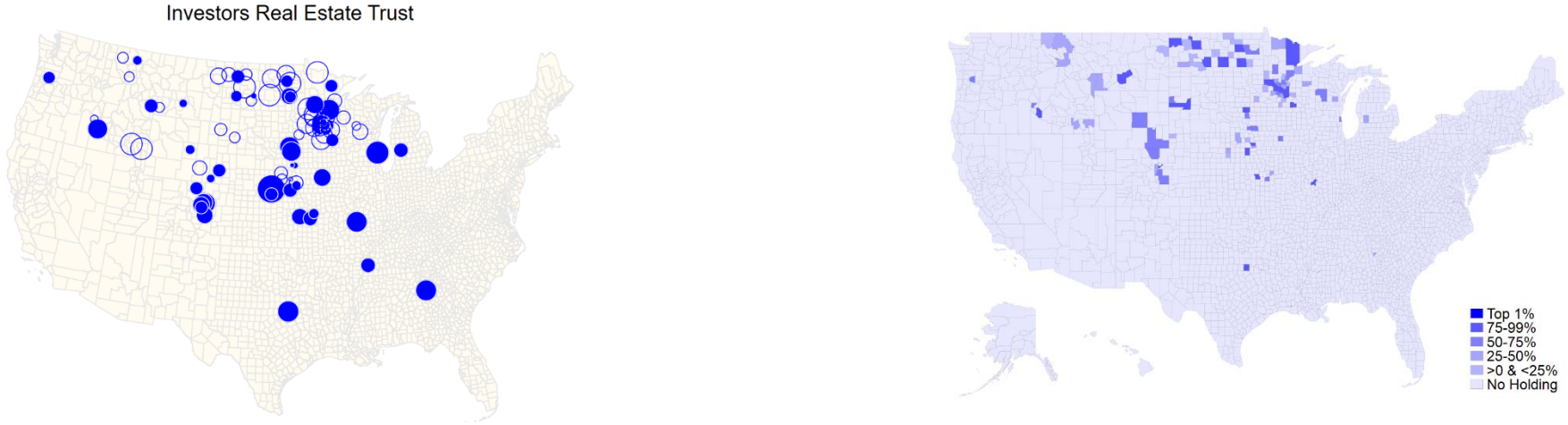
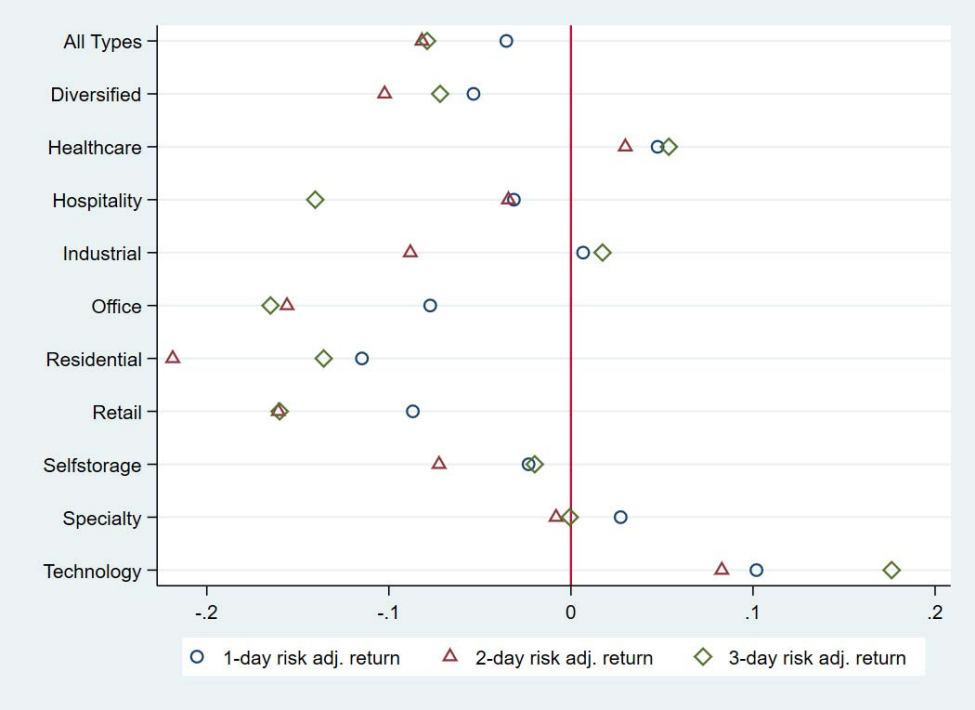


Figure 5: Correlations between Risk-Adjusted Returns and COVID-19 Growth by Property Type

This figure presents the correlations between risk-adjusted returns across property types and the growth rate of COVID-19 cases. Panel A depicts the correlations for risk-adjusted returns based on the S&P 500 Index. Panel B depicts the correlations for risk-adjusted returns based on the S&P 500 Index based on the NAREIT Equity Index. See Appendix 1 for variable descriptions and Appendix 2 for descriptions of property types.

