The Covid-19 shock: Examining abnormal returns in European commercial real estate

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Abstract

This paper empirically analyses the geographical exposure of real estate portfolios to Covid-19 growth rates by examining its effect on abnormal stock returns. Sector differences and the role of government non-pharmaceutical interventions (NPIs) are also explored. The main result finds that higher portfolio exposure to Covid-19 growth decreases abnormal returns. Firms that invest in hotel and retail assets are most negatively impacted, whereas those that invest in industrial and healthcare assets are positively impacted. Announcements of NPIs ameliorate the negative effect on abnormal returns. The analysis gives insight into the risk posed by pandemics, details how different sectors are affected, and highlights the positive role of government interventions.

1. Introduction

The global COVID-19 pandemic has seen massive consequences for the health of the world population and the global economy. Everyday life was completely upended, with governments worldwide implementing restrictions and regulations to curb the spread of the virus. And even today, as we seemingly move away from the most severe years of this pandemic, there are still many rippling effects in the world economy with supply chain issues and labour shortages. Throughout the pandemic, an ongoing discussion has been conducted between policymakers, researchers and the public about how to balance public health and economic concerns. Understanding and successfully mitigating the negative impact of both the epidemiological and regulatory situation has proven to be a challenging task. This comes at a time when many observers point to the dangers of future pandemics or new mutations of the current virus (Madhav et al. 2018; Antràs et al.2020; Pak et. al 2020).

One insight that might aid the understanding of how Covid-19 has impacted the global economy is to examine how the real estate industry was affected in response to the outbreak. This is the industry analysed in this paper, and it serves as a good study subject since it is an integral part of the broader economy and can convey information on how the overall economy and sectors within it are impacted. Furthermore, the real estate industry can also give insight into the local

effects of the pandemic. To this end, the geographical and sectorial portfolio breakdown of publicly listed real estate firms is examined. Additionally, the role of government policy responses to the pandemic will be studied, with the analysis examining how lockdown-style interventions, such as lockdowns, impacted the real estate industry.

Previous literature studying the market shock of Covid-19 and other health crises find a significant adverse effect on the economy, the stock market, and the real estate industry (Weil 2007; Francke and Korevaar 2021; Harjoto et al. 2021; Padhan and Prabheesh 2021; Jordà et al. 2022). The Covid-19 pandemic is found to affect sectors of the economy differently, with manufacturing, information technology, education, and healthcare seeing a positive shock, whereas hospitality, transportation, and environment industries experience a negative shock (He et al. 2020; Mazur et al. 2021). Concerning government policy in response to the outbreak, the literature demonstrates that it is linked to a slowing viral spread and increased economic performance (Correia et al. 2020; Demirgüç-Kunt et al. 2020). However, government interventions around social distancing have also been found to cause problems, such as deteriorating mental well-being (Brodeur et al. 2021).

In response to the Covid-19 pandemic, authors have also pointed out the need to establish new models and methods to measure risk exposure (Alfaro et al. 2020; Barro et al. 2020). One such method, is to analyse firm exposure geographically using asset-level data. This approach is taken in the work of Ling et al. (2020), who study REITs in the United States. The authors construct a measure which matches the daily growth rates of Covid-19 cases with the location of portfolio assets and use this measure as a predictor of abnormal stock returns. Their results indicate a significant adverse effect, with a one-standard-deviation increase in daily Covid-19 cases lowering abnormal returns by 0.24 percentage points the following day.

This thesis builds on prior literature and the analysis of Ling et. Al (2020) by examining the stock market shock following the Covid-19 outbreak in the European commercial real estate industry. European commercial real estate portfolios are examined together with national growth rates of Covid-19 cases. Based on the following literature review, hypotheses are set out, and multiple regression models are formulated, which in addition to examining the overall shock effect of Covid-19 on real estate firms, investigate sectorial differences and the impact of government policy in response to the pandemic.

2. Literature Review

The Covid-19 pandemic constitutes a major global health crisis with far-reaching public health and socio-economic consequences. Understanding how such an event impacts the economy requires insights into what role health plays on economic performance and the historical impact of pandemics. Weil (2007) quantitatively assesses the role of health differences in contributing to the gap between rich and developing countries worldwide. He finds a modest but significant negative effect of poor health on GDP per worker. The total negative economic impact is expected to be even higher when accounting for the indirect effects of poor health. In the case of health crises like pandemics, one might expect to see a similar negative economic impact. This expectation is in keeping with the literature, with the historical analysis of pandemics indeed revealing negative economic consequences. Jordà et al. (2022) examine rates of return on assets after major pandemics stretching back to the fourteenth century. The authors describe how pandemics hurt the economy by inducing labour scarcity and precautionary savings, unlike wars that destroy capital. This paper further demonstrates the prolonged economic after-effects of pandemics, which in some cases persist for decades. In the case of the Covid-19 pandemic, Padhan and Prabheesh (2021) show in their literature survey that it, too, has caused significant adverse economic effects around the world.

Considering the negative role that pandemics and health crises play in the economy, it is understandable that the outbreak of Covid-19 brought about a negative stock market shock in countries worldwide. Investors consider companies' present and future performance, which in the case of a pandemic outbreak is likely to be depressed. Harjoto et al. (2021) confirm that this negative market shock occurred in their analysis of global stock price reactions to Covid-19. Furthermore, their research reveals that this negative shock was stronger for emerging markets and smaller firms. Mazur et al. (2021) find the same negative shock in their analysis of the US stock market while also pointing out that different sectors of the economy responded varyingly to the pandemic outbreak. They explain that the natural gas, food, healthcare, and software stocks experienced high positive returns. Conversely, entertainment, hospitality and the real estate sectors experienced stark negative returns. He et. al (2020) also examine differences among sectors of the economy by studying the Chinese stock market reaction. They observe that transportation, mining, electricity & heating, and environment industries were adversely affected, with manufacturing, information technology, education and health industries seeing a positive effect.

When examining the real estate industry, broader economic trends will presumably also translate into this sector of the economy. Historically, pandemics have been found to negatively impact the local real estate market in the short term, with evidence from urban housing markets showing significant reductions in price levels in the first six months after an outbreak (Francke and Korevaar 2021). However, in these cases, the price shock was found to be primarily transitory, with long-term price paths proving resilient. In the case of the Covid-19 pandemic, as mentioned earlier, the real estate industry was found to be negatively impacted (Mazur et al. 2021). The retail, residential, office, and hospitality sectors were most negatively affected within the real estate industry. In contrast, the healthcare and technology sectors were positively impacted (ling et al. 2020). These results seem to align with the earlier discussed dynamics of the broader economy.

In response to the pandemic outbreak, governments worldwide implemented policies such as school and business closures and social distancing rules to curb the spread of the virus. The literature refers to these policy measures, which do not involve the provision of medicine or vaccines for the virus, as non-pharmaceutical government interventions (NPIs). The types of interventions form the basis of the policy response in the initial stages of the Covid-19 pandemic. Even though NPIs can directly involve barriers to normal economic operations, the literature finds that they can ultimately benefit the economy. For example, Correia et al. (2020) find, in the case of the 1918 influenza virus, that the strong and early implementation of NPIs mitigates adverse economic consequences in addition to lowering mortality. Similar results are found by Demirgüç-Kunt et al. (2020), who studied NPIs in response to the Covid-19 pandemic in Europe and Asia. Within the real estate industry, evidence from the US market also indicates a positive economic impact of NPIs (Ling et al. 2020). However, there is evidence pointing in the opposite direction since some health outcomes, such as mental well-being, have been worsened by NPI measures like social distancing (Brodeur et al. 2021).

2.1 Research question & hypotheses

Insights from the literature on the economics of health and pandemics, the real estate industry, and government NPIs inform the analysis of this paper. Building on the study of Ling et al (2020), firm abnormal returns in response to daily Covid-19 growth rates will be investigated. The main research question that is set out to be answered is:

How does the Covid-19 pandemic affect abnormal returns in the European commercial real estate sector?

Answering this question involves exploring different elements of the relationship between Covid-19 and the European real estate industry. The pandemic's negative economic effect suggests that firms more exposed to Covid-19 growth could see more adverse consequences. Studying this relationship is central to the analysis of this paper. Furthermore, the literature review points to significant sector differences in response to the pandemic, which therefore supports analysing the effects on different real estate sectors. Finally, since NPIs have been found to impact the economy positively, the analysis also considers the role that they have played in the European real estate industry. Based on these insights, the following three hypotheses are formulated, which will be tested in the research:

1. Real estate firms experience lower abnormal returns if the weighted average of daily Covid-19 growth rates among portfolio countries is higher. Covid-19 growth rates are weighted by the share of total portfolio assets invested per country.

2. The percentage share of portfolio assets invested per real estate sector moderates the effect of weighted daily Covid-19 growth rates on firm abnormal returns.

