Granular Property Shocks and Commercial Real Estate Returns

David C. Ling
University of Florida
david.ling@warrington.ufl.edu

Chongyu Wang
University of Hong Kong
chw12010@hku.hk

Tingyu Zhou
College of Business, Florida State University
tzhou@business.fsu.edu

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Abstract

The relation between private and public commercial real estate (CRE) returns has been studied extensively. The existing studies focus on the return correlation between private and public markets or the ability of one market to predict returns in the other. However, no prior study has established a causal relation between returns in these parallel CRE markets. We construct a new measure of idiosyncratic shocks to private real estate markets, granular property shocks (GPS). We show that this unexpected return risk in local property markets is subsequently capitalized into the prices of listed CRE companies. To establish causality, we adopt the Granular Instrumental Variable (GIV) approach recently developed by Gabaix and Koijen (2020, 2021). This approach allows us to isolate exogenous variation in the performance of the local markets in which a CRE manager invests that is independent of firm-manager factors. Our results suggest that idiosyncratic shocks from granular, private CRE markets, instrumented by the GIV, have a large and significant effect on listed REIT returns. Specifically, a one-standard-deviation increase in GPS predicts a 1.34% rise in quarterly REIT returns, which is 40% of its mean value.

Keywords: Commercial real estate (CRE) returns, granular property shocks, granular instrumental variable, REITs, gateway markets

JEL classification: G11, G12, D82, R11

1. Introduction

The relation between private and public commercial real estate (CRE) returns has been studied extensively (e.g., Riddiough, Moriarty and Yeatman 2005; Pagliari, Scherer and Monopoli, 2005; Horrigan, Case, Geltner, and Pollakowski, 2009; Boudry, Coulson, Kallberg and Liu, 2013; Yunus, Hansz and Kennedy 2012; Muhlhofer, 2013; Ling and Naranjo, 2015). The consensus is that predictability runs from public markets to private markets at the index level (e.g., Nelling and Gyourko, 1998; Ling, Naranjo and Ryngaert, 2000). In contrast, a recent study by Ling, Wang and Zhou (2021) shows that, at the firm-level, equity REIT returns follow the returns of the underlying direct property market; that is, predictability runs from private markets to public markets. However, to the best of our knowledge, none of these studies establishes a causal relationship between returns in these parallel CRE markets. The objective of this paper is to fill this gap in the literature.

If property portfolios are evenly dispersed across geographies, the overall return performance of the portfolio should not be affected by idiosyncratic shocks to individual markets because allocations to each market would be small relative to the overall size of the property portfolio. However, when the geographic distribution of property portfolios is fat-tailed, shocks to large, non-atomistic property markets may generate non-diversifiable "grains." When aggregating across markets, these "granular" property shocks can directly affect the performance of CRE portfolios that consist of geographically concentrated assets. Our empirical strategy makes use of the fact that the property portfolios of most equity real estate investment trusts (REITs) are geographically concentrated. For example, a typical equity REIT invests 53% of its assets in its top-three metropolitan statistical areas (MSAs). Building on the concept of "granularity" introduced by (Gabaix, 1999, 2011), this paper investigates how idiosyncratic shocks in individual, private property markets propagate to the portfolio level and cause movements in asset values and returns in the public market.

To measure granular CRE risk in private CRE markets, we first regress quarterly NCREIF NPI returns at the MSA level on measures of MSA market fundamentals and MSA and time fixed effects. The residuals obtained from these MSA-level regressions capture the quarterly idiosyncratic return risk in each U.S. MSA. Next, we aggregate the estimated MSA-level return residuals to the firm level using the percentage of the REIT's portfolio invested in each MSA in quarter t as weights. Our test variable, granular property shocks (GPS), therefore captures geographically weighted property portfolio risk in the private CRE markets in which the REIT is invested. We then test whether these granular property shocks predict REIT returns by running OLS regressions with time-varying firm characteristics, firm (or property-type) fixed effects, and time fixed effects. We find that unexpected return risk in local property markets is capitalized into the prices of listed CRE companies.

To establish a causal relationship between GPS and REIT returns, we adopt the Granular Instrumental Variable (GIV) approach recently developed by Gabaix and Koijen (2020, 2021). We exploit the fat tail properties of the distribution of CRE portfolio allocations across locations by extracting the variation in the share-weighted aggregated property market shocks that can be attributed to large, "granular" markets. More specifically, the GIV is the difference between share-weighted and unweighted aggregated property market shocks. Conditional on the distribution of market shares being fat-tailed, idiosyncratic shocks to MSAs allow us to remove any firm-year effects from REIT returns. This "isolation" of the exogenous variation in the performance of local markets that is independent of firm-manager factors allows us to achieve identification. Consistent with this interpretation, GIV satisfied both the relevance and exogeneity assumptions. Our results suggest that idiosyncratic shocks from private CRE markets, instrumented by the GIV, have a large and significant effect on listed REIT returns. The economic magnitude of the effect is large: a one-standard-deviation shock to GPS is associated with a change in REIT returns of 1.34%, which is 40% of its mean value.

We then show that the private-to-public link we document is not contaminated by the liquidity of local property markets. We also find that the relation is driven mainly by negative return shocks to private markets, by shocks to large ("gateway") markets, and by shocks to price appreciation (not operating incomes) in the MSAs in which the REIT is invested. Lastly, we conduct robustness tests using alternative measures of GPS based on property-type specific NCREIF NPI sub-indices. We also investigate the effects of including lagged MSA-level NCREIF NPI returns in our first-stage private market return model to mitigate the lagging and smoothing concerns associated with NCREIF NPI returns. We also construct alternative measures of GIV based on principal component analysis (PCA) and provide evidence that our results are not driven by a particular subperiod.

Our paper contributes to several literatures. First, we are the first to establish a causal relation between the idiosyncratic risks of granular property markets and portfolio level CRE returns. In contrast, most existing studies focus on the correlation or co-movements between private and public markets or the ability of one market to predict returns in the other (e.g., Riddiough, Moriarty and Yeatman 2005; Pagliari, Scherer and Monopoli, 2005; Horrigan, Case, Geltner and Pollakowski, 2009; Boudry, Coulson, Kallberg and Liu, 2013; Yunus, Hansz and Kennedy 2012; Muhlhofer, 2013; Ling and Naranjo, 2015; Cohen, Ling, Naranjo and Wang, 2021; Ling, Wang, and Zhou, 2021).

Second, since Gabaix's (1999, 2011) seminal work, a growing literature has investigated the "granular" origins of aggregate fluctuations in a variety of contexts. Examples include business cycles (Carvalho and Grassi, 2019), institutional ownership (Ben-David, Franzoni, Moussawi and Sedunov 2021), and bank credit risk (Galaasen, Jamilov, Juelsrud and Rey, 2021). We are the first to establish that, given that the distribution of geographic property weights is fat-tailed, idiosyncratic shocks to the granular property markets in which REITs invest cause movements in CRE portfolio returns.

To the best of our knowledge, no study in the real estate literature examines the granular nature of geographic asset allocations except Dombrowski, Narayanan and Pace (2020) who show that the rank-size relationship exists in the CRE industry.[1] They also demonstrate how large concentrations in these assets can impact the ability to diversify a portfolio. Dombrowski, Narayanan and Pace (2020) focus on how portfolio concentrations affect the *risk* of holding CRE assets; in contrast, we focus on how high concentrations in local markets affect CRE *returns* in the capital market.

Lastly, our paper is related to the large literature on portfolio diversification, which includes both the portfolio weights (i.e., concentration) and the variance-covariance matrix of the returns (i.e., correlation). Hayunga and Pace (2010) suggest that CRE portfolio returns exhibit statistically significant spatial correlations at close distances. Importantly, there are simply not enough qualifying properties to hold, making a strategy of equally-weighted portfolios macro-inconsistent. Why investors choose to hold geographically concentrated

[1] The rank-size rule is an empirical rule for the size and rank order. One of the most well-known examples is a log-linear relationship between urban sizes and the rank of urban sizes (Zipf, 1949).

portfolios is beyond the scope of this paper.[2] Instead, we take the documented power-law distribution in the literature as given and focus on the causal impact of granular property shocks on CRE returns. Our instrumental approach controls for the potential endogeneity of asset allocation decisions and firm-manager characteristics.