Panel A: Risk-Adjusted Returns based on S&P 500



Panel B: Risk-Adjusted Returns based on NAREIT Equity Index

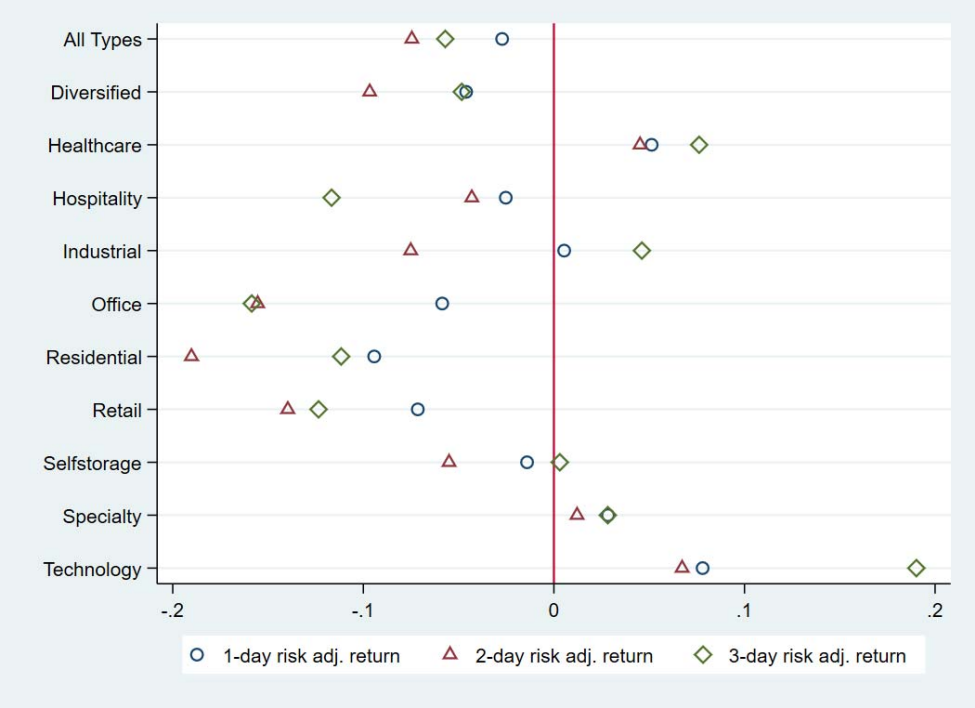
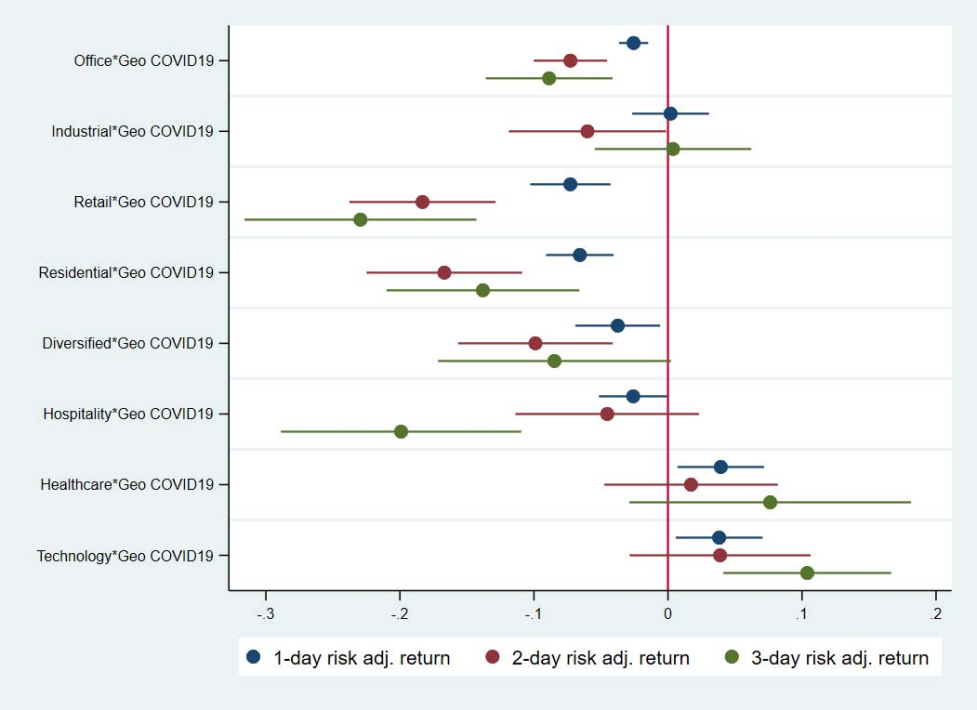


Figure 6: Coefficients on Property Type and *GeoCOVID* Interactions

This figure presents the coefficients on property type interactions with geographic-weighted COVID19 growth in Table 3. Panel A depicts the coefficients from models using risk-adjusted returns based on the S&P 500 Index as the dependent variable in Panel A of Table 3. Panel B depicts the coefficients from models using risk-adjusted returns based on the NAREIT Equity Index in Panel B of Table 3. See Appendix 1 for variable descriptions and Appendix 2 for descriptions of property types.