3. Implementation of non-pharmaceutical interventions in portfolio countries ameliorates the negative effect of weighted daily Covid-19 growth rates on firm abnormal returns.

This paper seeks to contribute to the literature by testing these hypotheses and analysing how the Covid-19 pandemic affected the European commercial real estate industry. The analysis expands on prior research into the effects of Covid-19 on the real estate industry by examining abnormal returns in the previously unaddressed European market. The time horizon of the study also expands on prior work, covering almost all of 2020. Furthermore, the analysis presented in this paper examines how independent sovereignties with separate policy plans steered the effects of the pandemic.

3. Empirical Strategy

Taking the research question and hypotheses and translating them into an empirical analysis requires an operationalization of the main concepts outlined in the next section. Once the operationalized variables are determined and defined, the adopted methodology is detailed.

3.1 Operationalization

The main relationship being studied is the impact of Covid-19 on the real estate industry, which means determining a response variable for the performance of the real estate industry and an explanatory variable capturing exposure to the pandemic outbreak. The performance variable is estimated using abnormal stock returns, which are widely accepted in the literature (Sefcik & Thompson 1986; Kothari 2001) and finds use in papers studying the Covid-19 shock (e.g., Liu, et al. 2020; Harjoto et al 2021). The measure of Covid-19 exposure is determined by taking the daily growth rate in cumulative cases, which has support in previous Covid-19 and pandemic literature studying shocks in stock market returns (e.g., Al-Awadhi et al. 2020; Ashraf 2020). Next, based on the methodology put forth by Ling et al. (2020), these daily growth rates are geographically matched against the portfolio investments of real estate firms. To accurately measure the total exposure of a firm, the average of all Covid-19 growth rates is taken, which is weighted by the share of portfolio assets invested per country. National Covid-19 growth rates are used, with literature suggesting this might be the most appropriate level of analysis for the Covid-19 pandemic (Goolsbee & Syverson 2021).

Beyond establishing the overall impact of Covid-19 growth, the analysis continues in answering how different sectors are impacted and what role non-pharmaceutical government interventions play. The reported share of portfolio investments per sector is accounted for to analyse the differential impact on real estate sectors. As for non-pharmaceutical government interventions, two different approaches are included. The first deals with the intensity level of implemented interventions, using score indices from the Oxford Covid-19 Government Response Tracker (Hale et al. 2021). These indices, established ex-post, provide a measure of the severity of policy interventions and differentiate different intervention types. The second approach follows a similar setup to Ling et al. (2020) by estimating firms' exposure to the announcements of lockdowns and reopenings. Although this second analysis does not capture the magnitude of enacted interventions, it represents the information available to investors at the time.

3.2 Variable definitions

Before detailing the methodology used for the analysis, this section defines and elaborates on all the variables used. An overview of all variable definitions and sources is also provided in Table A1 of the appendix.

Response variables: abnormal returns

The response variables in the regression models, *1-day AR*, *2-day CAR* and *3-day CAR*, are the measures of the price performance of the real estate firms. These variables refer to daily or cumulative abnormal returns over a multi-day period. The multi-day windows can account for a longer time frame before the shock of asset-level Covid-19 exposure is fully translated into firm-level abnormal returns. The *1-day AR* variable is calculated as: $R_{i,t} - \beta_i(M_t)$, where β_i is the market beta for firm *i* and M_t is the daily market return on day *t*. The market beta is obtained through Refinitiv Eikon for each firm on the 28th of January, using the best available lookback period of up to 5 years. In some cases, this estimate could entail differing lookback periods; however, alternative beta estimates had significant data availability limitations, with the current estimate providing complete information on firm risk profiles compared to the overall market. The market return is the daily return of the STOXX Europe 600 index, a benchmark covering 90% of the broader European free-floating stock market, beyond only the Eurozone. It entirely consists of countries also used in the present analysis sample (Qontigo 2022). *2-day CAR* is calculated by summing *1-day AR* for days *t* and *t+1*, with *3-day CAR* additionally including day *t-1* for a total of 3 days per observation. The cumulative returns are constructed using non-overlapping data to ensure that each observation is unique. Consequently, models containing these variables have smaller sample sizes.

Explanatory variables

The main explanatory variable is GeoCovid, which captures aggregate asset-level exposure to Covid-19. This measure is introduced by Ling et al. (2020), and the construction of the authors is followed in this paper. It entails taking the weighted average of national Covid-19 growth rates of the countries where a firm is invested. The weighting is based on the share of total portfolio assets invested per country. The daily growth rates are calculated as $\ln(1 + \text{cum.cases}_{c,t}) - \ln(1 + \text{cum.cases}_{c,t-1})$. This calculation method is based on observed days *t*, which are trading days. This calculation ensures that any growth during unobserved days, such as weekends, is captured by the growth rate on day *t*. When used in regressions, *GeoCovid* is

lagged by one day to allow for a time gap before the information is translated into market prices. For the sector analysis, this variable is interacted with variables capturing investment per sector. These sector variables are *Retail*, *Industrial*, *Residential*, *Office*, *Healthcare*, and *Hotel*. They are constructed as continuous variables based on the reported share invested into each sector in the firm's property portfolios. No separate variables are included for student-housing or self-storage warehouses; instead, they are captured by *Residential* and *Industrial*.

Two different sets of models are used to analyse non-pharmaceutical government interventions' (NPIs) impact on Covid-19 exposure. The first set captures the intensity of NPI levels. These modelled variables are *Stringency* for lockdown-style policies, *Govt Response* for overall policy, *ContainHealth* for a combination of lockdown-style and health-system policy, and *Economic Support* for policy aimed at, e.g., debt relief and income support. All these variables are constructed as an index with scores between 0-100, with higher values indicating stronger levels of the policy in question. These indices are based on the work of Hale et al. (2021). The second set of models uses the variables *GeoNPI* and *GeoReopen,* following the approach of Ling et al. (2020) and building on the work of Cheng et al. (2020). These variables capture the geographically weighted percentage of assets exposed to lockdown-style NPIs and reopenings based on public announcements. They are constructed by taking the portfolio share per country multiplied by a country-level dummy variable which equals 0 before and 1 after that country has made the first public NPI or reopening announcement.

Control variables

The regression analyses include control variables accounting for the epidemiological situation and firm characteristics that might influence abnormal returns. The combination of all these controls finds precedent in the work of Ling et al. (2020). The two epidemiological controls are *Days since outbreak* and *GeoPopDen*. *Days since outbreak* is included to capture the temporal effect of the pandemic, which literature finds can predict pandemic severity (Wheaton & Thompson 2020). The squared form is also included to account for the exponential nature of case growth and is found to be significant in the Covid-19 shock analysis of Ling et al. (2020). *GeoPopDen*, capturing population density, is added since it acts as a catalyzer in the spread of Covid-19, with significant economic effects as a result (Castex, et al. 2020; Rocklöv & Sjödin 2020). It is calculated by matching the population density per sq. km of land area with the firm portfolio share invested per country. This variable is logged to adjust for the skewness in the distribution.

Next, the control variables accounting for firm characteristics are *Leverage*, *Cash Ratio*, *Total Assets*, *Tobin's q*, *Prior Return*, *Strat Ownership*, *ROA*, and *Investment*. All these characteristics find usage as controls for price performance in the Covid-19 and broader shock literature (e.g., Albuquerque et al. 2020; Ling et al. 2020; Xiong & Zhang 2020). *Leverage* and *Cash Ratio* capture elements of a firm's financial buffer and have extensive support as a predictor of performance in market downturns and the Covid-19 shock (Ramelli & Wagner 2020). *Leverage* is calculated as the ratio of reported total assets to the book value of total debt at the end of 2019Q4. *Cash Ratio* is the ratio of cash and short-term investments to reported total assets at the end of 2019Q4. *Total Assets* is used to capture firm size, with literature suggesting larger firms outperform smaller ones in the pandemic (Xiong & Zhang 2020). The natural log is also taken here to account for the skewed nature of the distribution. *Tobin's q* captures the market value relative to intrinsic value, calculated by taking the market capitalization plus the book value of total debt as a ratio to reported total assets. *Prior Return* is the 2019Q4 cumulative stock return, which captures preceding firm price performance. *Strat Ownership* is the percentage of strategic shareholders, with some research suggesting that non-retail investors are linked to worse performance in the Covid-19 shock (Glossner et al. 2020). *ROA* captures firm profitability and is calculated as EBITDA over total assets. Finally, *Investment* measures the growth in non-cash holdings over 2019.

3.3 Methodology

The relationship between the operationalized variables is studied using regression models. The abnormal returns and Covid-19 exposure are collected over time, within and across different firms. The regressions are therefore estimated as pooled cross-sectional models. These models can determine if an association between the response and predictor variables exists across all observations through time while accounting for groupings of observations within firms. The models examine abnormal returns as a function of Covid-19 and NPI exposure. Investment levels per asset class are interacted with *GeoCovid* to estimate sector differences. Additionally, several controls are included, which account for time, population density, and firm predictors of abnormal returns.