2. Empirical Strategy

2.1 Granular Property Shocks (GPS) and REIT Returns

To extract idiosyncratic shocks to property market z in time t, we estimate the following regression:

$$NCREIF_{zt} = \boldsymbol{\beta}' \boldsymbol{X_{zt}} + \gamma_z + \delta_t + \varepsilon_{zt} \qquad (1)$$

where $NCREIF_{zt}$ is the aggregate NCREIF NPI total return for MSA z in time t,[3] γ_z is a vector of MSA fixed effects and δ_t is a vector of time (quarterly) fixed effects. X_{zt} includes time-varying controls for market fundamentals that vary across MSAs and over time (e.g., Cotter, Gabriel and Roll, 2015; Ghent, 2021).[4] We are primarily interested in the estimated residuals from equation (1), $\hat{\varepsilon}_{zt}$, which captures unexpected, idiosyncratic shocks to individual MSA returns. These shocks could include unexpected changes in local demand and supply conditions, natural disasters, and unanticipated relocations of corporate headquarters. This approach is similar to prior studies that extract idiosyncratic shocks in labor and other markets (e.g., Foster, Haltiwanger and Syverson, 2008; Hsieh and Klenow, 2009; di Giovanni,

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[2] Locally concentrated investment has been a long-standing puzzle in financial economics and stands in contrast to the prescription of standard portfolio theory (Sharpe, 1964). Two competing explanations for the high level of local investment (i.e., "home bias") are found in the literature. The first is that proximity provides a persistent information advantage to local investors due to costly information (e.g., Van Nieuwerburgh and Veldkamp, 2009). Locally concentrated investment does not necessarily lead to higher portfolio returns if investment allocation and selection decisions are based on a familiarity bias, rather than relevant information (Huberman, 2001; Seasholes and Zhu, 2010; Pool, Stoffman and Yonker, 2012).

[3] Established in 1982, NCREIF is a not-for-profit institutional real estate industry association that collects, processes, validates, and disseminates information on the risk/return characteristics of commercial real estate assets owned by institutional (primarily pension and endowment fund) investors. NCREIF's flagship index, the NCREIF Property Index (NPI), tracks property-level returns on a large pool of commercial real estate assets acquired in the private market for investment purposes only. The property composition of the NPI changes quarterly as data contributing NCREIF members buy and sell properties. However, all historical property-level data remain in the database and index.

[4] We also perform tests using property-type specific MSA sub-indices in this first-stage regression, which are discussed in section 4.3.

Levchenko and Mejean, 2014; Blackwood, Foster, Grim, Haltiwanger and Wolf, 2021; Fagereng, Guiso and Pistaferri, 2018).[5]

Next, we aggregate the estimated idiosyncratic property market shocks obtained from equation (1) to the firm level by weighting MSA-level shocks by the percentage allocations of each REIT to each MSA at the beginning of each quarter as follows:[6]

$$\bar{\varepsilon}_{it} = \sum_{z \in Z_i} s_{izt} \hat{\varepsilon}_{izt}. \quad (2)$$

where s_{izt} is the percentage of firm i's property portfolio in MSA z in time t and $\hat{\varepsilon}_{izt}$ is the estimated MSA return residual from equation (1). We refer to $\bar{\varepsilon}_{it}$ as the firm's exposure to "granular property shocks" (GPS) at time t because it captures weighted shocks to a CRE firm's underlying property markets that are not diversified away at the firm level. Therefore, we expect GPS to affect firm-level outcomes.

To investigate this potential relationship, we estimate the following OLS regression:

$$R_{it} = \beta \bar{\varepsilon}_{it} + \alpha_i + \gamma_t + \boldsymbol{\delta}'\boldsymbol{X} + \epsilon_{it} \quad (3)$$

where R_{it} is the stock return of firm i at time t in excess of risk-free rate, $\bar{\varepsilon}_{it}$ is the firm-specific granular property shock estimated from equation (2), α_i are firm fixed effects, and γ_t are time fixed effects. The vector $\boldsymbol{X}$ includes determinants of REIT returns identified in the prior literature (e.g., Bond and Xue, 2017; Letdin, Sirmans, Sirmans and Zietz, 2019; Ling, Wang and Zhou, 2021). Because the test variable, $\bar{\varepsilon}_{it}$, is estimated, standard errors are corrected with a bootstrapping procedure.

2.2 Granular Instrumental Variable (GIV)

Regressing firm-level returns on granular property shocks ($\bar{\varepsilon}_{it}$) may result in a biased estimate of β if unobserved firm characteristics are correlated with $\bar{\varepsilon}_{it}$. To demonstrate this, we rewrite equation (3) as:

$$R_{it} = \beta \sum_{z \in Z_i} s_{izt} \varepsilon_{zt} + \alpha_i + \gamma_t + \boldsymbol{\delta}'\boldsymbol{X} + v_{it} \quad (3)'$$

[5] In robustness tests, we also perform a principal component analysis (PCA) using a richer version of equation (1) that allows time-varying coefficient estimates. We then extract residuals orthogonalized to a maximum two parametric components and reconstruct GPS. These results are discussed in Section 4.3.

[6] The MSA weights are based on the book value of the firm's assets. The U.S. S&P Global Real Estate database reports the book value of assets at the end of each calendar year. Thus, our MSA portfolio weights remain constant throughout the four quarters of each year.

Suppose ε_{izt} in equation (2) can be written as

$$\varepsilon_{izt} = \vartheta_i v_{it} + u_{izt} \quad (4)$$

where ϑ_i is the firm loading and u_{izt} is firm-MSA-level idiosyncratic risk. Then $corr\left(\sum_{z\in Z_i} s_{izt}\varepsilon_{izt}, v_{it}\right) = corr\left(\sum_{z\in Z_i} s_{izt}(\vartheta_i v_{it} + u_{izt}), v_{it}\right) \neq 0$, and β is biased.

To mitigate this potential bias, we adopt the "granular instrumental variable" (GIV) approach developed by Gabaix and Koijen (2021). GIV is constructed to remove v_{it} by using the following equation:

$$GIV_{it} = \sum_z s_{izt}\varepsilon_{izt} - \sum_z \tfrac{1}{N_i}\varepsilon_{izt} = \sum_z s_{izt}u_{izt} - \sum_z \tfrac{1}{N_i}u_{izt} \quad (5)$$

where $\sum_z s_{izt}\varepsilon_{izt}$ is the sum of idiosyncratic private market return shocks weighted by portfolio allocations to each MSA and $\sum_z \frac{1}{N_i}\varepsilon_{izt}$ represents the sum of equally-weighted private market return shocks. In equation (5), firm-by-year factors, such as shocks to the firm's cost of operating, v_{it}, are removed. $\sum_z s_{izt}u_{zt} - \sum_z \frac{1}{N_i}u_{zt}$ therefore contains only idiosyncratic risk. GIV is the time-varying difference between geographically-weighted firm shocks and equally-weighted firm shocks aggregated to the firm level. By construction, GIV overweighs shocks to markets in which the REIT has relatively large allocations and its variation comes from a few "granular" markets. If there is no granularity, i.e., all MSA risk exposures have similar effects on firm-level returns, there is no cross-firm variation in GIV.

Finally, we replace $\bar{\varepsilon}_{it}$ in equation (3) with $\bar{u}_{it}$ and estimate the following second-stage regression of the two-stage least square (2SLS) analysis:

$$R_{it} = \beta\bar{u}_{it} + \alpha_i + \gamma_t + \boldsymbol{\delta}'\boldsymbol{X} + v_{it} \quad (3)"$$

where $\bar{u}_{it}$ is the fitted value from the first-stage regression of the endogenous covariate $\bar{\varepsilon}_{it}$ on GIV_{it}. The identification assumption is that $s_{izt}u_{izt}$ is uncorrelated with v_{it} (the exclusion assumption). Formally, for all i and t, $\sum_z^Z E[s_{izt}u_{zt}v_{it}] = 0$. This is a plausible assumption given that u_{izt} is mechanically constructed to be orthogonal to firm factors. In robustness tests, we allow this factor to vary across firms by adding the firm's property-type focus and other firm characteristics to equation (4).

3. Sample Construction

We first identify the 284 equity REITs that were listed on NYSE, Nasdaq, or AMEX during 2003-2018 from CRSP-Ziman database. Observations are deleted if any of the following information is missing: firm ID (PERMNO), stock return, price, the REIT's property type and sub-type focus, and market capitalization. Next, we augment this firm-level data using the S&P Global Real Estate database. This database includes detailed information on REIT-owned properties, including property owner, property type and sub-type, MSA (state) location, acquisition date, sale date, and the time-varying book value of each property.[7]

MSA-level macroeconomic data (e.g., gross metropolitan product, GMP) first became available in 2001 and thus dictates the beginning of our sample period. We further identify 100 equity REITs that primarily invest in property types other than residential, office, industrial, and retail because the NCREIF NPI does not track returns on these "non-core" property types. Our initial sample contains 258,658 property-year observations for 118 unique core REITs spanning 16 years from 2003 to 2018. As a robustness check, a full sample of REITs (including those with a non-core property type focus) is also included in selected regressions.

To estimate our key test variable, granular property shocks (GPS), we first calculate the percentage of a firm's property holdings in each MSA at the end of each year. These percentages remain constant for the following calendar year. We then link these percentages to quarterly NCREIF NPI return data for each MSA. We first use aggregate MSA-level NPI returns, which are a value-weighted average of quarterly returns for the four core property types and hospitality.[8] We require non-missing MSA-level data for the following NCREIF variables: total quarterly return (*NCREIF*), the estimated market value of NCREIF NPI properties at the beginning of the quarter (*PropSize*), and the turnover of NCREIF NPI properties during the quarter. Turnover (*PropTO*) equals the total dollar value NCREIF NPI properties in the MSA that were sold during the quarter divided by the beginning of quarter market value of all properties in the MSA. We collect MSA-level economic activity data from

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[7] In June of 2003, the U. S. Office of Management and Budget adopted new standards for Metropolitan Areas (OBM-https://www.whitehouse.gov/omb/inforeg_statpolicy#ms). A metropolitan statistical area (MSA) has at least one urbanized area with a population of at least 50,000, based on the 2000 Census. As of June 6, 2003, the OMB has defined a total of 362 Metropolitan Statistical Areas containing approximately 83% of the US population.