Panel A: Risk-Adjusted Returns based on S&P 500



Panel B: Risk-Adjusted Returns based on NAREIT Equity Index

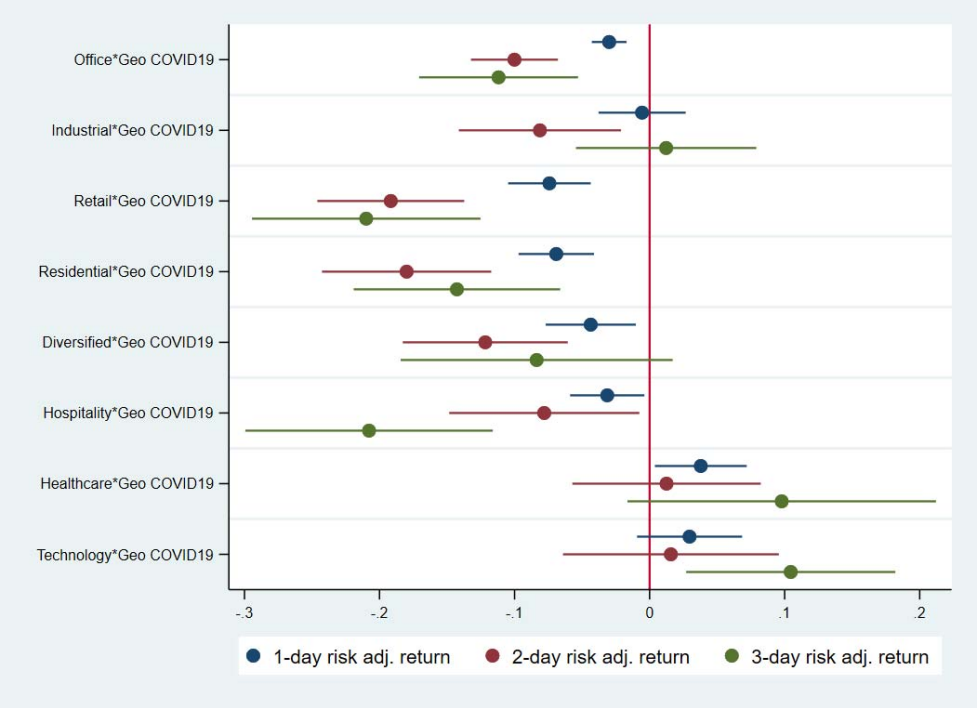
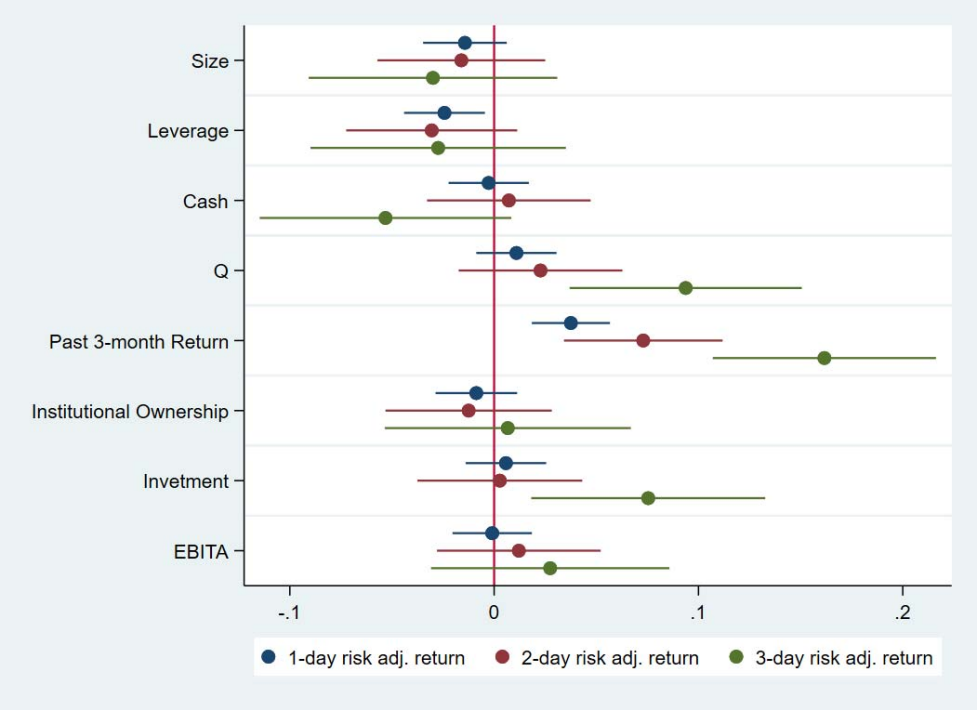


Figure 7: Coefficients on Firm Characteristics

This figure presents the coefficients on firm characteristics estimated in Table 5. Panel A depicts the coefficients from models using risk-adjusted returns based on the S&P 500 Index as the dependent variable in Panel A of Table 5. Panel B depicts the coefficients from models using risk-adjusted returns based on the NAREIT Equity Index as the dependent variable in Panel B of Table 5. See Appendix 1 for variable descriptions.

Panel A: Risk-Adjusted Returns based on S&P 500



Panel B: Risk-Adjusted Returns based on NAREIT Equity Index

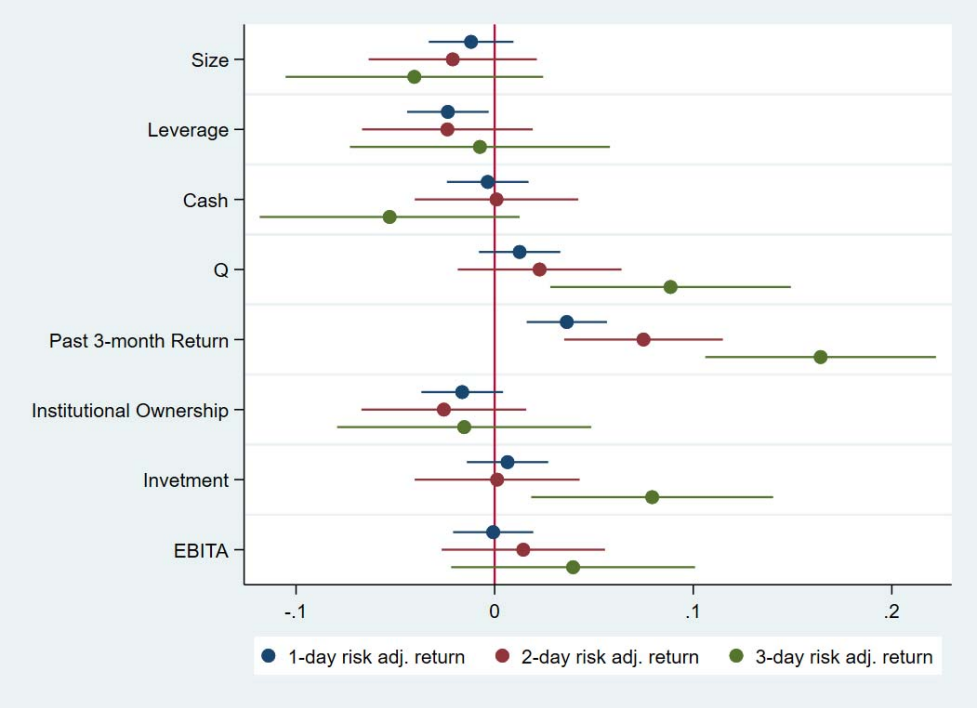


Table 1: Summary Statistics

This table shows summary statistics (number of observations, mean, standard deviation (SD), and 25th, 50th, and 75th percentiles) for a sample of 11,210 firm-day observations from the period Tuesday, January 21, 2020, through Wednesday, April 15, 2020.