The primary analysis of Covid-19 exposure, which all other models are adapted from, takes on the following functional form:

$$\begin{aligned} 1\text{-}day\ AR_{i,t} = {} & \beta 0 + \beta 1\ Geocovid_{i,t-1} + \beta 2\ Days\ since\ outbreak_{i,t} \\ & + \beta 3\ Days\ since\ outbreak^2{}_{i,t} + \beta 4\ ln(GeoPopDen)_i \\ & + \sum_{k=1}^{k} \beta_k\ Firm\ Controls_i^k + FE + u_{i,t} \end{aligned} \quad (1)$$

The models based on equation (1) have $1\text{-}day\ AR_{i,t}$ as the response variable, which indicates the abnormal returns for firm *i* on day *t*. Addition models based on this regression equation use the following alternative specifications of the response variable: $2\text{-}day\ CAR_{i,t,t+1}$ and $3\text{-}day\ CAR_{i,t-1,t,t+1}$. These variables indicate cumulative abnormal returns over multi-day periods for firm *i* on days *t* and *t+1* and days *t-1*, *t* and *t+1*, respectively. $\beta 1\ Geocovid_{i,t-1}$ is the main explanatory variable and represents the geographically weighted daily growth rate of Covid-19 cases on day *t-1*. *Days since outbreak* and it's squared form are control variables and are calculated based on the number of days since the first case was reported in any country where firm *i* has properties. $Ln(GeoPopDen)_i$ is another control variable and measures the geographically weighted average country population density per firm. $Firm\ Controls_i^k$ represents a vector of control variables which are predictors of firm performance: *Leverage*, *Cash Ratio*, *ln(Total Assets)*, *Tobin's q*, *Prior Return*, *Strat Ownership*, *ROA*, and *Investment*. *FE* refers to either property type or firm fixed effects, with the former based on dummies for portfolios with 90% or more invested into one sector. Definitions and sources for each variable are provided in Table A1 of the appendix.

4. Data and variables

4.1 Data

The regression analysis sample consists of 106 publicly listed real estate companies that fit the criterion that property portfolios are exclusively in Europe. Furthermore, only firms that derive their income from the ownership, trade, or development of real estate assets are included. Data from these firms is obtained manually from company publications of annual reports. The selection is based on two market indices tracking the European commercial real estate industry, namely the FTSE Developed Europe Real Estate ETF (DWS 2022) and the European Property Yield UCITS ETF (BlackRock 2022). REITs and non-REITs are included, with the selection of non-REITs comprising firms that focus their investments on income-producing commercial

real estate assets. This setting is preferred to capture the broader European market, where many countries do not have mature REIT schemes compared to, e.g., the US market. The time sample runs from the start of the pandemic, from the first day a case was confirmed in any country where a firm holds assets, to the last day of daily reported Covid-19 cases, before The European Centre for Disease Prevention and Control (ECDC) adopted a weekly reporting standard. This translates into a period from the 28th of January to the 14th of December in 2020.

Based on this sample, the total firm-day observations amount to 23,440. Data on stock prices, balance sheet items and shareholders are collected through Refinitiv Eikon. Annual reports for the fiscal year 2019 are used to manually obtain data on the geographical spread of firm portfolios and the sectorial breakdown. The firms are invested in 21 different European countries listed in figure 1. This figure also displays the geographical diversification of portfolio investments. Almost all investment activities belong to the following sectors: retail, industrial, residential, office, healthcare, and hotel, with Table 1 listing the percentage invested per sector. Historically reported data on daily Covid-19 cases per country are collected from the ECDC (2020). The population density per country is based on data from the World Bank (2022). Daily returns of the STOXX Europe 600 index are collected from investing.com (2022). Data on public announcements of NPIs are retrieved from the CoronaNet Research Project (Cheng et al. 2020) and NPI intensity indices from the Oxford Covid-19 Government Response Tracker (Hale et al. 2021).

Table 1

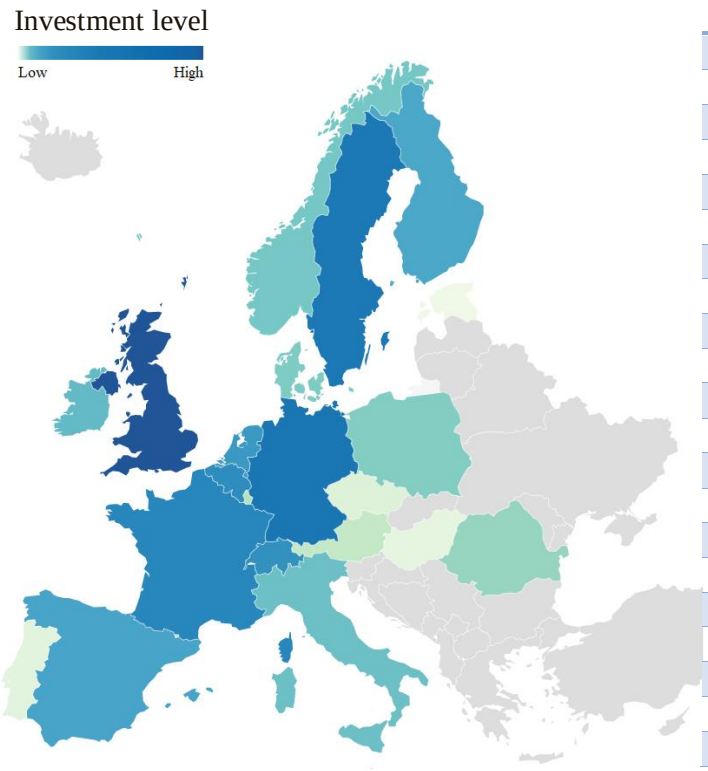
Investment level per real estate sector

Sector	Percentage
Office	30,8%
Retail	24,7%
Residential	19,1%
Industrial	17,9%
Healthcare	5,4%
Hotel	2,1%

This table reports the percentage of all firms' portfolios investments per real estate sector.

Figure 1

Geographical spread of portfolio investements



Country	Percentage
Austria	0,4%
Belgium	6,5%
Czech Republic	0,2%
Denmark	1,3%
Estonia	0,1%
Finland	3,1%
France	8,3%
Germany	14,4%
Hungary	0,1%
Ireland	2,0%
Italy	1,7%
Luxembourg	0,5%
Netherlands	4,6%
Norway	1,4%
Poland	1,3%
Portugal	0,2%
Romania	1,0%
Spain	3,4%
Sweden	12,6%
Switzerland	5,5%
United Kingdom	31,4%

This figure displays the geographical spread of portfolio investments and the level of investment per country. The table on the right lists the percentage invested per country.

4.2 Summary statistics

The descriptive statistic statistics of the samples used in the regression analyses are given in Table 2. Between the 28th of January to the 14th of December of 2020, we see that the mean abnormal returns are close to 0. For the 1-day AR, we see a mean of -0.02% and a standard deviation of 2.85%. The high standard deviation relative to the mean and the wide range of observed returns could indicate a volatile market. GeoCovid has a mean of 0.061, which means that when the daily Covid-19 case growth rate that a firm's asset portfolio is exposed to is, on average, 6.1%. This overall rate for a firm's portfolio is based on weighting all national growth rates by the percentage of total assets invested in the corresponding country. The average NPI index scores for a firm's portfolio in the case of *Stringency*, *Govt Response*, *ContainHealth* and *Economic Support* are 56.0, 53.8, 52.4, and 63.8, respectively. These scores reflect that, on average, portfolios were exposed to a medium-strength level of government measures in the different policy areas. To have an indication of the heterogeneity of NPI strictness among the sample countries, Table 3 reports descriptives on *Stringency* per country.

Table 2 Descriptive Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Response					
1-day AR	23,440	-0.000	0.029	-0.256	0.336
2-day CAR	11,682	-0.000	0.042	-0.379	0.440
3-day CAR	7,745	-0.001	0.051	-0.562	0.658
Explanatory					
GeoCovid	23,440	0.061	0.151	-0.098	3.283
Stringency	23,440	56.001	20.374	0.056	93.112
Govt Response	23,440	53.849	17.500	0.031	80.383
ContainHealth	23,440	52.426	16.021	0.036	84.389
Economic Support	23,440	63.819	33.221	0	100
GeoNPI	13,304	0.64	0.464	0	1
GeoReopen	13,304	0.413	0.477	0	1
Control					
Days since outbreak	23,440	159	92	0	324
GeoPopDen	23,440	215	111	15	518
Leverage	23,440	0.372	0.110	0.064	0.614
Cash Ratio	23,440	0.034	0.033	0.001	0.133
Total Assets	23,440	5512	7645	260	56476
Tobin's q	23,440	1.042	0.342	0.626	3.89
Prior Return	23,440	0.075	0.087	-0.151	0.280
Strat Ownership	23,440	0.195	0.189	0.000	0.681
Investment	23,440	0.166	0.326	-0.189	2.286
ROA	23,440	0.038	0.017	-0.014	0.110
Sector					
Retail	23,440	0.249	0.361	0	1
Industrial	23,440	0.180	0.315	0	1
Residential	23,440	0.191	0.368	0	1
Office	23,440	0.305	0.354	0	1
Healthcare	23,440	0.054	0.213	0	1
Hotel	23,440	0,021	0,106	0	1

This table reports the descriptive statistics of all variables included in the different regression analyses. It lists the mean values, standard deviation, and minimum and maximum value. Definitions of the different variables used in the models are given in Table A1.