[8] We show later that our findings are robust to using property-type specific MSA return indices in Section 4.3.

various sources. The yearly percentage change in the gross metropolitan product (GMP) and personal income are from the Bureau of Economic Analysis (BEA) website. Unemployment rates are from the Bureau of Labor Statistics (BLS) website. We use the average monthly unemployment rate over the prior quarter in our predictive model of *NCREIF*. We also include the number of listed firms headquartered in each MSA in the prior quarter (Compustat) and the lagged total stock market capitalization of these firms.

After constructing our time-varying, firm-level, measures of GPS, we turn to the predictors of equity REIT returns used to estimate our second-stage regression (equation (3)). *Momentum* equals a firm's cumulative return over the prior quarter, *ILLIQ* is the logarithm of the prior quarter's Amihud (2002) illiquidity measure,[9] and *IVOL* is the idiosyncratic volatility of the stock price in the prior quarter. Using accounting information from Compustat, we calculate *Size* as the logarithm of a firm's book value of total assets and *B/M* as the ratio of book equity to market equity. *Profitability* is defined as annual revenues minus the sum of cost of goods sold, interest expense, and selling, general, and administrative expenses. This dollar measure of profitability is divided by the book value of equity at the end of the previous fiscal year. *Investment* is the quarterly growth in non-cash assets, and *Leverage* is the ratio of the total book value of debt to the book value of total assets. These predictors of REIT returns are measured at the end of the quarter prior to when returns are measured. Our final dataset contains 3,423 firm-quarter return observations for 109 core REITs. See Appendix 1 for variable descriptions.

4. Results

4.1 Summary Statistics

Panel A of Table 1 reports summary statistics for several MSA-level NCREIF NPI returns and measures of market fundamentals. Panel B summarizes the key variables used in our firm-level return analysis. All variables are constructed at a quarterly frequency. The mean quarterly return of the national NCREIF NPI index is 2.07% with a standard deviation of 2.74%. On average, 1.54% of this 2.07% total return comes from quarterly price appreciation: the remaining 0.55% from operating income. Yearly growth in MSA GMP

[9] Amihud (2002) defines illiquidity as the daily volume price impact of trading during year *t*.

averaged 3.96% over our sample period while MSA income grew at an average rate of 4.29%. On average, 2% of the properties in the NCREIF NPI database were sold each quarter. The mean quarterly return for the REITs in our sample is 3.27% with a standard deviation of 16.55 %. The mean REIT allocation to a MSA, as a percentage of a REIT's overall portfolio (*PropSHR*), is 0.073%. However, the median is only 0.028%; thus, the MSA allocations of REITs are highly skewed. In Figure 1, we plot the density of *PropSHR* for a cross-section of MSAs pooled across all firms as of the end of our sample period. The positive-skewed distribution (with a long right tail) suggests that REIT allocations to most MSAs proxied by *PropSHR* are very small, if not negligible, relative to the overall size of the property portfolio. This figure reveals that portfolio allocations for an average REIT in our sample are concentrated in relatively few MSAs, supporting the "granular" nature of CRE portfolios.

Moving from firm-MSA-level property shares (*PropSHR*) to our firm-level variable, *GPS*, we still observe a highly positively skewed distribution with a median (-0.022%), which is much smaller than the mean (-0.012%). Figure 2 displays *GPS*'s skewed distribution, which has a larger mass in the left tail, and the standard deviation of *GPS* is much larger than the mean. Figure 3 presents a heatmap of *GPS* at the MSA level as of the end of our sample period. The geographic patterns are depicted in terms of quintiles. The substantial variations across markets provide further support for the importance of a few, large markets for the typical REIT. The summary statistics for the controls used in our analysis of firm-level REIT returns are similar to those reported in other studies (e.g., Ling, Wang and Zhou, 2021; Bond and Xue, 2017; Letdin, Sirmans and Sirmans, 2019).

4.2 Baseline Results

Table 2 presents our first-stage results estimated using equation (1). The purpose of this estimation is to obtain estimates of idiosyncratic shocks to private real estate markets. The dependent variable for the results reported in column (1) is the NCREIF NPI aggregate return (including all four property types) for MSA z in quarter t. In columns (2)-(5) we report the corresponding results for each of the four core property types: industrial, residential, office, and retail. The explanatory variables are lagged one quarter and include our time-varying MSA-level measures of economic activity, including growth in the real gross domestic product (*GMP growth*), income growth (*Inc growth*), the unemployment rate (*Unemp*), the stock market capitalization of listed firms headquartered in the MSA (*$ listed firms*), property turnover (*PropTo*), and market size (*MktSize*). We also include MSA fixed effects to remove persistent return risk at the MSA level and quarter fixed effects to control for macro-level systematic risk.

The coefficient estimates have the expected signs. As reported in column (1), local economic growth, income growth and property turnover (liquidity) positively predict MSA-level private real estate returns at the aggregate level. In contrast, MSAs that contain more NCREIF NPI properties (based on market value) are associated with lower private market returns. Unemployment is weakly negatively related to private market returns. These findings on the drivers of local real estate performance are consistent with prior studies (e.g., Cotter, Gabriel and Roll, 2015, Smajlbegovic, 2019, Ling, Wang and Zhou, 2021, Ghent, 2021).

The number of quarterly return observations available to estimate our regressions for each property type is reduced relative to our aggregate regressions because in some quarters there are not enough properties of a particular property type in the NCREIF NPI database to produce a MSA-level return index. Except for retail properties, local economic and income growth are positively related to quarterly MSA-level returns. The effects of unemployment vary noticeably by type of property whereas property turnover is positively associated with returns in all specifications. Overall, our return model explains less of the variation in retail returns than other property types. Residuals from these estimated models are used to construct time-varying geographically weighted idiosyncratic shocks for each REIT.

It is well known that the quarterly appreciation return calculated by NCREIF for each property in the NCREIF NPI database is not based on a transaction price unless the property happened to be sold in that quarter. Instead, the market value of the property at the end of the quarter is estimated by a third-party fee appraiser or by the owner's asset manager. These "appraisal-based" appreciation returns are thought to produce estimated price appreciation returns that are lagged and smoothed, and this smoothing understates return volatility (see, for example, Geltner, 1993, Geltner and Ling, 2007).

To address this potential concern, we re-estimate our aggregate private market return model after adding a one-quarter lag of the dependent variable to mitigate potential lagging and smoothing in NCREIF NPI returns. These results are reported in column (6) of Table 2. Although the estimated coefficient on lagged *NCREIF* is positive and highly significant, as expected, a comparison of columns (6) and (1) reveals that its inclusion has little impact on the coefficient estimates of the explanatory variables or the adjusted R-squared.

In Table 3, we report the results from our initial investigation of the relation between granular property risk (*GPS*) from the private market and listed REIT returns using panel regressions and firm-quarter return observations. *GPS* is calculated following equation (2) by multiplying the estimated residual, $\hat{\varepsilon}_{zt}$, which captures unexpected, idiosyncratic shocks to private real estate markets in individual MSAs, by the percentage of the REIT's portfolio invested in each MSA.

As a benchmark, we first estimate equation (3) without *GPS*. These results are reported in columns (1)-(4). NCREIF NPI returns are only available for industrial, residential, office, retail, and hospitality properties. We therefore restrict our initial sample to REITs that primarily own and operate the four core property types (excluding hospitality properties).[10] These results are reported in columns (1) through (3). The results displayed in column (1) contain quarter fixed effects but neither firm nor property type (focus) fixed effects. We find that lagged book-to-market, leverage, profitability, and illiquidity are positively and significantly associated with REIT returns in the subsequent quarter, while return momentum and idiosyncratic stock price volatility are negatively related to total returns.[11] The inclusion of a dummy variable that controls for the property type focus of the REIT (column (2)) has little impact on the coefficient estimates or their significance. The inclusion of firm fixed effects in place of property type fixed effects (column (3)) eliminates the significance of leverage and illiquidity; however, the estimated coefficient on investment becomes positive and significant at the 5% level.

In column (4), we report the results obtained using both core and non-core REITs. Time and firm fixed effects are also included. This specification increases the number of firm-quarter observations from 3,423 to 4,269. The estimated coefficient on book-to-market (illiquidity) remains positive (negative) and highly significant, although the statistical significance of momentum, profitability, and investment are reduced in the full sample

[10] The property type focus of each REIT in each quarter, which may vary over time, is obtained from CRSP/Ziman.
[11] In contrast to most research conducted with data prior to the financial credit crisis of 2007-2008, Daniel and Moskowitz (2016) finds that stock return momentum is negatively associated with subsequent returns in the post-crisis period.

estimation. Nevertheless, the results using all REITs are highly consistent with the results for REITs that focus their investments on the four core property types.