Variable	N	Mean	SD	p25	p50	p75
Risk Adj. Returns (*based on S&P500*)						
1-day risk adj. return	11,210	-0.006	0.061	-0.022	-0.001	0.013
2-day risk adj. return	5,510	-0.013	0.079	-0.039	-0.003	0.016
3-day risk adj. return	3,800	-0.019	0.102	-0.054	-0.005	0.019
Risk Adj. Returns (*based on NAREIT*)						
1-day risk adj. return	11,210	-0.008	0.070	-0.026	-0.001	0.016
2-day risk adj. return	5,510	-0.015	0.087	-0.046	-0.004	0.017
3-day risk adj. return	3,800	-0.022	0.112	-0.061	-0.006	0.020
COVID-19 Exposure Variables						
GeoCOVID	11,210	0.066	0.094	0	0.005	0.117
Days since outbreak	11,210	33	29	11	33	56
Control Variables						
GeoDensity	11,210	4887	9373	1180	1793	4165
PropHHI	11,210	0.788	0.280	0.583	0.949	0.999
GeoHHI	11,210	0.119	0.175	0.020	0.049	0.126
Leverage	11,210	0.490	0.159	0.403	0.474	0.575
Cash	11,210	0.037	0.083	0.005	0.013	0.036
Size	11,210	6641	10129	1664	3925	8297
Tobin's Q	11,210	1.498	0.584	1.147	1.372	1.690
LAG3MRET	11,210	0.034	0.061	0.001	0.040	0.066
InstOwn	11,210	0.811	0.237	0.688	0.880	0.979
Investment	11,210	0.092	0.331	-0.032	0.028	0.171
EBITDA/AT	11,210	0.021	0.012	0.015	0.020	0.025
Office	11,210	0.111	0.314	0	0	0
Industrial	11,210	0.068	0.252	0	0	0
Retail	11,210	0.189	0.392	0	0	0
Residential	11,210	0.074	0.261	0	0	0
Diversified	11,210	0.147	0.354	0	0	0
Hospitality	11,210	0.142	0.349	0	0	0
Health Care	11,210	0.105	0.307	0	0	0
Self-storage	11,210	0.037	0.188	0	0	0
Specialty	11,210	0.095	0.293	0	0	0
Technology	11,210	0.032	0.175	0	0	0

Table 2: Baseline Results – Risk-Adjusted Returns and Geographically Weighted COVID19 Growth

This table shows regression results on the relationship between risk-adjusted returns and the growth rate of geographic-weight COVID-19 cases. The dependent variable, *Ret,* is the daily risk adj. returns in Columns (1)-(3), the 2-day risk adj. returns in Columns (4)-(6), and the 3-day risk adj. returns in Columns (7)-(9). *GeoCOVID* is the average of county-level daily growth rates of COVID-19 cases, weighted by the percentage of the REIT's portfolio allocated to each county at the end of 2019Q4. Panel A (B) shows the results using risk-adjusted returns based on the S&P 500 Index (NAREIT Equity Index) as the dependent variable. The numbers in parentheses are *t*-statistics. Standard errors are clustered at firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Risk-Adjusted Returns based on S&P 500

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ret (1-day)	*Ret (1-day)*	*Ret (1-day)*	*Ret (2-day)*	*Ret (2-day)*	*Ret (2-day)*	*Ret (3-day)*	*Ret (3-day)*	*Ret (3-day)*
GeoCOVID	-0.024***	-0.026***	-0.022***	-0.070***	-0.086***	-0.080***	-0.089***	-0.099***	-0.088***
	(-4.70)	(-3.82)	(-3.01)	(-6.72)	(-5.98)	(-5.13)	(-5.91)	(-4.72)	(-3.89)
Days since outbreak		-0.000***	-0.000***		-0.000***	-0.000***		-0.001***	-0.001***
		(-7.01)	(-6.72)		(-6.39)	(-5.89)		(-6.53)	(-6.23)
Days since outbreak^2		0.000***	0.000***		0.000***	0.000***		0.000***	0.000***
		(8.73)	(8.24)		(9.00)	(8.42)		(8.51)	(8.06)
ln(GeoDensity)		0.001***			0.001***			0.002***	
		(5.17)			(6.08)			(5.73)	
PropHHI		-0.001*			-0.003**			-0.005**	
		(-1.97)			(-2.16)			(-2.22)	
GeoHHI		-0.002*			-0.003			-0.006*	
		(-1.97)			(-1.28)			(-1.86)	
Leverage		-0.003***			-0.006***			-0.009***	
		(-2.82)			(-2.99)			(-2.93)	
Cash		-0.003*			-0.006			-0.011*	
		(-1.66)			(-1.38)			(-1.74)	
ln(Size)		0.000			0.000			0.000	
		(1.42)			(1.41)			(0.92)	
Tobin's Q		0.001*			0.001**			0.002**	
		(1.79)			(1.98)			(2.18)	
LAG3MRET		0.000***			0.000***			0.001***	
		(20.05)			(20.76)			(19.42)	
InstOwn		0.001			0.001			0.003	
		(0.65)			(0.57)			(1.10)	
Investment		0.000			0.000			0.000	
		(0.19)			(0.02)			(0.32)	
EBITDA/AT		0.005			0.011			0.013	
		(0.33)			(0.42)			(0.33)	
Constant	-0.005***	-0.001	-0.004***	-0.008***	-0.003	-0.008***	-0.013***	-0.002	-0.011***
	(-12.18)	(-0.70)	(-8.99)	(-10.00)	(-0.73)	(-8.46)	(-10.86)	(-0.43)	(-8.97)
FE	Prop type	Prop type	Firm	Prop type	Prop type	Firm	Prop type	Prop type	Firm
R Squared	0.005	0.012	0.013	0.016	0.034	0.037	0.018	0.041	0.044
Observations	11210.000	11210.000	11210.000	5510.000	5510.000	5510.000	3800.000	3800.000	3800.000