In the case of *GeoNPI* and *GeoReopen*, there are fewer observations since the observed time period lasts until the 31st of July. This shorter time frame is because these variables track the first public announcements of NPIs reopenings, which occurred before this date. The means represent the average percentage of portfolios exposed to NPIs or reopenings during this period. As time progresses, larger percentages of portfolios are exposed to NPIs, followed by larger exposure to subsequent reopenings. Population density per portfolio sees an extensive range between 15 and 518 people per square kilometer, with the mean at 215 people. Furthermore, among the firm controls, we observe a mean leverage ratio of 37.2%, cash holdings at 3.4%, and total assets at 5,512 million euros.

Table 3

NPI Stringency per country

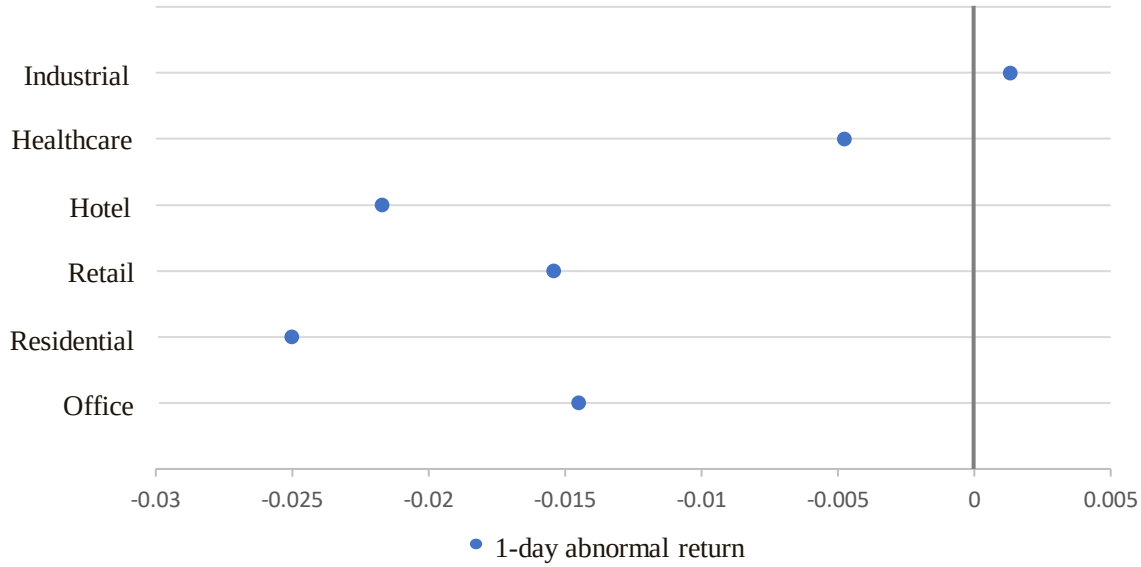
Country	Mean	Min	Max
Italy	64,7	2,78	93,52
United Kingdom	56,9	5,56	79,63
Spain	56,3	0	85,19
Ireland	56,0	0	90,74
France	54,3	2,78	87,96
Portugal	54,2	5,56	87,96
Germany	51,8	5,56	82,41
Belgium	51,2	5,56	81,48
Romania	50,0	2,78	87,04
Netherlands	49,2	0	78,7
Sweden	49,0	0	69,44
Hungary	48,5	0	76,85
Poland	47,7	5,56	87,04
Austria	47,1	0	82,41
Denmark	45,6	0	72,22
Czech Republic	44,8	11,11	82,41
Luxembourg	42,7	0	79,63
Switzerland	42,3	0	73,15
Norway	41,7	0	79,63
Finland	38,9	5,56	71,3
Estonia	36,4	0	77,78

This table reports on the mean, min and max values of the *Stringency* scores of all the countries in the analysis sample. S*tringency* is defined in Table A1

The mean of Tobin's q sits at 1.04, and the mean of cumulative stock returns over 2019Q4 is at 7.5%. Looking at the sector variables, we see a breakdown of 24.9% retail assets, 18% industrial, 19.1% residential, 30.5% office, 5.4% healthcare, and the smallest group of hotel assets at just 2.1%. To get an initial impression of the data, figure 2 displays the correlations between abnormal returns across firms predominantly invested in a particular real estate sector and the geographical exposure to daily growth rates of Covid-19. It shows that the correlations are negative for all but one sector, which could point to a negative relationship between a firm's portfolio exposure to Covid-19 cases and its abnormal returns. Furthermore, these correlations seem to display significant differences in this relationship across different sectors, e.g., *Industrial* has a slightly positive correlation. These sector differences will be further explored in chapter 4.2 of the results.

Figure 2

Abnormal returns and GeoCovid correlations



This figure displays the correlations between the 1-day abnormal returns per real estate sector and the geographical exposure to Covid-19 growth rates, as captured by *GeoCovid*. Property type and variable descriptions are given in Table A1.

5. Results

The results cover three different analyses: the main relationship between *GeoCovid* and abnormal returns, the difference in effects among firms invested in different sectors, and the impact on NPIs. The first regression analysis examining the effect of *GeoCovid* corresponds with the correlation matrix shown in Table B1. Additional correlation matrices for further models are also included in Appendix B.

5.1 Covid-19 exposure and abnormal returns

Table 4 reports the pooled cross-sectional regression models assessing the relationship between asset-level Covid-19 exposure and firm-level abnormal returns captured by the coefficients of *GeoCovid*. All models use clustered standard errors at the firm level to account for the panel setting. Model 1 reports the baseline regression with just the explanatory variable and property type fixed effects. We observe a statistically significant, negative relationship between GeoCovid on day *t-1* and abnormal returns on day *t*. This result suggests that asset-level exposure to daily growth rates of Covid-19 negatively impacts the price performance of firms on the following day.

Model 2 expands the regression with control variables capturing the duration of the pandemic, the geographically adjusted population density, and firm-level predictors of price performance. It finds that the effect of GeoCovid is robust when accounting for these controls, retaining a negative and statistically significant coefficient. Although tempered compared to model 1, the economic significance remains present with a coefficient of -0.006. This can be interpreted as a one-standard-deviation increase in daily Covid-19 growth rates at the asset level being associated with an 0.09 percentage point decrease (= -0.006*0.151) in abnormal stock returns on the following day. A decrease of that magnitude represents a decline of more than four times the sample's mean decline (0.02). This result supports hypothesis 1 and aligns with the findings of Ling et al. (2020). They find a negative relationship between GeoCovid on abnormal returns of 0.24 percentage points for REITs in the US. Furthermore, the finding is consistent with the literature finding that the Covid-19 shock generally leads to decreased abnormal stock returns (Liu et al. 2020; Harjoto et al. 2021; Ramelli & Wagner 2020).

Table 4

GeoCovid Regressions	(1)	(2)	(3)
	1-day AR	1-day AR	1-day AR
GeoCovid	-0.009***	-0.006***	-0.006***
	(0.001)	(0.001)	(0.001)
Days since outbreak		0.000***	0.000***
		(0.000)	(0.000)
Days since outbreak^2		-0.000	-0.000
		(0.000)	(0.000)
Constant	0.000*	-0.001	-0.003***
	(0.014)	(0.082)	(0.000)
Firm-level Controls	No	Yes	No
Fixed Effects	Prop. type	Prop. type	Firm
R-squared	0.004	0.004	0.005
Observations	23,440	23,440	23,440

This table reports the coefficients of multiple abnormal return regression models. Standard errors are clustered at the firm level and reported in parentheses. The significance level is reported with *, **, ***, indicating a 95%, 99% and 99.9% confidence level, respectively. The 1-day abnormal returns are used as the dependent variable, with models using multi-day abnormal returns reported in Appendix C. The main explanatory variable is *GeoCovid* which captures the daily geographically weighted firm-level exposure to Covid-19 cases. Model 1 includes no control variables; Model 2 includes all controls and model 3 only includes temporal controls. Model 3 includes firm fixed effects, with the remaining models using property type fixed effects. All models are pooled cross-sectional regressions. Definitions and sources of all variables are given in Table A1.