In columns (5) through (8), we report results obtained after adding *GPS* to the four specifications. The results using REITs that focus on the four core property types are displayed in columns (5)-(7); the corresponding results using all REITs are reported in column (8). The estimated coefficients on the one-quarter lag of *GPS* are positive and significant at the 1% level in all specifications. Using the model specification in column (7), with both firm and quarter fixed effects, we find that a one-standard-deviation change in *GPS* is associated with an economically meaningful increase in quarterly *RetRf* of 3.3 percentage points (=1.275*2.59). This might be indicative of a causal relation between *GPS* and REIT returns. The estimated coefficients on the control variables are altered little by the inclusion of *GPS* and remain consistent with prior studies. Lagged profitability is positively and significantly associated with REIT returns, while size and idiosyncratic stock price volatility are negatively related to total returns (e.g., Bond and Xue, 2017; Letdin, Sirmans and Sirmans, 2019).

Table 4 displays the results from estimating our 2SLS model following equation (3"). Columns (1-4) contain the results for the exactly identified model in which *IV_GPS* is instrumented with GIV. The first stage results show a strong positive relation between *GPS* and *GIV*, which is our instrumental variable for *GPS* (see panel A of Appendix 2). GIV passes the weak instrument test with an F-statistic of 111 to 144. The results for the 2nd stage regression reveal that *IV_GPS* ($\bar{u}_{it}$ in equation 3") is associated with positive REIT returns in subsequent quarters, which is consistent with our OLS results in Table 3. Based on our preferred specification in column (4), the economic magnitude is large: a one-standard-deviation shock to *IV_GPS* affects REIT returns by 1.34%, about 40% of its mean value (3.27% in Table 1).

Figure 4 supports our identification assumptions discussed in Section 2.2. As shown in Panel A, there is a strong positive correlation between GIV and GPS. In Panel B, GIV does not correlate with idiosyncratic firm risk. Gabaix and Koijen (2021) propose a test for over-identifying restrictions to further evaluate the exogeneity of the GIV. We follow their method by ranking MSAs based on the market value of NCREIF properties in the MSA (*MktSize*). We then sort the MSAs into markets with an even rank (*GIV_even*) and those with an odd rank (*GIV_odd*). For the results reported in columns 5-8 of Table 6, the Hansen J-statistic fails to reject the null that the instrument is exogenous. Importantly, the second stage results are highly consistent with the OLS results, suggesting that idiosyncratic risk from private real estate markets, instrumented by GIV, has a large and statistically significant effect on listed real estate returns. The results are robust to specifications with different sets of fixed effects. In Appendix 3, we show that the results are robust to the use of GMM in place of 2SLS.

4.3 Additional Results

Our results above provide causal evidence that public real estate returns respond to idiosyncratic shocks in the private real estate markets in which a REIT's underlying property portfolio is located. However, prior literature has established a significant correlation in liquidity between the public market and the private market (e.g., Bond and Chang, 2012; Agarwal and Hu, 2014). Downs and Zhu (2019) show that private market liquidity influences the liquidity of publicly-traded REITs.[12] It is, therefore, possible that the link between private and public real estate returns we document is driven, at least in part, by the (il)liquidity in the private market.

To investigate this issue, we construct *GPS_liquidity*, which is calculated by replacing NCREIF NPI returns with NCREIF NPI property turnover in the first step of the analysis (equation (1)). Quarterly property turnover in each MSA is calculated as the transaction value (in dollar terms) of all properties in the NCREIF NPI index that were sold in a quarter divided by the total market value of all properties in the NCREIF NPI database in that MSA at the beginning of the quarter.[13] For each firm quarter, we calculate a geographically weighted average of the estimated residual in each market in which the REIT owns properties. The weights are each firm's portfolio allocation in each MSA. *GPS_liquidity* therefore captures a firm's time-varying exposure to liquidity shocks (instead of return shocks) in the private markets in which it is invested. In the results reported in Table 5, the estimated coefficient on *GPS_liquidity* cannot be distinguished from zero in any model, suggesting that idiosyncratic liquidity shocks from private markets do not explain REIT returns.

[12] Wang, Cohen and Glascock (2018) also find that cross-learning about peer firms' underlying assets helps to explain liquidity commonality among REITs.
[13] If NCREIF NPI turnover cannot be calculated for a MSA in a given quarter, it is calculated at the state level.

In Table 6, we examine the asymmetric effects of granular property shock. We report two sets of specifications: with and without GIV. Columns (1) through (3) present the OLS estimates; columns (4) through (6) contain the GIV-instrumented estimates. The OLS results reported in column (1) reproduce, for comparison, the return results obtained using REITs that invest in core properties with time and property type fixed effects (column (6) in Table 3). Similarly, the IV results reported in column (4) reproduce the results obtained from estimating the exactly identified IV model with time and property type fixed effects (column (4) in Table 4). In columns (2) and (5), we explore positive-only shocks to local property markets; in columns (3) and (6) we condition on negative shocks.[14] The estimated coefficient on *IV_GPS* using OLS is positive and significant at the 1% level for both positive and negative granular return shocks, which indicates that both shocks are associated with lower returns. However, when instrumenting for *GPS*, only negative private market return shocks have a significant (negative) impact on REIT returns. In terms of economic significance, a one standard deviation negative shock to *IV_GPS* lowers REIT returns by 3.07%, which is much larger than the average effect of 1.34%.

Granular shocks to the private market returns in large MSAs are not easily diversified away at the REIT level. Moreover, these larger markets that have historically attracted a disproportionate share of investment capital are thought by some to have investment advantages over the remaining 300-plus MSAs, including increased liquidity and information revelation due to the size and depth of these markets and the amount of market research directed at them. We divide the 362 U.S. metropolitan areas in which a REIT could potentially invest into two categories: (1) gateway markets and (2) non-gateway markets. Industry professionals have long defined the following six metropolitan areas as "gateway" markets: Boston, Chicago, Los Angeles, New York, San Francisco, and Washington, D.C.[15] We include these six markets in our gateway subsample. Using the S&P Global Real Estate Properties database, we assign each property held by each REIT in our sample to gateway and non-gateway markets based on the book value of each property at the beginning of each year. This classification is performed for each REIT at the beginning of each year. We then

[14] First-stage results are presented in Panel B of Appendix 2.
[15] See, for example, Pai and Geltner (2007) and Geltner, Miller, Clayton and Eichholtz (2014).

investigate whether the documented link between *GPS* and REIT returns is more pronounced in gateway markets.

The structure of Table 7 follows that of Table 6 in which we present OLS estimates in columns (1)-(3) and GIV-instrumented estimates in columns (4)-(6). The OLS results in columns (2) and (3) suggest that REIT returns are positively correlated with value-weighted shocks from both gateway and non-gateway markets. GIV-instrumented results confirm a positive causal link between granular shocks in gateway markets and REIT returns (column (5)). However, the results reported in column (6) reveal a negative relation between non-gateway return shocks and REIT returns, although the coefficient estimate is only marginally significant. These results are consistent with prior studies that find that capitalization rates in gateway markets are lower than cap rates in non-gateway markets because a larger portion of the total return in gateway markets is expected to come from future rental growth and price appreciation than in non-gateway markets (e.g., Beracha, Downs and MacKinnon, 2017). Ling, Wang and Zhou (2021) also find that REIT property portfolio returns associated with allocations to gateway markets are more predictive of REIT returns than those produced by allocations to secondary and tertiary markets.

We next examine the channel(s) through which *GPS* drives REIT returns. CRE returns consist of two components: the return from net rental income (net operating income, NOI) and the return from property price appreciation. We therefore decompose the quarterly NCREIF NPI return into an income return component (*NCREIF_INC*) and a price appreciation component (*NCREIF_PRC*). Our summary statistics in Table 1 indicate that the income component represents a significant fraction of NCREIF NPI total returns; on average, 76% (=1.57%/2.07%) of *NCREIF* is derived from *NCREIF_INC*. However, the standard deviation of *NCREIF_PRC* is about 5 times its mean. In contrast, the standard deviation of *NCREIF_INC* is just 20% of its mean. This is because property prices are highly sensitive to unanticipated changes in cap rates and rent growth. In addition, the information available on cap rates and market values is restricted by the infrequency with which comparable properties sell. This suggests that the link between *GPS* and REIT returns should be largely driven by the appreciation component rather than the more predictable income component.

To investigate this issue, we decompose *GPS* into its income and price appreciation components. Specifically, we replace NCREIF NPI total returns in equation (1) with

NCREIF_INC (or *NCREIF_PRC*) and calculate *GPS_INC* (or *GPS_PRC*). The results reported in Table 8 are consistent with the price appreciation story. Although all the OLS coefficient estimates are positively and highly significant, only *GPS_PRC* explains REIT returns after instrumenting using GIV.