Panel B: Risk-Adjusted Returns based on NAREIT

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ret (1-day)	*Ret (1-day)*	*Ret (1-day)*	*Ret (2-day)*	*Ret (2-day)*	*Ret (2-day)*	*Ret (3-day)*	*Ret (3-day)*	*Ret (3-day)*
GeoCOVID	-0.021***	-0.031***	-0.028***	-0.069***	-0.108***	-0.105***	-0.070***	-0.103***	-0.094***
	(-3.92)	(-4.32)	(-3.61)	(-6.44)	(-7.15)	(-6.53)	(-4.42)	(-4.53)	(-3.80)
Days since outbreak		-0.000***	-0.000***		-0.000***	-0.001***		-0.001***	-0.001***
		(-6.99)	(-6.30)		(-6.24)	(-5.34)		(-6.66)	(-5.98)
Days since outbreak^2		0.000***	0.000***		0.000***	0.000***		0.000***	0.000***
		(10.55)	(9.57)		(10.79)	(9.79)		(10.24)	(9.37)
ln(GeoDensity)		0.001***			0.002***			0.002***	
		(6.58)			(7.35)			(6.80)	
PropHHI		-0.002**			-0.003**			-0.005**	
		(-2.31)			(-2.50)			(-2.52)	
GeoHHI		-0.003**			-0.003			-0.008**	
		(-2.15)			(-1.12)			(-2.09)	
Leverage		-0.003***			-0.007***			-0.010***	
		(-3.48)			(-3.75)			(-3.62)	
Cash		-0.004**			-0.008*			-0.014**	
		(-2.41)			(-1.88)			(-2.54)	
ln(Size)		0.000			-0.000			-0.000	
		(0.16)			(-0.06)			(-0.34)	
Tobin's Q		0.001***			0.001***			0.002***	
		(2.61)			(3.22)			(3.04)	
LAG3MRET		0.000***			0.000***			0.001***	
		(22.85)			(24.27)			(22.43)	
InstOwn		0.001			0.001			0.004	
		(1.14)			(1.03)			(1.62)	
Investment		-0.000			-0.001			-0.001	
		(-0.92)			(-1.33)			(-0.85)	
EBITDA/AT		-0.001			0.004			-0.004	
		(-0.07)			(0.18)			(-0.12)	
Constant	-0.006***	-0.002	-0.006***	-0.011***	-0.004	-0.013***	-0.018***	-0.005	-0.018***
	(-14.70)	(-1.05)	(-10.98)	(-12.04)	(-0.99)	(-11.04)	(-13.66)	(-0.80)	(-11.60)
FE	Prop type	Prop type	Firm	Prop type	Prop type	Firm	Prop type	Prop type	Firm
R Squared	0.004	0.013	0.014	0.014	0.041	0.043	0.014	0.045	0.048
Observations	11210.000	11210.000	11210.000	5510.000	5510.000	5510.000	3800.000	3800.000	3800.000

Table 3: Risk Adjusted Returns and Geographically weighted COVID19 Growth by Property Type

This table shows regression results on the relationship between daily risk-adjusted returns and the growth rate of geographic-weight COVID-19 cases interacted with property type dummies. Columns (1)-(3) ((4)-(6)) present the results using risk-adjusted returns based on the S&P 500 Index (NAREIT Equity Index) as the dependent variable. *GeoCOVID* is the average of county-level daily growth rates of COVID-19 cases, weighted by the percentage of the REIT's portfolio allocated to each county at the end of 2019Q4. Control variables are the same as Columns (2) in Table 2 and suppressed. See Appendix 1 for variable descriptions and Appendix 2 for descriptions of property types. The numbers in parentheses are *t*-statistics. Standard errors are clustered at firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Risk Adj. using S&P500			*Risk Adj. using NAREIT*		
	Ret (1-day)	*Ret (2-day)*	*Ret (3-day)*	*Ret (1-day)*	*Ret (2-day)*	*Ret (3-day)*
Office × GeoCOVID	-0.026***	-0.073***	-0.089***	-0.030***	-0.100***	-0.112***
	(-4.67)	(-5.24)	(-3.69)	(-4.59)	(-6.13)	(-3.75)
Industrial × GeoCOVID	0.002	-0.060**	0.004	-0.006	-0.081***	0.012
	(0.13)	(-2.02)	(0.13)	(-0.34)	(-2.67)	(0.36)
Retail × GeoCOVID	-0.073***	-0.183***	-0.229***	-0.074***	-0.192***	-0.210***
	(-4.80)	(-6.62)	(-5.23)	(-4.79)	(-6.95)	(-4.89)
Residential × GeoCOVID	-0.066***	-0.167***	-0.138***	-0.069***	-0.180***	-0.143***
	(-5.15)	(-5.67)	(-3.78)	(-4.88)	(-5.66)	(-3.68)
Diversified × GeoCOVID	-0.037**	-0.099***	-0.085*	-0.044**	-0.122***	-0.084
	(-2.34)	(-3.38)	(-1.92)	(-2.58)	(-3.93)	(-1.64)
Hospitality × GeoCOVID	-0.026**	-0.045	-0.199***	-0.031**	-0.078**	-0.208***
	(-2.00)	(-1.30)	(-4.38)	(-2.25)	(-2.19)	(-4.47)
Health Care × GeoCOVID	0.039**	0.017	0.076	0.038**	0.013	0.098*
	(2.41)	(0.52)	(1.43)	(2.20)	(0.35)	(1.69)
Self-storage × GeoCOVID	-0.016**	-0.073***	-0.039	-0.021***	-0.089***	-0.041
	(-2.20)	(-2.93)	(-0.70)	(-2.77)	(-3.69)	(-0.78)
Specialty × GeoCOVID	0.016	-0.020	-0.013	0.011	-0.026	-0.003
	(0.92)	(-0.62)	(-0.17)	(0.66)	(-0.71)	(-0.04)
Technology × GeoCOVID	0.038**	0.039	0.104***	0.030	0.016	0.105***
	(2.33)	(1.14)	(3.27)	(1.50)	(0.39)	(2.66)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
FE	Prop type	Prop type	Prop type	Prop type	Prop type	Prop type
R Squared	0.023	0.058	0.071	0.022	0.061	0.071
Observations	11210	5510	3800	11210	5510	3800

Table 4: Asset Allocation and COVID19 Growth

This table shows regression results on the relationship between risk-adjusted returns and the interaction between an indicator variable and *Avg Growth*. The dependent variable, *Ret,* is the daily risk adj. returns in Columns (1)-(3), the 2-day risk adj. returns in Columns (4)-(6), and the 3-day risk adj. returns in Columns (7)-(9). *Indicator (GeoCOVID > 75th PCT)* equals to one if the growth rate of geographically weighted COVID-19 cases is above the 75th percentile of daily growth rates across all counties in which a REIT owns any property at the end of 2019Q4. *AvgCOVID* is the arithmetic average of daily growth rates across all counties in which a REIT owns any property at the end of 2019Q4. Panel A (B) shows the results using risk-adjusted returns based on the S&P 500 Index (NAREIT Equity Index) as the dependent variable. The numbers in parentheses are *t*-statistics. Standard errors are clustered at firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Risk-Adjusted Returns based on S&P 500