Except *Days since outbreak*, the control variables are not separately reported for clarity. Interesting results here include that the log of geographically weighted population density is found to be statistically significant and positive. This result aligns with Ling et al. (2020) and points to real estate firms performing better in densely populated areas. Furthermore, *Tobin's q* reports a negative relationship, indicating that overvalued firms (relative to their asset replacement costs) were more severely penalized in the Covid-19 shock. The final control variable *Investment*, capturing the level of investment over the year leading up to the pandemic, is found to positively impact abnormal returns at the 95% confidence level. This estimate could imply that investors value firms with pipeline projects and possibly improved long-term prospects.

Column 3 in Table 4 reports the third model, which adapts the regression specification by swapping property type fixed effects with firm fixed effects. Furthermore, all firm-level variables are excluded from the model to regress using firm fixed effects. This model is included in the analysis to ensure that the main relationship being studied between *GeoCovid* and abnormal returns is robust to unobserved time-invariant firm characteristics. This seems to be the case, with the coefficient of *GeoCovid* staying at -0.006 with a strong statistical significance.

Additional specifications with 2-day and 3-day cumulative abnormal returns are reported in Table C1 of the appendix. These results are mostly consistent with the earlier models, with almost all coefficients retaining their statistical and economic significance. There is, however, a breakdown of consistency with the coefficient of *GeoCovid* in models 5 and 6 becoming statistically insignificant. This means that once controlled for other factors, no association is found between the cumulative abnormal returns of the day before, the day of, and the day after assets are exposed to specific Covid-19 growth rates. This could imply, also considering that the 2-day estimate is significant, that investors cannot price in future growth rates of Covid-19 consistently.

5.2 Sector analysis

Table 5 reports the sector regressions, which study how the main Covid-19 relationship from the earlier models differs for firms invested in various real estate sectors. All the controls modelled in the Table 4 regressions are again included here but not separately reported for clarity. Since the analysis concerns the effect of investment levels in different assets of different

sectors, fixed effects are not included for either property type or firm. Due to the exhaustive nature of including all sector variables, inferences for the hotel sector need to be made based on the non-interacted term of *GeoCovid*. Furthermore, due to the diversified nature of European listed real estate firms, the variables capturing these sectors are not overall firm-level dummy variables such as in the analysis of Ling et al. (2020) and instead capture the reported share of portfolios invested in each sector per firm. Using this construction means the results only carry implications for the overall sector allocation of firms and not for local effects on different assets.

Model 1 shows that the most negative effect of exposure to daily growth rates of Covid-19 cases is found for firms that invest in hotel assets. The statistically significant coefficient relating to this relationship has a value of -0.053. This indicates that for every one-standard-deviation increase in the weighted average of daily Covid-19 growth rates for a firm invested in hotel assets; abnormal returns are decreased by 0.8 percentage points (= -0.053*0.151) on the following day. This result is in line with the expectation that the wider hospitality sector suffered more than most from the Covid-19 pandemic (Mazur et al. 2021). Also linked to the hospitality sector, retail is the next worst performer, with a negative coefficient of -0.009 (= -0.053+0.044). This coefficient corresponds with a 0.14 percentage point decline in abnormal returns for every standard deviation increase in Covid-19 growth rates (-0.009*0.151).

Moving further down the table, we find that the reported coefficient for *GeoCovid*Industrial* is estimated at 0.057. Interestingly, this result implies a positive effect of the Covid-19 shock on abnormal returns for firms invested in industrial properties. Namely, the model estimates a positive regression coefficient of 0.004 (= -0.053 + 0.057), which implies an associated increase of 0.06 percentage points in abnormal returns. The same dynamic is present for healthcare assets with a positive coefficient of 0.002, corresponding with a rise of 0.03 percentage points in abnormal returns. These results are in accordance with the literature, which establishes that the manufacturing, technology, and healthcare industries exhibit positive reactions to the Covid-19 pandemic (He et al. 2020; Mazur et al. 2020). Furthermore, the industrial investments include many warehouses, linked to the increase in e-commerce, a sector which experienced substantial growth due to the Covid-19 pandemic (Bhatti et al. 2020).

Table 5

Sector Regressions	(1)	(2)	(3)
	1-day AR	2-day CAR	3-day CAR
GeoCovid (Hotel)	-0.053***	-0.115***	-0.263***
	(0.007)	(0.011)	(0.058)
GeoCovid*Retail	0.044***	0.096***	0.246***
	(0.007)	(0.013)	(0.058)
GeoCovid*Industrial	0.057***	0.128***	0.281***
	(0.007)	(0.012)	(0.058)
GeoCovid*Residential	0.048***	0.110***	0.261***
	(0.007)	(0.012)	(0.058)
GeoCovid*Office	0.047***	0.105***	0.252***
	(0.007)	(0.012)	(0.060)
GeoCovid*Healthcare	0.055***	0.118***	0.291***
	(0.008)	(0.016)	(0.058)
Controls	Yes	Yes	Yes
R-squared	0.005	0.010	0.016
Observations	23,440	11,682	7,745

This table reports the coefficients of multiple abnormal return regression models. Standard errors are clustered at the firm level and reported in parentheses. The significance level is reported with *, **, ***, indicating a 95%, 99% and 99.9% confidence level, respectively. Model 1 has 1-day abnormal returns as the dependent variable, which is replaced in models 2 and 3 with nonoverlapping 2- and 3-day cumulative abnormal returns. The main explanatory variable is GeoCovid which captures the daily geographically weighted firm-level exposure to Covid-19 cases. The other reporter predictors are interactions with firm-level sector allocation. Hotel is omitted and therefore captured by GeoCovid. All models are pooled cross-sectional regressions. Definitions and sources of all variables are given in Table A1.

The remaining residential and office sector coefficients have moderate estimates of -0.05 and -0.06, respectively. These are in line with the overall negative impact reported in Table 4. This means that a one-standard-deviation increase in daily Covid-19 growth rates corresponds with a 0.08 percentage point decrease in abnormal returns for the residential sector and a 0.09 percentage point decrease for the office sector. Overall, the results from all sectors support hypothesis 2, since investment allocation significantly changes the impact of *GeoCovid* on abnormal returns. All the results are robust for adapting the dependent variable to cover non-overlapping 2- and 3-day cumulative abnormal returns. The coefficients remain statistically significant and report higher coefficient values than model 1. This, however, reflects the cumulative nature of the returns. Therefore, all the coefficients retain the same implications regarding the effects of sector allocation on Covid-19 exposure and abnormal returns.

5.3 Government policy effects

Reported in Table 6 are the regression models analyzing the effects of different government policies in response to the pandemic. The first four models report on different daily indices constructed by the Oxford Covid-19 Government Response Tracker (OxCGRT). These indices are based on *ex-post* calculated levels of NPI intensity. Models 5 and 6 report on the effects of NPI and reopening announcements based on data from the CoronaNet Research Project. These models use a shorter time horizon in their sample to address the first announcement of NPIs and reopenings in response to Europe's first wave of the pandemic. As with the regressions in Table 5, the same control variables are included but not separately reported. All models include property type fixed effects and clustered standard error at the firm level.

Model 1-4 report on the portfolio exposure to different non-pharmaceutical government interventions, weighted by the percentage of total assets invested per country. *Stringency* captures the strictness of lockdown-style policies, *ContainHealth* combines NPI strictness with health-system policies, *Economic Support* scores economic support measures, and *Govt Response* scores the strength of the overall government response. All these indices exhibit a positive relationship with abnormal returns without a moderating effect on *GeoCovid*. This indicates that investors value firms more when these firms have asset portfolios invested in countries subject to stricter lockdown-style measures and more health-system and economic support measures. These results highlight that NPI measures improve abnormal returns, which aligns with the literature (Correia et al. 2020; Demirgüç-Kunt et al. 2020).

Models 5 and 6 address a slightly different policy analysis compared to the previous models. Here the shock effect on abnormal returns in response to the first public announcement of NPIs (*GeoNPI*) and reopenings (*GeoReopen*) is examined. We see that abnormal returns are higher both after NPIs and reopenings have been announced. Furthermore, at a 99% confidence level, the model also estimates that the positive effect of NPI announcements also decreases a firm's sensitivity to asset-level Covid-19 exposure. This inference follows from the positive coefficient reported when GeoCovid interacts with *GeoNPI*. This finding supports hypothesis 3 since the negative effect of *GeoCovid* is lessened after NPIs are announced. This finding also adds to the evidence supporting that NPIs as positive for the economy, and it aligns with the results reported in the analysis of Ling et al. (2020) for the United States real estate market.