Lastly, we conduct a battery of robustness tests and summarize the results in Table 9. First, the aggregate NCREIF NPI return index for each MSA may conceal return variation among residential, office, industrial, and retail properties. We therefore construct *GPS* (and *IV_GPS*) using property type specific NCREIF NPI sub-indices. For example, for industrial REITs we construct *GPS* using the NCREIF NPI Industrial return index for each MSA in the estimation of equation (1). In column (1) of Table 9, we report the 2SLS coefficient estimates of GIV using our preferred model specification (with quarter and firm fixed effects). The estimated coefficient on *GPS* using this refined model of MSA-level private market returns is 0.594, which is significant at the 5% level.

In column (2), we address the lagging and smoothing concern about NCREIF NPI returns. We re-estimate GPS using a model that contains the lagged NPI MSA return as an additional explanatory variable (see column (6) of Table 2) and find robust results. In column (3), we examine the stability of our results by estimating a richer, more flexible model specification of equation (4). Specifically, we add the firm's property-type focus to allow factor loadings to vary across property types and re-estimate GPS. The results are highly consistent.

Although the estimated private market return residual is orthogonal to a range of time-varying MSA characteristics and fixed effects, it may still contain unobserved common components across property markets. To mitigate this concern, we follow Gabaix and Koijen (2021) and perform a principal component analysis (PCA) on the residuals obtained from estimating a richer version of equation (1) with time-varying MSA-specific regressors. Next, we obtain residuals with respect to a maximum of two parametric common components. Then, we re-construct GPS (or *IV_GPS)* and GIV using the orthogonalized residuals. In column (4), we include the newly estimated GPS as well as the two GPS based on the orthogonalized residuals as additional controls. Again, the estimated coefficient on GPS is statistically significant and quantitatively similar to our baseline results.

Finally, we check if our results are driven by the crisis period. In the results displayed in column (5) of Table 9, we include a dummy variable, *Crisis*, to control for the Great

Recession (2017Q1 – 2019Q2, as defined by NBER). We find that *GPS* affects REIT returns in both the crisis and non-crisis periods; however, the effects of granular return shocks are larger in the crisis period.

5. Conclusion

A large literature exists on the extent to which returns in the listed commercial real estate (CRE) market predict returns in private CRE markets. Using index-level data, these studies find that returns on equity real estate investment trusts (REITs) predict returns in the parallel private CRE market; however, the reverse is not true. This "public predicts private" result found in time-series studies is generally attributed to imperfections in the private CRE market, including a lack of liquidity and price revelation, that are exacerbated by the use of aggregate national indices based on lagged and smoothed estimates of price appreciation among the constituent properties. In contrast to the "public predicts private" result documented in the time-series, index-level studies, Ling, Wang, and Zhou (2021) find a "private predicts public" result in a cross-sectional, firm-level, context using a geographically weighted proxy for the quarterly performance of the local markets in which a REIT is invested. However, Ling, Wang and Zhou (2021) do not establish a causal relationship between returns in private markets and firm-level REIT returns. This paper provides such evidence by adding a novel "private causes public" result to the literature.

If the property portfolios of listed CRE firms are evenly dispersed across geographies, the overall return performance of the portfolio should not be affected by idiosyncratic shocks to individual markets. However, when the geographic distribution of property portfolios is heavily tilted toward just a few markets (MSAs), shocks to one or more of these markets may generate non-diversifiable "grains." When aggregating across markets, these "granular" property shocks can directly affect the return performance of listed REITs. In addition to being publicly-traded, equity REITs provide a suitable testing environment for our private predicts public hypothesis because the property portfolios of most equity REITs are geographically concentrated.

We first construct a new measure of idiosyncratic shocks to private real estate markets, granular property shocks (GPS). We show that this unexpected return risk in local property markets is subsequently capitalized into the prices of listed CRE companies. To establish a causal relationship between granular property shocks in the local markets in which a REIT is invested and REIT returns, we adopt the Granular Instrumental Variable (GIV) approach recently developed by Gabaix and Koijen (2020, 2021). This approach allows us to achieve identification by isolating the exogenous variation in the geographically weighted performance of the local markets in which a REIT is invested from firm-manager factors. Our results suggest that idiosyncratic shocks from private CRE markets have a large and economically significant effect on listed REIT returns: a one-standard-deviation shock to our instrumented granular shock is associated with a change in REIT returns of 1.34%, which is 40% of its mean value.

We then show that the private causes public result we document is not driven by the liquidity of local property markets that is correlated with private market returns. We also provide evidence that the private causes public relation is driven mainly by negative return shocks to the private markets in which REITs invest, by shocks to the large ("gateway") markets in which they are invested, and by shocks to price appreciation (not operating incomes) in the MSAs in which the REIT is invested. We conduct robustness tests using alternative measures of idiosyncratic shocks to local private markets based on property-type specific NCREIF NPI sub-indices. We also construct alternative measures of our instrumented granular shock variable based on principal component analysis (PCA) as well as providing evidence that our results are not driven by a particular subperiod.

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Figure 1: Distribution of REIT Property Shares

This figure depicts the distribution of REIT property shares for the period from 2003 to 2018. Property share is defined as the proportion of a REIT portfolio that is allocated to a particular MSA in a given year. The figure plots the pooled property shares for all REITs, MSAs, and years.

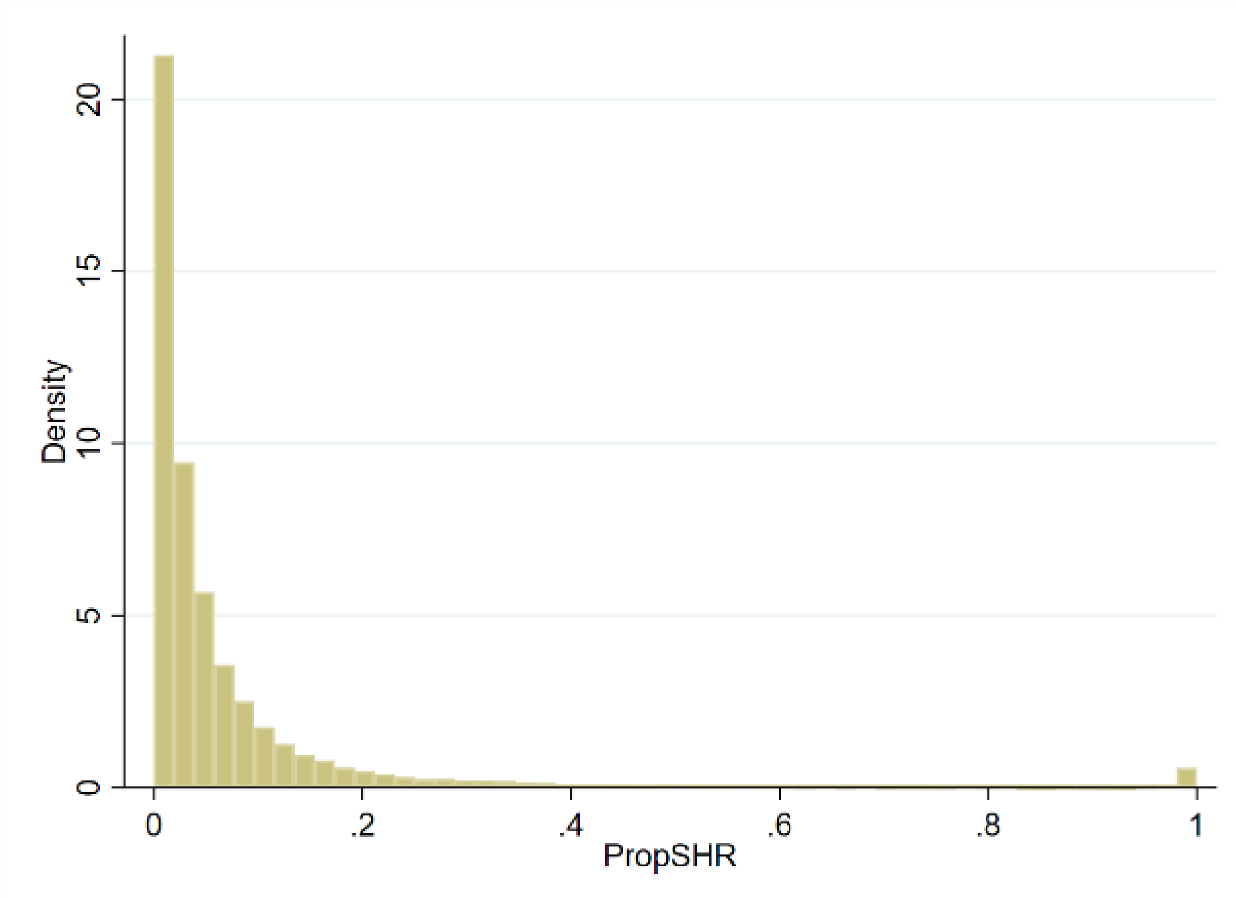


Figure 2: Distribution of Granular Property Shocks (GPS)

This figure shows the pooled distribution of geographic property shock (i.e. GPS) estimated from equation (1).