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ret (1-day)	*Ret (1-day)*	*Ret (1-day)*	*Ret (2-day)*	*Ret (2-day)*	*Ret (2-day)*	*Ret (3-day)*	*Ret (3-day)*	*Ret (3-day)*
HighGeoCOVID ×	-0.045***	-0.052***	-0.049***	-0.117***	-0.136***	-0.133***	-0.119***	-0.157***	-0.158***
AvgCOVID	(-2.98)	(-3.33)	(-3.03)	(-5.07)	(-5.85)	(-5.38)	(-3.00)	(-3.85)	(-3.59)
HighGeoCOVID	0.004	0.002	0.000	0.015	0.012	0.009	0.013	0.011	0.010
	(0.64)	(0.35)	(0.05)	(1.65)	(1.40)	(0.95)	(0.96)	(0.88)	(0.66)
AvgCOVID	-0.002	-0.001	-0.002	0.011	0.011	0.010	-0.041	-0.040	-0.039
	(-0.12)	(-0.04)	(-0.12)	(0.51)	(0.62)	(0.50)	(-1.08)	(-1.12)	(-1.01)
Days since outbreak		-0.000***	-0.000***		-0.000***	-0.000***		-0.000***	-0.000***
		(-4.78)	(-4.26)		(-4.15)	(-3.43)		(-3.87)	(-2.96)
Days since outbreak²		0.000***	0.000***		0.000***	0.000***		0.000***	0.000***
		(8.63)	(7.70)		(8.50)	(7.41)		(8.48)	(7.52)
ln(GeoDensity)	-0.045***	-0.052***	-0.049***	-0.117***	-0.136***	-0.133***	-0.119***	-0.157***	-0.158***
	(-2.98)	(-3.33)	(-3.03)	(-5.07)	(-5.85)	(-5.38)	(-3.00)	(-3.85)	(-3.59)
Controls	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
FE	Prop type	Prop type	Firm	Prop type	Prop type	Firm	Prop type	Prop type	Firm
R Squared	0.009	0.013	0.017	0.027	0.037	0.046	0.036	0.050	0.061
Observations	11210	11210	11210	5510	5510	5510	3800	3800	3800

Panel B: Risk-Adjusted Returns based on NAREIT

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ret (1-day)	*Ret (1-day)*	*Ret (1-day)*	*Ret (2-day)*	*Ret (2-day)*	*Ret (2-day)*	*Ret (3-day)*	*Ret (3-day)*	*Ret (3-day)*
HighGeoCOVID ×	-0.030*	-0.047***	-0.044**	-0.084***	-0.127***	-0.123***	-0.085	-0.153***	-0.153***
AvgCOVID	(-1.73)	(-2.66)	(-2.35)	(-2.86)	(-4.41)	(-4.05)	(-1.57)	(-2.85)	(-2.71)
HighGeoCOVID	-0.001	-0.004	-0.007	0.002	-0.002	-0.006	-0.000	-0.004	-0.008
	(-0.14)	(-0.50)	(-0.76)	(0.20)	(-0.17)	(-0.51)	(-0.01)	(-0.25)	(-0.39)
AvgCOVID	-0.019	-0.017	-0.019	-0.035	-0.030	-0.036	-0.082	-0.077	-0.081
	(-1.13)	(-1.03)	(-1.13)	(-1.29)	(-1.26)	(-1.41)	(-1.58)	(-1.59)	(-1.59)
Days since outbreak		-0.000***	-0.000***		-0.000***	-0.000***		-0.000***	-0.000***
		(-5.12)	(-4.14)		(-4.22)	(-3.07)		(-4.28)	(-2.94)
Days since outbreak^2		0.000***	0.000***		0.000***	0.000***		0.000***	0.000***
		(10.85)	(9.33)		(10.90)	(9.25)		(10.80)	(9.37)
ln(GeoDensity)		0.001***			0.001***			0.002**	
		(3.08)			(2.87)			(2.57)	
Controls	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
FE	Prop type	Prop type	Firm	Prop type	Prop type	Firm	Prop type	Prop type	Firm
R Squared	0.008	0.015	0.018	0.027	0.047	0.055	0.033	0.060	0.069
Observations	11210	11210	11210	5510	5510	5510	3800	3800	3800

Table 5: Risk-Adjusted Returns and Geographically Weighted COVID19 Growth by Asset Allocation