Table 6 Government Policy Regressions	(1) 1-day AR	(2) 1-day AR	(3) 1-day AR	(4) 1-day AR	(5) 1-day AR	(6) 1-day AR
GeoCovid	-0.004*	-0.006*	-0.006***	-0.006***	-0.006***	-0.006***
	(0.003)	(0.004)	(0.001)	(0.003)	(0.002)	(0.001)
Stringency	0.000***					
	(0.000)					
GeoCovid*Stringency	0.000					
	(0.000)					
ContainHealth		0.000***				
		(0.000)				
GeoCovid*ContainHealth		0.000				
		(0.000)				
Economic Support			0.000***			
			(0.000)			
GeoCovid*Economic Support			0.000			
			(0.000)			
Govt Response				0.000***		
				(0.000)		
GeoCovid*Govt Response				0.000		
				(0.000)		
GeoNPI					0.011***	
					(0.002)	
GeoCovid*GeoNPI					0.019**	
					(0.009)	
GeoReopen						0.003***
						(0.001)
GeoCovid*GeoReopen						0.015
						(0.037)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Prop. type	Prop. type	Prop. type	Prop. type	Prop. type	Prop. type
R-squared	0.007	0.008	0.007	0.008	0.019	0.006
Observations	23,440	23,440	23,440	23,440	13.304	13.304

This table reports the coefficients of multiple abnormal return regression models. Standard errors are clustered at the firm level and reported in parentheses. The significance level is reported with *, **, ***, indicating a 95%, 99% and 99.9% confidence level, respectively. All models have 1-day abnormal returns as the dependent variable with alternative specifications using 2- and 3-day cumulative abnormal returns being reported in Appendix X. The main explanatory variable is GeoCovid which captures the daily geographically weighted firm-level exposure to Covid-19 cases. The other reporter predictors are different measures of government policy matched against firm portfolios. Models 5 and 6 assess a shorter time frame until 31-7-2020. All models are pooled cross-sectional regressions. Definitions and sources of all variables are given in Table A1.

For reopenings, there is no significant interaction effect found. This means that no evidence is found to support the idea that reopening the economy decreases the adverse risk posed by the pandemic. In addition to aligning with Ling et al. (2020), who found similar results, it is also consistent with Goolsbee & Syverson (2021). They find that government-imposed shutdowns and repeals had little impact on consumer visits to businesses, which instead are driven by individual choices.

6. Conclusion

In an ever-globalizing world with increased pandemic risks, understanding the effects of the Covid-19 pandemic can offer valuable lessons for the future. This paper addresses the problem from an economic perspective by asking how the Covid-19 pandemic affects abnormal stock returns in the European commercial real estate sector. This is investigated by studying the effects of geographic asset-level exposure to Covid-19 growth rates. Multiple different models are estimated using different model specifications. Results are controlled for temporal effects, population density, firm predictors of stock price performance, and firm or property type fixed effects. The first year of the pandemic is observed, and 106 publicly listed real estate firms are examined. The analysis finds that increasing growth rates are linked to lower abnormal returns. Specifically, a one-standard-deviation increase in the weighted average of daily Covid-19 growth rates among portfolio countries (weighted by share of total assets invested per country) is associated with a 0.09 percentage point decrease in firm-level abnormal returns on the following day. This represents a decline of more than four times the mean decline in the sample. This negative result, although smaller, is in line with the negative effect found by Ling et al. (2020) in their analysis of REITs in the United States.

After establishing the main negative relationship, further analyses examine the differential impact on real estate sectors and the effects of non-pharmaceutical government interventions. Among the firms, those invested primarily in hotel assets are found to be most severely impacted by Covid-19 exposure, experiencing the lowest abnormal returns. Following in second are firms that invest more in retail assets, which also display a marked negative effect. Comparatively moderate adverse effects are found for firms in the office and residential sectors. Finally, firms invested in healthcare and industrial properties are positively impacted. Regarding the non-pharmaceutical interventions (NPIs), the analysis finds that both lockdown-style interventions and economic and health-system support measures are positively linked to abnormal returns during the pandemic. The analysis also shows evidence supporting a

moderating role of NPI announcements, which are found to ameliorate the negative effect of Covid-19 growth rates on abnormal returns. Finally, announcements of NPIs being lifted do not impact the adverse effects of Covid-19 exposure.

Limitations to the conclusions include that the outcome measures are based on market pricing. Therefore, no statement on the real-world performance of real estate assets can be made. Additionally, the epidemiological analysis is national, which could mean that regional differences are overlooked. Lastly, manually collected firm data is subject to observational error and entails data limitations for the sector analysis, which does not examine specific local effects on properties but aggregate sector allocation. Nevertheless, the results do bring forth evidence for the conclusion that portfolio exposure to the pandemic negatively impacts firm performance. Furthermore, they highlight how the post-outbreak economy is characterized by winners and losers, with firms invested in different sectors experiencing highly varying consequences. And finally, the results add to the growing literature, which suggests that non-pharmaceutical government interventions help instead of hurt the economy (Correia et al. 2020; Demirgüç-Kunt et al. 2020) by improving medium to long-term prospects. Building on these findings, future research can examine how different real estate assets are impacted by local Covid-19 exposure and what specific government measures struck the best balance between economic and health concerns.

Appendix A

Table A1
Variable Definitions

Variable name	Definition	Source
Response variables: Daily abnormal returns		
1-day AR	Daily abnormal returns based on CAPM calculated as $R_{i,t} - \beta_i(M_t)$. β_i is the market beta for firm *i* at the start of the pandemic from best available lookback periods up to 5 years. M_t is the daily STOXX Europe 600 return on day *t*	Refinitiv Eikon, Investing.com
2-day CAR	The 2-day cumulative abnormal returns based on days *t* and *t+1*	Refinitiv Eikon, Investing.com
3-day CAR	The 2-day cumulative abnormal returns based on days *t-1* to *t+1*	Refinitiv Eikon, Investing.com
Explanatory variables: Covid-19 exposure		
GeoCovid	Firm-level geographic exposure to daily country growth rates of Covid-19 cases. Constructed by matching property portfolios with growth rates calculated per country *c* on day *t* as ln(1 + cum.cases$_{c,t}$) - ln(1 + cum.cases$_{c,t-1}$)	ECDC, annual reports
Stringency	Firm-level geographic exposure to strictness of lockdown policies. Constructed by matching property portfolios with the OxCGRT Stringency Index measured daily between 0 - 100	Oxford COVID-19 Government Response Tracker, annual reports
Govt Response	Firm-level geographic exposure to overall government response intensity. Constructed by matching property portfolios with the OxCGRT Government Response Index measured daily between 0 - 100	Oxford COVID-19 Government Response Tracker, annual reports
ContainHealth	Firm-level geographic exposure to a combination of lockdown and healthcare policies. Constructed by matching property portfolios with the OxCGRT Containment and Health Index measured daily between 0 - 100	Oxford COVID-19 Government Response Tracker, annual reports
Economic Support	Firm-level geographic exposure to government economic relief measures. Constructed by matching property portfolios with the OxCGRT Economic Support Index measured daily between 0 - 100	Oxford COVID-19 Government Response Tracker, annual reports
GeoNPI	Firm-level geographic exposure to lockdown-style non-pharmaceutical interventions (NPIs). Constructed by matching property portfolios with a dummy variable indicating 0 before and 1 after the first public NPI announcement	CoronaNet Research Project, annual reports
GeoReopen	Firm-level geographic exposure to reopenings. Constructed by matching property portfolios with a dummy variable indicating 0 before and 1 after the first public reopening announcement	CoronaNet Research Project, annual reports

(continued)

Table A1
Continued

Variable name	Definition	Source
Control variables: Performance predictors		
Days since outbreak	The total number of days at time *t* since the first Covid-19 case in any country where a firm holds property	ECDC, annual reports
GeoPopDen	Population density per sq. km of land area weighted by the share of firm property portfolios	The World Bank, annual reports
Leverage	Ratio of reported Total Assets to the book value of Total Debt at the end of 2019Q4	Refinitiv Eikon
Cash Ratio	Ratio of Cash and Short-term Investments to reported Total Assets at the end of 2019Q4	Refinitiv Eikon
Total Assets	Reported Total Assets at the end of 2019Q4 in millions of Euros	Refinitiv Eikon
Tobin's q	Ratio of Market Capitalization plus book value of Total Debt to reported Total Assets	Refinitiv Eikon
Prior Return	Total realized stock return over 2019Q4	Refinitiv Eikon
Strat Ownership	Percentage of shares held by strategic entities including individuals, corporations, holding companies and government agencies at the end of 2019Q4	Refinitiv Eikon
Investment	Growth of non-cash assets capturing the level of investment over FY 2019	Refinitiv Eikon
ROA	Ratio of earnings before tax, appreciation, and amortization (EBITDA) to reported Total Assets	Refinitiv Eikon
Sector variables		
Retail	Percentage of portfolio dedicated to retail properties including i.a. shopping malls, outlet centers and other big box or free-standing commercial space	Annual reports
Industrial	Percentage of portfolio dedicated to industrial including i.a. industrial parks, factories, and logistics space such as warehouses and distribution centers. Self-storage warehouses are included as industrial due to relatively small prevalence in data.	Annual reports
Residential	Percentage of portfolio dedicated to residential properties including i.a. multi- and single-family housing and apartment buildings. Student-housing is included with residential due to a relatively small prevalence in the data.	Annual reports
Office	Percentage of portfolio dedicated to office properties including i.a. business parks, high-rise office buildings and co-working spaces.	Annual reports
Healthcare	Percentage of portfolio dedicated to healthcare properties including i.a. medical facilities, assisted housing, elderly care, and hospitals	Annual reports
Hotel	Percentage of portfolio dedicated to lodging and leisure properties including i.a. hotels and resorts.	Annual reports

This table reports the names, definitions and sources of all variables used in the regression analyses.