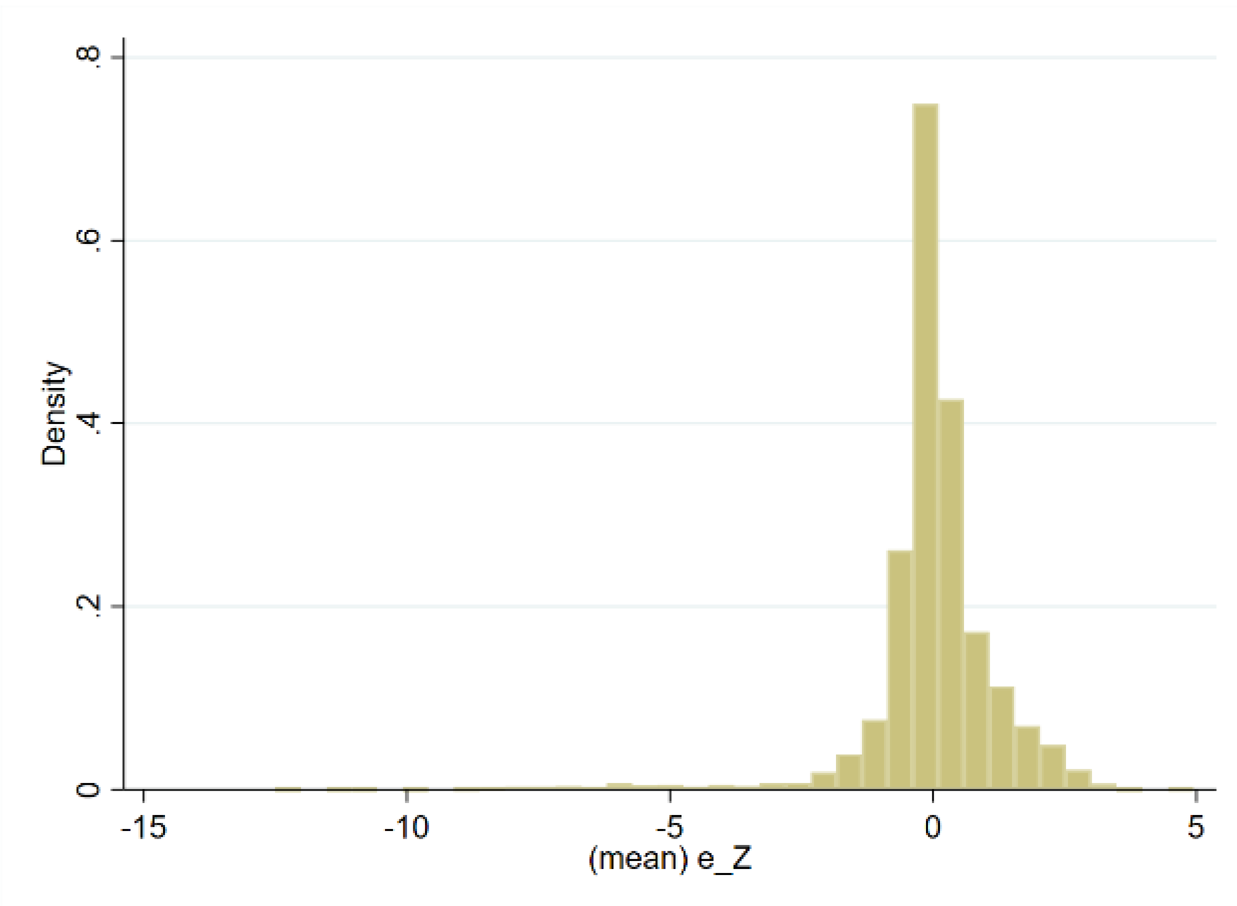


Figure 3: Geographic Dispersion in Granular Property Shocks

This figure plots the geographic distribution of GPS as of the end of our sample period.

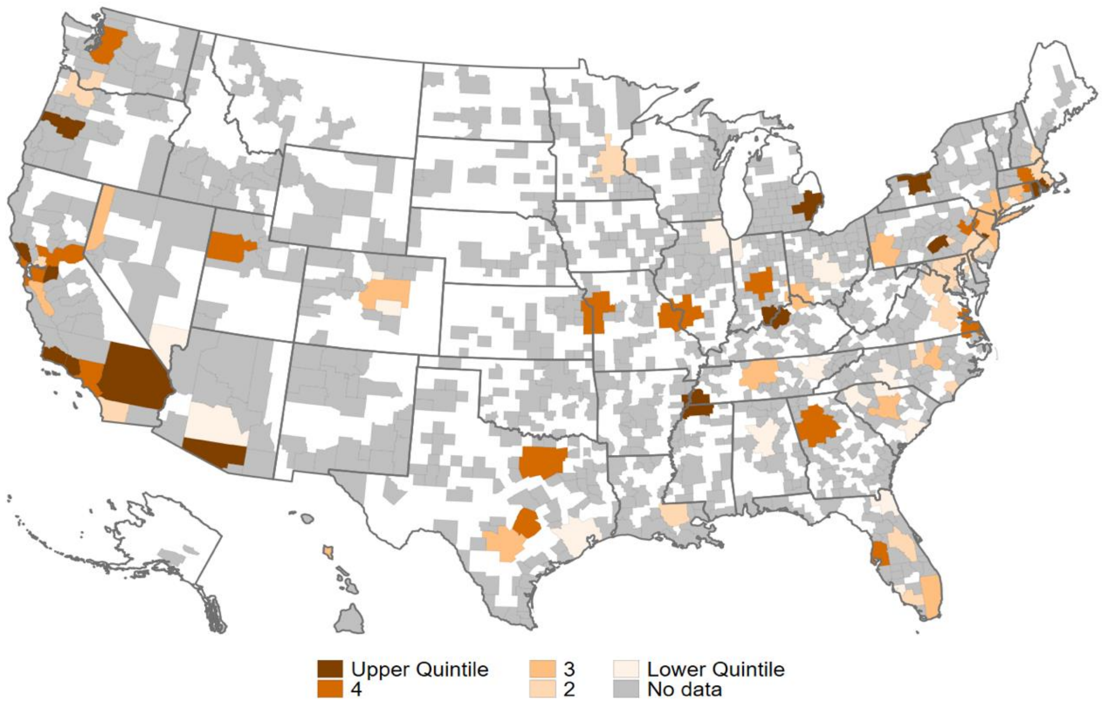
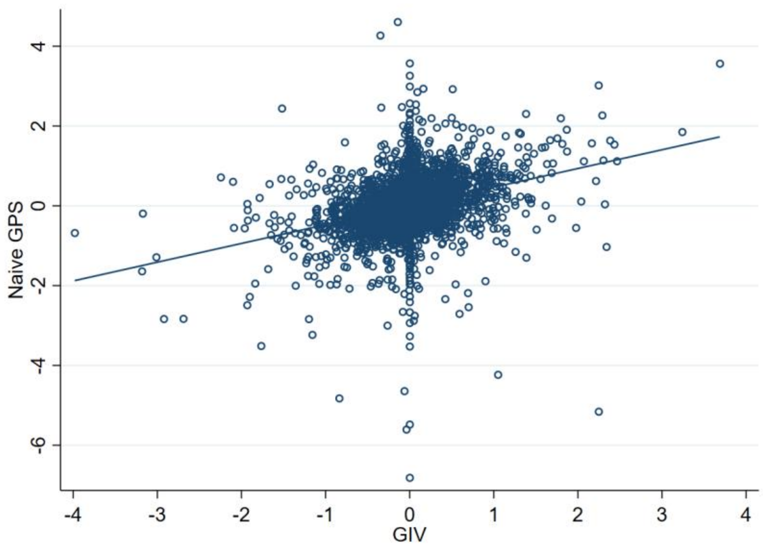


Figure 4: IV Validation

Panel A plots the correlation between GIV and Naïve GPS. Panel B plots the correlation between GIV and idiosyncratic firm risk.

Panel A: First-stage correlation



Panel B: Exogeneity check

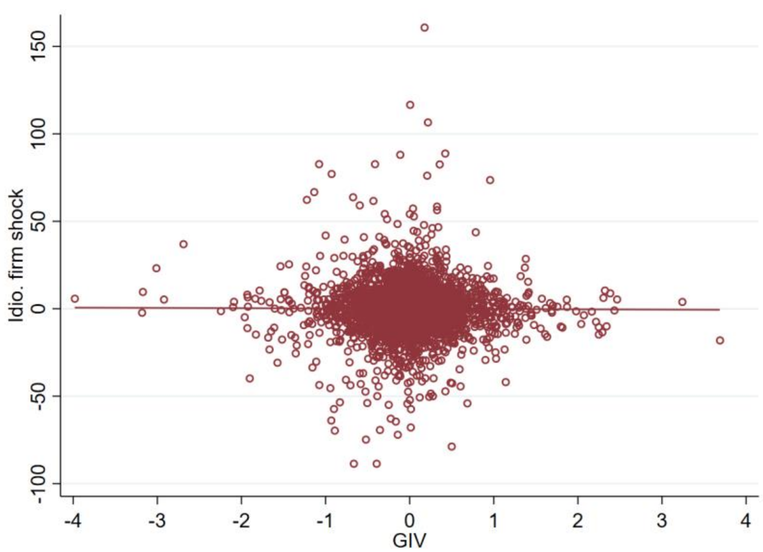


Table 1: Summary Statistics

This table shows summary statistics (number of observations, mean, standard deviation (SD), and 25th, 50th, and 75th percentiles) for a sample of 4,051 MSA-quarter and 4,264 firm-quarter observations from 2003-2018. See Appendix 1 for variable descriptions.