This table shows regression results on the relation between risk-adjusted returns and the geographically weighted growth rate of confirmed COVID-19 cases, interacted with geographically weighted population density (*GeoDensity*), property type concentration (*PropHHI*), and geographic concentration (*GeoHHI*). The dependent variable, *Ret,* is the 1-day risk adj. return in Columns (1) to (3), the 2-day risk adj. return in Columns (4) to-(6), and the 3-day risk adj. return in Columns (7) to (9). *Dummy (above median)* indicates that the asset allocation variable of a firm is above the sample median. *GeoCOVID* is the average of county-level daily growth rates of COVID-19 cases, weighted by the percentage of the REIT's portfolio allocated to each county at the end of 2019Q4. Panel A (B) shows the results using risk-adjusted returns based on the S&P 500 Index (FTSE-NAREIT All Equity REITs Index) as the dependent variable. The control variables included are the same as those used in our baseline regressions (see Table 2). The control variable results are suppressed. See Appendix 1 for variable descriptions. Property type fixed effects are included in the regression. The numbers in parentheses are *t*-statistics. Standard errors are clustered at firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1) *Ret (1-day) Density*	(2) *Ret (1-day) PropHHI*	(3) *Ret (1-day) GeoHHI*	(4) *Ret (2-day) Density*	(5) *Ret (2-day) PropHHI*	(6) *Ret (2-day) GeoHHI*	(7) *Ret (3-day) Density*	(8) *Ret (3-day) PropHHI*	(9) *Ret (3-day) GeoHHI*
Panel A: Risk Adj. Return (Using S&P500)									
Dummy (above median) × GeoCOVID	-0.023**	-0.000	-0.004	-0.056**	-0.002	-0.003	-0.108***	-0.041	-0.063**
	(-2.20)	(-0.03)	(-0.41)	(-2.59)	(-0.12)	(-0.15)	(-3.58)	(-1.36)	(-2.02)
Dummy (above median)	0.002***	-0.000	0.000	0.005***	-0.000	0.001	0.009***	0.002	0.005**
	(2.63)	(-0.01)	(0.67)	(3.32)	(-0.05)	(0.80)	(4.14)	(1.07)	(2.33)
GeoCOVID	-0.011	-0.024***	-0.022**	-0.048**	-0.081***	-0.080***	-0.029	-0.077***	-0.051*
	(-1.06)	(-3.04)	(-2.32)	(-2.30)	(-4.73)	(-4.65)	(-1.00)	(-3.29)	(-1.73)
R Squared	0.010	0.009	0.009	0.028	0.027	0.027	0.034	0.032	0.033
Panel B: Risk Adj. Return (Using NAREIT)									
Dummy (above median) × GeoCOVID	-0.024**	0.001	-0.001	-0.065***	-0.004	-0.006	-0.141***	-0.032	-0.081**
	(-2.16)	(0.12)	(-0.12)	(-2.96)	(-0.18)	(-0.30)	(-4.43)	(-1.00)	(-2.52)
Dummy (above median)	0.002**	-0.000	0.001	0.005***	-0.000	0.002	0.011***	0.001	0.007***
	(2.55)	(-0.39)	(0.79)	(3.71)	(-0.26)	(1.56)	(4.96)	(0.55)	(3.12)
GeoCOVID	-0.015	-0.030***	-0.028***	-0.062***	-0.101***	-0.098***	-0.012	-0.083***	-0.040
	(-1.42)	(-3.49)	(-2.98)	(-2.86)	(-5.46)	(-5.64)	(-0.37)	(-3.20)	(-1.34)
R Squared	0.008	0.008	0.008	0.028	0.026	0.026	0.031	0.028	0.029
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE	Prop type	Prop type	Prop type	Prop type	Prop type	Prop type	Prop type	Prop type	Prop type
Observations	11210	11210	11210	5510	5510	5510	3800	3800	3800

Table 6: Risk-Adjusted Returns and Geographically Weighted COVID19 Growth by Firm Characteristics

This table shows regression results on the relationship between daily risk-adjusted returns and geographically weighted growth rate of COVID-19 confirmed cases interacted with firm financial characteristics. The dependent variable, *Ret,* is the daily risk adj. returns in Panel A, the 2-day risk adj. returns in Panel B, and the 3-day risk adj. returns in Panel C. *Dummy (above median)* indicates that the firm characteristic variable of a firm is above sample median. *GeoCOVID* is the average of county-level daily growth rates of COVID-19 cases, weighted by the percentage of the REIT's portfolio allocated to each county at the end of 2019Q4. Property type fixed effects are included in the regression. The numbers in parentheses are *t*-statistics. Standard errors are clustered at firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Firm Characteristics	*Ln(Size)*	*Leverage*	*Cash*	*Tobin's Q*	*LAG3MRET*	*InstOwn*	*Investment*	*EBITA/AT*
Panel A. Dependent variable: 1-day risk adj. return (using S&P500)								
Dummy (> Median)	0.001*	0.001	0.000	-0.000	0.003***	0.001	-0.000	0.000
	(1.70)	(1.34)	(0.34)	(-0.58)	(3.49)	(1.13)	(-0.31)	(0.69)
GeoCOVID	-0.022**	-0.018***	-0.027***	-0.035***	-0.047***	-0.020**	-0.032***	-0.029***
	(-2.06)	(-2.70)	(-2.90)	(-3.69)	(-4.70)	(-2.00)	(-3.67)	(-3.03)
Dummy (> Median) ×	-0.014	-0.024**	-0.003	0.011	0.038***	-0.009	0.006	-0.001
GeoCOVID	(-1.38)	(-2.42)	(-0.27)	(1.10)	(3.87)	(-0.86)	(0.58)	(-0.10)
R Squared	0.009	0.010	0.009	0.009	0.008	0.009	0.009	0.009
Observations	11210	11210	11210	11210	11210	11210	11210	11210
Panel B. Dependent variable: 2-day risk adj. return (using S&P500)								
Dummy (> Median)	0.002	0.001	-0.000	-0.001	0.007***	0.001	0.000	0.000
	(1.22)	(0.38)	(-0.25)	(-0.47)	(3.38)	(0.91)	(0.12)	(0.02)
GeoCOVID	-0.091***	-0.091***	-0.103***	-0.113***	-0.137***	-0.088***	-0.103***	-0.109***
	(-4.33)	(-6.81)	(-5.52)	(-6.03)	(-6.32)	(-4.30)	(-5.23)	(-5.69)
Dummy (> Median) ×	-0.016	-0.031	0.007	0.023	0.073***	-0.012	0.003	0.012
GeoCOVID	(-0.77)	(-1.44)	(0.36)	(1.12)	(3.71)	(-0.60)	(0.14)	(0.60)
R Squared	0.027	0.027	0.027	0.027	0.024	0.027	0.027	0.027
Observations	5510	5510	5510	5510	5510	5510	5510	5510
Panel C. Dependent variable: 3-day risk adj. return (using S&P500)								
Dummy (> Median)	0.003	-0.001	0.004*	-0.005**	0.007**	0.001	-0.004**	-0.001
	(1.26)	(-0.24)	(1.68)	(-2.35)	(2.28)	(0.31)	(-2.17)	(-0.33)
GeoCOVID	-0.073**	-0.092***	-0.065**	-0.141***	-0.179***	-0.087***	-0.138***	-0.114***
	(-2.25)	(-4.27)	(-2.02)	(-4.94)	(-5.82)	(-2.80)	(-4.89)	(-3.92)
Dummy (> Median) ×	-0.030	-0.027	-0.053*	0.094***	0.162***	0.007	0.075**	0.027
GeoCOVID	(-0.97)	(-0.86)	(-1.70)	(3.26)	(5.83)	(0.22)	(2.60)	(0.93)
R Squared	0.032	0.032	0.032	0.034	0.032	0.032	0.033	0.032
Observations	3800	3800	3800	3800	3800	3800	3800	3800
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE	Prop type	Prop type	Prop type	Prop type	Prop type	Prop type	Prop type	Prop type