Appendix B

Table B1
Correlation Matrix

	1-day AR	GeoCovid	Days	ln(GPD)	Leverage	Cash Ratio	ln(TA)	Tobin's q	Prior Return	Strat Owner	ROA	Invest.
1-day AR	1											
GeoCovid	-0.050***	1										
Days since outbreak	0.054***	-0.386***	1									
ln(GeoPopDen)	-0.003	0.019**	0.009	1								
Leverage	0.000	-0.012	-0.000	-0.357***	1							
Cash Ratio	0.005	0.006	0.011	0.102***	-0.152***	1						
ln(Total Assets)	-0.002	-0.004	0.005	-0.235***	0.234***	-0.093***	1					
Tobin's q	-0.006	-0.001	0.003	0.014*	-0.001	-0.237***	-0.017**	1				
Prior Return	-0.004	0.003	0.008	-0.115***	0.117***	0.127***	0.172***	0.192***	1			
Strat Ownership	-0.004	-0.011	0.000	-0.392***	0.288***	0.030***	0.107***	-0.106***	0.147***	1		
ROA	0.004	-0.002	0.004	0.080***	0.256***	-0.220***	-0.069***	-0.018**	0.042***	-0.083***	1	
Investment	0.012	-0.002	0.002	-0.059***	-0.012	0.336***	-0.111***	-0.060***	0.005	-0.000	-0.155***	1

This table reports the correlation coefficients of the variables for the regression analysis of GeoCovid exposure (Table 6). The significance level is reported with *, **, ***, indicating a 95%, 99% and 99.9% confidence level, respectively. All variable definitions are given in Table A1.

Table B2
Sector Correlations

	Residential	Office	Retail	Hotel	Healthcare	Industrial
Residential	1					
Office	-0.354***	1				
Retail	-0.328***	-0.311***	1			
Hotel	-0.067***	-0.045***	-0.092***	1		
Healthcare	-0.125***	-0.183***	-0.163***	-0.030***	1	
Industrial	-0.285***	-0.215***	-0.271***	-0.083***	-0.128***	1
1-day AR	0.011	-0.007	-0.013*	-0.002	0.003	0.009
GeoCovid	-0.000	-0.002	-0.001	-0.001	0.003	0.002
Days since outbreak	-0.000	-0.014*	0.008	0.002	0.002	0.004
ln(GeoPopDen)	0.051***	-0.252***	0.027***	0.053***	0.124***	0.091***
Leverage	0.069***	-0.035***	0.162***	0.095***	-0.131***	-0.170***
Cash Ratio	0.165***	0.012	-0.153***	0.020**	0.115***	-0.114***
ln(Total Assets)	0.106***	0.176***	-0.014*	0.152***	-0.139***	-0.262***
Tobin's q	-0.141***	-0.133***	-0.016*	-0.020**	0.147***	0.241***
Prior Return	-0.104***	0.172***	-0.180***	0.028***	0.033***	0.103***
Strat Ownership	-0.115***	0.082***	0.156***	-0.033***	-0.193***	0.005
ROA	-0.023***	-0.205***	0.098***	0.008	0.103***	0.073***
Investment	0.281***	-0.102***	-0.309***	0.067***	0.149***	0.018**

This table reports the correlation coefficients of the variables for the sector regression models (Table 5). The significance level is reported with *, **, ***, indicating a 95%, 99% and 99.9% confidence level, respectively. All variable definitions are given in Table A1.

Table B3

NPI Correlations

	Stringency	ContainHealth	EconSup	GovRes	GeoNPI	GeoReopen
1-day AR	0.072***	0.077***	0.063***	0.076***	0.099***	0.055***
GeoCovid	-0.288***	-0.363***	-0.358***	-0.376***	-0.351***	-0.389***
Days since outbreak	0.382***	0.545***	0.457***	0.545***	0.618***	0.764***
ln(GeoPopDen)	0.110***	0.167***	0.227***	0.187***	0.378***	0.224***
Leverage	-0.109***	-0.096***	-0.257***	-0.138***	-0.137***	-0.034***
Cash Ratio	0.041***	0.047***	0.010	0.040***	0.038***	0.035***
ln(Total Assets)	-0.051***	-0.039***	-0.196***	-0.078***	-0.074***	0.001
Tobin's q	-0.004	-0.016*	0.066***	0.002	-0.037***	-0.050***
Prior Return	0.020**	0.004	0.014*	0.007	-0.118***	-0.098***
Strat Ownership	-0.074***	-0.078***	-0.168***	-0.102***	-0.182***	-0.091***
ROA	-0.026***	-0.010	-0.069***	-0.024***	0.018*	0.031***
Investment	-0.007	-0.023***	0.012	-0.016*	-0.048***	-0.039***

This table reports the correlation coefficients of the variables for the NPI regression models (Table 6). The significance level is reported with *, **, ***, indicating a 95%, 99% and 99.9% confidence level, respectively. All variable definitions are given in Table A1.

Appendix B

Table C1

GeoCovid Regressions

	(1)	(2)	(3)	(4)	(5)	(6)
	2-day CAR	2-day CAR	2-day CAR	3-day CAR	3-day CAR	3-day CAR
GeoCovid	-0.018***	-0.010***	-0.010***	-0.019***	-0.007	-0.010
	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)
Days since outbreak		0.001**			0.001**	
		(0.002)			(0.001)	
Days since outbreak^2	0.000*	-0.002	-0.006***	0.000	-0.005**	-0.006***
	(0.000)	(0.002)	(0.001)	(0.000)	(0.002)	(0.001)
Constant	0.000*	-0.002	-0.006***	0.000	-0.005**	-0.006***
	(0.000)	(0.002)	(0.001)	(0.000)	(0.002)	(0.001)
Firm-level Controls	No	Yes	No	No	Yes	No
Fixed Effects	Prop. type	Prop. type	Firm	Prop. type	Prop. type	Firm
R-squared	0.004	0.008	0.013	0.004	0.010	0.017
Observations	11.682	11.682	11.682	7.745	7.745	7.745

This table reports the coefficients of multiple abnormal return regression models. Standard errors are clustered at the firm level and reported in parentheses. The significance level is reported with *, **, ***, indicating a 95%, 99% and 99.9% confidence level, respectively. Models 1-3 (4-6) use nonoverlapping 2-day (3-day) cumulative abnormal returns . The main explanatory variable is *GeoCovid* which captures the daily geographically weighted firm-level exposure to Covid-19 cases. Model 1 and 4 include no control variables, Model 2 and 5 include all controls and model 3 and 6 only include temporal controls. Model 3 and 6 include firm fixed effects, with the remaining models using property type fixed effects. All models are pooled cross-sectional regressions. Definitions and sources of all variables are given in Table A1.

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Stata commands

```
- clear all
- import excel
- replace Cashratio ="." if Cashratio =="NULL"
- destring Cashratio, replace
- replace Noncash ="." if Noncash =="NULL"
- destring Noncash, replace
- encode ISIN, gen(ISIN_N)
- recast double ISIN_N
- tsset ISIN_N Date
- generate Dayssinceoutbreak_2 = Dayssinceoutbreak^2,
  after(Dayssinceoutbreak)
- gen TotalAssets_millions = TotalAssets/1000000,
  after(TotalAssets)
- drop TotalAssets
- rename TotalAssets_millions TotalAssets
- gen Q4return_rate = Q4return/100
- drop Q4return
- rename Q4return_rate Q4return
- gen LnSize = log(TotalAssets)
- gen LnGeoPopDen = log(GeoPopDen)
- replace Noncash = . if ISIN_N == 63
- gen PropType = 0
- replace PropType = 1 if Retail > 0.9
- replace PropType = 2 if Industrial > 0.9
- replace PropType = 3 if Residential > 0.9
- replace PropType = 4 if Office > 0.9
- replace PropType = 5 if Healthcare > 0.9
- replace PropType = 6 if Hotel > 0.9
```

```
- label define proplabel 0 "Diversified" 1 "Retail" 2
  "Industrial" 3 "Residential" 4 "Office" 5 "Healthcare" 6
  "Hotel"
- label values PropType proplabel
- gen Retail_D90 = 0
- gen Industrial_D90 = 0
- gen Residential_D90 = 0
- gen Office_D90 = 0
- gen Healthcare_D90 = 0
- gen Hotel_D90 = 0
- gen Diversified_D = 0
- replace Retail_D90 = 1 if Retail > 0.9
- replace Industrial_D90 = 1 if Industrial > 0.9
- replace Residential_D90 = 1 if Residential > 0.9
- replace Office_D90 = 1 if Office > 0.9
- replace Healthcare_D90 = 1 if Healthcare > 0.9
- replace Hotel_D90 = 1 if Hotel > 0.9
- replace Diversified_D = 1 if
  Retail_D90+Industrial_D90+Residential_D90+Office_D90+Healthc
  are_D90+Hotel_D90 == 0

- ///Regressions
- //Baseline
- *reg Ar GeoCovid_L1 i.PropType if model_main, vce (cluster
  ISIN_N)

- //Plus controls
- *reg Ar GeoCovid_L1 Dayssinceoutbreak Dayssinceoutbreak_2
  LnGeoPopDen Leverage Cashratio LnSize TQ Q4return Stratowner
  EBITDATA Noncash i.PropType, vce (cluster ISIN_N)

- //Firm FE
```