	# Obs.	Mean	SD	P25	P50	P75
MSA-level						
NCREIF	4,051	2.073	2.741	1.364	2.294	3.338
NCREIF (INC)	3,924	1.537	0.307	1.351	1.524	1.721
NCREIF (PRC)	3,924	0.553	2.723	-0.148	0.776	1.828
NCREIF (I)	2,284	2.277	2.981	1.582	2.553	3.635
NCREIF (A)	2,062	2.148	2.948	1.346	2.287	3.403
NCREIF (O)	1,646	1.947	3.141	1.081	2.119	3.314
NCREIF (R)	2,026	2.343	3.102	1.340	2.217	3.508
GMP growth	4,051	3.951	3.438	2.212	3.958	5.862
Inc growth	4,051	4.234	3.391	2.700	4.400	6.300
Unemp	4,051	6.176	2.257	4.600	5.600	7.500
$ listed firms	4,051	7395.591	17165.034	0.000	283.711	5973.448
PropTO	4,051	0.020	0.040	0.000	0.003	0.024
MktSize	4,051	24.394	9.103	19.862	20.808	22.512
Firm-level						
RetRf2	4,264	3.271	16.549	-3.919	3.471	10.644
GPS	4,264	-0.012	1.275	-0.339	-0.022	0.436
GIV	4,264	-0.008	0.450	-0.187	0.000	0.161
GIV (odd)	4,264	-0.002	0.354	-0.098	0.000	0.107
GIV (even)	4,264	-0.006	0.363	-0.133	0.000	0.104
B/M	4,264	0.624	0.515	0.390	0.529	0.722
Size	4,264	7.403	1.378	6.639	7.488	8.245
Momentum	4,264	12.911	30.366	-1.516	13.692	27.312
Leverage	4,264	0.542	0.140	0.455	0.535	0.626
Profitability	4,264	1.042	8.216	0.073	1.057	2.126
Investment	4,264	2.434	11.854	-0.551	0.639	2.980
ILLIQ	4,264	0.031	0.201	0.000	0.001	0.004
IVOL	4,264	1.385	1.004	0.912	1.109	1.448
Firm-MSA-level						
PropSHR	48,465	0.073	0.146	0.009	0.028	0.071

Table 2: Regression Results of NCREIF Returns on MSA-level Economic Variables

This table shows the panel regression results on the relationship between quarterly total returns on the MSA-level NCREIF Property Index (*NCREIF*) and lagged MSA-level economic variables. Results based on the aggregate NCREIF returns and returns for each of the core property types are presented in Columns (1)-(5), respectively. In the last column, we augment our model in Column (1) with NCREIF returns lagged by one quarter. See Appendix 1 for variable descriptions. MSA and time fixed effects are included. The *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
NCREIF	Aggregate	Industrial	Residential	Office	Retail	Aggregate Lag 1
NCREIF (Lag 1)						0.212***
						(12.70)
GMP growth	0.037***	0.046**	0.040**	0.058**	0.013	0.027**
	(2.71)	(2.06)	(1.98)	(2.13)	(0.46)	(2.00)
Inc growth	0.083***	0.057**	0.112***	0.096***	0.000	0.053***
	(4.60)	(2.20)	(4.61)	(3.31)	(0.00)	(2.99)
Unemp	-0.067*	-0.145***	-0.063	-0.086	0.173**	-0.085**
	(-1.82)	(-2.65)	(-1.08)	(-1.23)	(2.52)	(-2.34)
$ listed firms	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(-1.43)	(-0.64)	(-1.20)	(-1.38)	(-1.43)	(-1.10)
PropTO	5.934***	5.133***	5.431***	12.376***	7.227***	5.709***
	(7.58)	(3.22)	(3.26)	(5.32)	(3.39)	(7.32)
MktSize	-0.184***	-0.303***	-0.046**	0.022	-0.021	-0.179***
	(-2.81)	(-2.84)	(-2.15)	(0.72)	(-1.10)	(-2.75)
Constant	6.397***	10.109***	2.963***	1.029	1.794***	6.112***
	(3.92)	(3.79)	(4.44)	(1.06)	(2.59)	(3.76)
MSA FEs	Yes	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.523	0.528	0.547	0.551	0.419	0.546
# Obs	4,051	2,284	2,062	1,646	2,026	3,974

Table 3: OLS Regression Results of Excess Returns on Granular Property Shocks

This table shows the naïve regression results on the relationship between REIT excess returns and granular property shocks (*GPS*). Results based on all (core) REITs are presented in Columns (1) and (5) (Columns (2)-(4) and (6)-(8)). The quarterly REIT excess returns (*RetRf*) are calculated using the chain-linked monthly excess returns of firm *i* in quarter *t* in excess of the rate of return of 30-day Treasury bills. *GPS* is the granular property shock of firm *i* in quarter *t-1*. See Appendix 1 for variable descriptions. The *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

RetRf	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GPS					2.875***	2.837***	2.590***	3.037***
					(10.58)	(9.04)	(10.81)	(10.51)
B/M	16.100***	17.042***	22.009***	17.317***	14.501***	15.365***	20.321***	16.133***
	(7.49)	(6.39)	(6.15)	(8.16)	(7.36)	(6.36)	(6.22)	(8.37)
Size	0.272	0.398*	-7.735***	-10.008***	0.293	0.399**	-7.172***	-9.310***
	(1.44)	(1.94)	(-7.37)	(-9.41)	(1.56)	(2.13)	(-8.15)	(-9.34)
Momentum	-0.039***	-0.042***	-0.032**	-0.004	-0.038**	-0.041***	-0.032**	-0.004
	(-3.18)	(-2.58)	(-2.24)	(-0.31)	(-2.40)	(-3.28)	(-2.39)	(-0.29)
Leverage	13.788***	12.307***	2.711	2.191	12.215***	10.744***	2.278	1.700
	(6.22)	(5.12)	(0.69)	(0.61)	(5.43)	(4.77)	(0.53)	(0.62)
Profitability	0.180***	0.165***	0.158***	0.077*	0.157***	0.147***	0.157**	0.084**
	(4.10)	(3.90)	(2.65)	(1.86)	(3.74)	(3.49)	(2.41)	(1.99)
Investment	0.038	0.034	0.035**	0.020	0.028	0.025	0.022	0.006
	(1.22)	(1.09)	(2.10)	(1.23)	(0.97)	(0.80)	(1.27)	(0.37)
ILLIQ	10.162***	10.380**	11.901	2.609	7.683**	7.821**	8.409	-0.100
	(3.25)	(2.46)	(1.53)	(0.76)	(2.50)	(2.41)	(1.44)	(-0.04)
IVOL	-8.665***	-8.964***	-11.148***	-9.785***	-6.078***	-6.368***	-8.462***	-6.851***
	(-8.88)	(-11.21)	(-9.31)	(-12.75)	(-6.07)	(-4.86)	(-6.64)	(-5.54)
Constant	-4.008	-3.120	54.698***	69.435***	-4.877*	-4.053	50.524***	63.818***
	(-1.33)	(-0.85)	(6.24)	(8.67)	(-1.76)	(-1.10)	(6.34)	(8.79)
Prop FEs	No	Yes	No	No	No	Yes	No	No
Firm FEs	No	No	Yes	Yes	No	No	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.266	0.275	0.363	0.327	0.313	0.321	0.400	0.369
# Obs	3,423	3,423	3,423	4,269	3,423	3,423	3,423	4,269

Table 4: Instrumental Variables Regression Results of Excess Returns on Granular Property Shocks

This table shows the instrumental variables regression results on the relationship between REIT excess returns and granular property shocks (*GPS*). Results based on all (core) REITs are presented in Columns (1) and (5) (Columns (2)-(4) and (6)-(8)). The quarterly REIT excess returns (*RetRf*) are calculated using the chain-linked monthly excess returns of firm *i* in quarter *t* in excess of the rate of return of 30-day Treasury bills. *GPS* is the granular property shock of firm *i* in quarter *t-1*. See Appendix 1 for variable descriptions. The *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