Appendix 1: Variable Definitions

Variable	Source	Definition
Daily Risk Adj. Returns		
1-day risk adj. return	S&P Global, NAREIT	The daily risk-adjusted returns are calculated as $R_{i,t} - \beta_i M_t$. β_i is estimated from the market model for firm *i* from the beginning of 2019 to Monday, January 20, 2020. $R_{i,t}$ denotes stock returns for firm *i* on day *t*. M_d denotes daily returns on either the S&P 500 index or the NAREIT All Equity Index.
2-day risk adj. return	S&P Global, NAREIT	The non-overlapping cumulative risk-adjusted returns from day *t* to *t+1*.
3-day risk adj. return	S&P Global, NAREIT	The non-overlapping cumulative risk-adjusted returns from day *t-1* to *t+1*.
COVID-19 Exposure Variables		
GeoCOVID	JHU COVID-19 Global Cases, S&P Global	The COVID-19 geographic exposure of a firm, calculated as the average of county-level daily growth rates of COVID-19 cases, weighted by the percentage of the REIT's portfolio allocated to each county at the end of 2019Q4. County-level daily growth rate of confirmed COVID-19 cases in county *l* on day *t* is calculated as $ln(1 + \#CASES_{l,t}) - ln(1 + \#CASES_{l,t-1})$.
HighGeoCOVID	JHU COVID-19 Global Cases, S&P Global	An indicator variable that equals one if *GeoCOVID* for REIT *i* on day *t* is in the upper quartile of the growth rates across all counties in which the REIT owns any property on day *t*
AvgCOVID	JHU COVID-19 Global Cases, S&P Global	The arithmetic average of daily growth rates of COVID-19 confirmed cases across all counties in which a REIT owns any property at the end of 2019Q4.
Days since outbreak	JHU COVID-19 Global Cases, S&P Global	The number of days since the outbreak of the COVID-19 Pandemic in counties where a REIT owns any property at the end of 2019Q4.
Days since outbreak^2	JHU COVID-19 Global Cases, S&P Global	The quadratic term of *Days since outbreak*.
Control Variables		
GeoDensity	S&P Global	The average of county-level population density weighted by the percentage of the REIT's portfolio allocated to each county at the end of 2019Q4. Population density is defined as the number of people per square miles.
GeoHHI	S&P Global	The Herfindahl Indexes of each REIT's property weights across the U.S. counties at the end of 2019Q4.
PropHHI	S&P Global	The Herfindahl Indexes of each REIT's property weights in each of the ten property categories, including office, industrial, retail, residential, diversified, hospitality, health care, self-storage, specialty, and technology at the end of 2019Q4.
Leverage	S&P Global	Sum of total long-term debt and debt in current liabilities divided by book value of assets at the end of 2019Q4.
Cash	S&P Global	The ratio of cash and cash equivalents to book value of assets at the end of 2019Q4.
Size	S&P Global	The book value of assets at the end of 2019Q4.
Tobin's Q	S&P Global	The ratio of the market value of equity plus the book value of debt to the book value of assets/
LAG3MRET	S&P Global	Cumulative stock returns over 2019Q4 (in percentage).

Variable	Source	Definition
InstOwn	S&P Global	The ratio of the number of shares held by institutional investors to the total number of shares outstanding at the end of 2019Q4.
Investment	S&P Global	The percentage growth rate in non-cash assets during 2019Q4.
EBITDA/AT	S&P Global	The ratio of EBITDA to book value of total assets at the end of 2019Q4.

Appendix 2: Property Type Descriptions

This Appendix summarizes REITs by property types. The classification is based on S&P Global and NAREIT.

Property Type	# Stocks	Description
Office	22	Office REITs own and manage office real estate and rent space in those properties to tenants. Those properties can range from skyscrapers to office parks. Some office REITs focus on specific types of markets, such as central business districts or suburban areas. Some emphasize specific classes of tenants, such as government agencies or biotech firms.
Industrial	14	Industrial REITs own and manage industrial facilities and rent space in those properties to tenants. Some industrial REITs focus on specific types of properties, such as warehouses and distribution centers. Industrial REITs play an important part in e-commerce and are helping to meet the rapid delivery demand.
Retail	37	Retail REITs own and manage retail real estate and rent space in those properties to tenants. Retail REITs include REITs that focus on large regional malls, outlet centers, grocery-anchored shopping centers and power centers that feature big box retailers. Net lease REITs own freestanding properties and structure their leases so that tenants pay both rent and the majority of operating expenses for a property.
Residential	15	Residential REITs own and manage various forms of residences and rent space in those properties to tenants. Residential REITs include REITs that specialize in apartment buildings, student housing, manufactured homes and single-family homes. Within those market segments, some residential REITs also focus on specific geographical markets or classes of properties.
Diversified	32	Diversified REITs own and manage a mix of property types and collect rent from tenants. For example, diversified REITs might own portfolios made up of both office and industrial properties.
Hospitality	27	Hospitality REITs own and manage hotels and resorts and rent space in those properties to guests. Hospitality REITs own different classes of hotels based on features such as the hotels' level of service and amenities. Hospitality REITs' properties service a wide spectrum of customers, from business travelers to vacationers.
Health Care	20	Health care REITs own and manage a variety of health care-related real estate and collect rent from tenants. Health care REITs' property types include senior living facilities, hospitals, medical office buildings and skilled nursing facilities.
Self-storage	7	Self-storage REITs own and manage storage facilities and collect rent from customers. Self-storage REITs rent space to both individuals and businesses.
Specialty	18	Specialty REITs own and manage a unique mix of property types and collect rent from tenants. Specialty REITs own properties that do not fit within the other REIT types. Examples of properties owned by specialty REITs include movie theaters, casinos, farmland and outdoor advertising sites. This category also includes four Timber REITs which specialize in harvesting and selling timber.
Technology	6	This category includes Data Center and Infrastructure REITs. Data center REITs own and manage facilities that customers use to safely store data. Data center REITs offer a range of products and services to help keep servers and data safe, including providing uninterruptable power supplies, air-cooled chillers and physical security. Infrastructure REITs' property types include fiber cables, wireless infrastructure, telecommunications towers and energy pipelines.
Total	198	