- *reg Ar GeoCovid_L1 Dayssinceoutbreak Dayssinceoutbreak_2 i.ISIN_N if model_main, vce (cluster ISIN_N)

- //Prop type with dummies
- *reg Ar GeoCovid_L1 c.GeoCovid_L1#Retail_D90 c.GeoCovid_L1#Industrial_D90 c.GeoCovid_L1#Residential_D90 c.GeoCovid_L1#Office_D90 c.GeoCovid_L1#Healthcare_D90 c.GeoCovid_L1#Hotel_D90 Dayssinceoutbreak Dayssinceoutbreak_2 LnGeoPopDen Leverage Cashratio LnSize TQ Q4return Stratowner EBITDATA Noncash if model_main, vce (cluster ISIN_N)

- //Prop type continuous
- *reg Ar GeoCovid_L1 c.GeoCovid_L1#c.Retail c.GeoCovid_L1#c.Industrial c.GeoCovid_L1#c.Residential c.GeoCovid_L1#c.Office c.GeoCovid_L1#c.Healthcare c.GeoCovid_L1#c.Hotel Dayssinceoutbreak Dayssinceoutbreak_2 LnGeoPopDen Leverage Cashratio LnSize TQ Q4return Stratowner EBITDATA Noncash if model_main, vce (cluster ISIN_N)

- //Oxford Indices
- *reg Ar GeoCovid_L1 Stringency c.GeoCovid_L1#c.Stringency Dayssinceoutbreak Dayssinceoutbreak_2 LnGeoPopDen Leverage Cashratio LnSize TQ Q4return Stratowner EBITDATA Noncash i.PropType if model_main, vce (cluster ISIN_N)
- *reg Ar GeoCovid_L1 ContainHealth c.GeoCovid_L1#c.ContainHealth Dayssinceoutbreak Dayssinceoutbreak_2 LnGeoPopDen Leverage Cashratio LnSize TQ Q4return Stratowner EBITDATA Noncash i.PropType if model_main, vce (cluster ISIN_N)
- *reg Ar GeoCovid_L1 EconSup c.GeoCovid_L1#c.EconSup Dayssinceoutbreak Dayssinceoutbreak_2 LnGeoPopDen Leverage

```
  Cashratio LnSize TQ Q4return Stratowner EBITDATA Noncash
  i.PropType if model_main, vce (cluster ISIN_N)
- *reg Ar GeoCovid_L1 GovRes c.GeoCovid_L1#c.GovRes
  Dayssinceoutbreak Dayssinceoutbreak_2 LnGeoPopDen Leverage
  Cashratio LnSize TQ Q4return Stratowner EBITDATA Noncash
  i.PropType if model_main, vce (cluster ISIN_N)

- //GeoNPI CoronaNet regressions
- *reg Ar GeoCovid_L1 GeoNPI c.GeoNPI#c.GeoCovid_L1
  Dayssinceoutbreak Dayssinceoutbreak_2 LnGeoPopDen Leverage
  Cashratio LnSize TQ Q4return Stratowner EBITDATA Noncash
  i.PropType, vce (cluster ISIN_N)

- //Opening regressions
- *reg Ar GeoCovid_L1 GeoReopen c.GeoReopen#c.GeoCovid_L1
  Dayssinceoutbreak Dayssinceoutbreak_2 LnGeoPopDen Leverage
  Cashratio LnSize TQ Q4return Stratowner EBITDATA Noncash
  i.PropType, vce (cluster ISIN_N)
- *reg Ar GeoNetNPI c.GeoNetNPI#c.GeoCovid_L1 GeoCovid_L1
  Dayssinceoutbreak Dayssinceoutbreak_2 LnGeoPopDen Leverage
  Cashratio LnSize TQ Q4return Stratowner EBITDATA Noncash
  i.PropType, vce (cluster ISIN_N)

- ///Summary stats
- *sum Ar Car2 Car3 GeoCovid_L1 Dayssinceoutbreak GeoNPI
  GeoReopen GeoNetNPI GeoPopDen Stringency GovRes
  ContainHealth EconSup Residential Office Retail Hotel
  Healthcare Industrial TotalAssets Q4return EBITDATA TQ
  Leverage Cashratio Stratowner Noncash

- ///Regression draft
- *reg Ar GeoCovid_L1 if Date > td(20-1-2020) & Date < td(1-8-
  2020), vce(cluster ISIN_N)
```

- *reg Ar GeoCovid_L1 Hotel Residential Retail Office Industrial Healthcare, vce(cluster ISIN_N)
- *reg reg Ar GeoCovid_L1 Dayssinceoutbreak Dayssinceoutbreak_2 LnGeoPopDen Leverage Cashratio LnSize TQ Q4return Stratowner EBITDATA Noncash i.PropType, vce(cluster ISIN_N)

- ///important commands
- //time periods
- *if Date < td(1-8-2020)
- *gen in_model_x = e(sample)
- *if in_model_x *optional: ==1*
- //supressing intercept for dummy regressions
- *reg, noconstant
- //detail time invariant vars by keeping only 1 ob per id
- *preserve
- *bysort ISIN_N: keep if _n==1
- *restore
- *asdoc sum

- ///regression assumptions
- *-->normality of residuals:
- *predict r, resid
- *kdensity r, normal
- *pnorm r
- *qnorm r
- *iqr r
- *swilk r
- *Central limit theory should apply N>30
- *estat ovtest --> model specification
- *estat dwatson --> autocorrelation (not neededed, clustered st errors at firm level)

- *estat imtest, White *or estat hettest* --> heteroskedasticity
- *estat vif --> multicollinearity
- *vce(cluster clustvar)

- ///installs
- *ssc install extremes
- *ssc install winsor2
- *ssc install outreg2
- *ssc install estout
- *ssc install logout
- *ssc install asdoc

- ///old property type dummy setup
- *gen Retail_D90 = 0
- *gen Industrial_D90 = 0
- *gen Residential_D90 = 0
- *gen Office_D90 = 0
- *gen Healthcare_D90 = 0
- *gen Hotel_D90 = 0
- *gen Diversified_D = 0
- *replace Retail_D90 = 1 if Retail > 0.9
- *replace Industrial_D90 = 1 if Industrial > 0.9
- *replace Residential_D90 = 1 if Residential > 0.9
- *replace Office_D90 = 1 if Office > 0.9
- *replace Healthcare_D90 = 1 if Healthcare > 0.9
- *replace Hotel_D90 = 1 if Hotel > 0.9
- *replace Diversified_D = 1 if Retail_D90+Industrial_D90+Residential_D90+Office_D90+Healthcare_D90+Hotel_D90 == 0
- *gen PropType = 0
- *replace PropType = 1 if Retail_D90 == 1

```
- *replace PropType = 2 if Industrial_D90 == 1
- *replace PropType = 3 if Residential_D90 == 1
- *replace PropType = 4 if Office_D90 == 1
- *replace PropType = 5 if Healthcare_D90 == 1
- *replace PropType = 6 if Hotel_D90 == 1
- *label define proplabel 0 "Diversified" 1 "Retail" 2
  "Industrial" 3 "Residential" 4 "Office" 5 "Healthcare" 6
  "Hotel"
- *label values PropType proplabel

  - *//Getting outputs
- *outreg2 using regressionx.txt, replace
- *seeout
- *estpost correlate Ar GeoCovid_L1 Dayssinceoutbreak
  LnGeoPopDen Leverage Cashratio LnSize TQ Q4return Stratowner
  EBITDATA Noncash if model_main == 1, matrix listwise
- *est store c1
- *esttab using correlationx.rtf, unstack not noobs compress

- *estat sum
```