RetRf	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IV_GPS	1.864*	2.129*	2.017**	2.070**	3.204***	3.300***	2.998***	3.071***
	(1.74)	(1.89)	(2.34)	(2.37)	(3.16)	(3.04)	(4.33)	(4.89)
B/M	15.062***	15.785***	20.696***	16.510***	14.317***	15.092***	20.056***	16.120***
	(5.99)	(7.27)	(5.70)	(5.44)	(5.22)	(6.03)	(7.45)	(6.88)
Size	0.286	0.399*	-7.293***	-9.529***	0.295	0.399*	-7.079***	-9.299***
	(1.17)	(1.79)	(-6.06)	(-9.92)	(1.51)	(1.67)	(-7.24)	(-11.78)
Momentum	-0.039**	-0.041***	-0.032**	-0.004	-0.038***	-0.040***	-0.032**	-0.004
	(-2.53)	(-3.49)	(-2.56)	(-0.24)	(-2.95)	(-2.80)	(-2.12)	(-0.30)
Leverage	12.763***	11.115***	2.348	1.840	12.030***	10.470***	2.187	1.679
	(4.42)	(5.36)	(0.50)	(0.65)	(4.31)	(3.64)	(0.47)	(0.46)
Profitability	0.165***	0.151***	0.157***	0.082**	0.155***	0.144***	0.157	0.084*
	(4.53)	(4.45)	(3.85)	(2.57)	(3.21)	(3.53)	(1.64)	(1.77)
Investment	0.032	0.027	0.025	0.010	0.027	0.023	0.019	0.006
	(1.18)	(0.89)	(1.40)	(0.97)	(1.02)	(0.66)	(1.31)	(0.31)
ILLIQ	8.555***	8.460***	9.187*	0.761	7.400**	7.404**	7.864*	-0.131
	(2.79)	(3.06)	(1.78)	(0.25)	(2.42)	(2.28)	(1.94)	(-0.04)
IVOL	-6.987***	-7.016***	-9.056***	-7.784***	-5.782***	-5.944***	-8.039***	-6.816***
	(-4.28)	(-5.09)	(-5.65)	(-8.79)	(-3.99)	(-3.36)	(-7.12)	(-6.31)
Constant	-2.931	-1.881	27.960***	45.589***	-2.812	-1.818	27.963**	44.880***
	(-0.76)	(-0.61)	(3.45)	(12.20)	(-0.75)	(-0.44)	(2.35)	(4.67)
1st stage F-stat	114.95	116.91	121.20	144.45	79.59	80.17	83.10	110.80
Prop FEs	No	Yes	No	No	No	Yes	No	No
Firm FEs	No	No	Yes	Yes	No	No	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
J-stat	N/A	N/A	N/A	N/A	1.22	0.88	1.16	3.10
R-squared	0.308	0.318	0.398	0.365	0.313	0.320	0.399	0.369
# Obs	3,423	3,423	3,423	4,269	3,423	3,423	3,423	4,269

Table 5: Regression Results of Excess Returns on Property Market Shocks: Liquidity

This table shows the instrumental variables regression results on the relationship between REIT excess returns and granular property shocks constructed using property market turnover (*GPS_liquidity*). The quarterly REIT excess returns (*RetRf*) are calculated using the chain-linked monthly excess returns of firm *i* in quarter *t* in excess of the rate of return of 30-day Treasury bills. *GPS_liquidity* is the granular property market liquidity shock of firm *i* in quarter *t-1*. Control variables are the same as Table 4 and suppressed for brevity. See Appendix 1 for variable descriptions. The *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

RetRf	(1)	(2)	(3)
GPS_liquidity	-10.364	-7.223	4.286
	(-0.36)	(-0.26)	(0.19)
Controls	Yes	Yes	Yes
1st stage F-stat	843.90	842.43	820.18
Prop FEs	No	Yes	No
Firm FEs	No	No	Yes
Time FEs	Yes	Yes	Yes
R-squared	0.265	0.274	0.364
# Obs	3,423	3,423	3,423

Table 6: Regression Results of Excess Returns on Granular Property Shocks: Positive versus Negative Shocks

This table shows the regression results on the relationship between REIT excess returns and granular property shocks (*GPS*). Naïve regression and instrumental variables regression results are presented in Columns (1)-(3) and (4)-(6), respectively. Columns (1) and (4) reproduce Column (3) in Table 3 and Column (4) in Table 4. The quarterly REIT excess returns (*RetRf*) are calculated using the chain-linked monthly excess returns of firm *i* in quarter *t* in excess of the rate of return of 30-day Treasury bills. *GPS* is the granular property shock of firm *i* in quarter *t-1*. *GPS (+)* (*GPS (-)*) are the positive (negative)-only shocks. Control variables are the same as Table 4 and suppressed for brevity. See Appendix 1 for variable descriptions. The *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
RetRf	OLS	OLS	OLS	IV	IV	IV
GPS	2.837***					
	(9.04)					
GPS (+)		3.459***				
		(6.69)				
GPS (-)			3.957***			
			(9.82)			
IV_GPS				2.017**		
				(2.34)		
IV_GPS (+)					0.567	
					(0.58)	
IV_GPS (-)						3.175***
						(7.38)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
1st stage F-stat	N/A	N/A	N/A	121.20	979.21	1247.38
Prop FEs	Yes	No	No	No	No	No
Firm FEs	No	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.321	0.376	0.405	0.398	0.367	0.403
# Obs	3,423	3,423	3,423	3,423	3,423	3,423

Table 7: Regression Results of Excess Returns on Granular Property Shocks: Gateway versus Non-Gateway Shocks

This table shows the regression results on the relationship between REIT excess returns and granular property shocks (*GPS*). Naïve regression and instrumental variables regression results are presented in Columns (1)-(3) and (4)-(6), respectively. Columns (1) and (4) reproduce Column (3) in Table 3 and Column (4) in Table 4. The quarterly REIT excess returns (*RetRf*) are calculated using the chain-linked monthly excess returns of firm *i* in quarter *t* in excess of the rate of return of 30-day Treasury bills. *GPS* is the granular property shock of firm *i* in quarter *t-1*. *GPS (GTW)* (*GPS (NGTW)*) are the gateway (non-gateway) shocks. Control variables are the same as Table 4 and suppressed for brevity. See Appendix 1 for variable descriptions. The *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

RetRf	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV
GPS	2.837*** (9.04)					
GPS (GTW)		3.225*** (7.47)				
GPS (NGTW)			3.024*** (8.52)			
IV_GPS				2.017** (2.34)		
IV_GPS(GTW)					2.441*** (6.56)	
IV_GPS(NGTW)						-4.287* (-1.95)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
1st stage F-stat	N/A	N/A	N/A	121.20	11968.2	112.63
Prop FEs	Yes	No	No	No	No	No
Firm FEs	No	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.321	0.384	0.386	0.398	0.383	0.251
# Obs	3,423	3,423	3,423	3,423	3,423	3,423

Table 8: Regression Results of Excess Returns on Granular Property Shocks: Income versus Appreciation Shocks

This table shows the regression results on the relationship between REIT excess returns and granular property shocks (*GPS*). Naïve regression and instrumental variables regression results are presented in Columns (1)-(3) and (4)-(6), respectively. Columns (1) and (4) reproduce Column (3) in Table 3 and Column (4) in Table 4. The quarterly REIT excess returns (*RetRf*) are calculated using the chain-linked monthly excess returns of firm *i* in quarter *t* in excess of the rate of return of 30-day Treasury bills. *GPS* is the granular property shock of firm *i* in quarter *t-1*. *GPS (INC)* (*GPS (PRC)*) are the income return (price appreciation) shocks. Control variables are the same as Table 4 and suppressed for brevity. See Appendix 1 for variable descriptions. The *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

RetRf	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV
GPS	2.837***					
	(9.04)					
GPS (INC)		13.888***				
		(3.58)				
GPS (PRC)			2.274***			
			(10.97)			
IV_GPS				2.017**		
				(2.34)		
IV_GPS(INC)					3.819	
					(0.52)	
IV_GPS(PRC)						1.139**
						(2.42)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
1st stage F-stat	N/A	N/A	N/A	121.20	750.24	1049.26
Prop FEs	Yes	No	No	No	No	No
Firm FEs	No	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.321	0.366	0.393	0.398	0.364	0.386
# Obs	3,423	3,423	3,423	3,423	3,423	3,423

Table 9: Robustness Tests

This table shows the instrumental variables regression results on the relationship between REIT excess returns and granular property shocks (*GPS*). For Columns (1) and (2), *GPS* is constructed based on the residuals from estimating Columns (2)-(5) and (6) in Table 2, respectively. In Column (3), *GIV* is constructed based on the residuals from estimating equation (4) with fixed effects that capture a firm's property type focus. In Column (4), *GPS_PC1* and *GPS_PC2* are constructed based on the residuals from performing a Principal Component Analysis on the residuals from estimating Column (1) in Table 2. Column (5) interacts *GPS* with an indicator for the global financial crisis. The quarterly REIT excess returns (*RetRf*) are calculated using the chain-linked monthly excess returns of firm *i* in quarter *t* in excess of the rate of return of 30-day Treasury bills. *GPS* is the granular property shock of firm *i* in quarter *t-1*. Control variables are the same as Table 4 and suppressed for brevity. See Appendix 1 for variable descriptions. The *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

RetRf	(1) GPS using sub-indexes	(2) Add *NCREIF* (Lag 1) in Eq(1)	(3) Add PropFE in Eq(1)	(4) GPS using PCA	(5) Control for Crisis
GPS	0.594**	1.852***	2.140**	2.178***	1.439***
	(2.06)	(4.09)	(2.42)	(6.14)	(4.98)
GPS_PC1				-5.052**	
				(-2.01)	
GPS_PC2				5.092**	
				(2.08)	
GPS # GFC					2.017***
					(3.79)
GFC					-7.582***
					(-6.47)
Controls	Yes	Yes	Yes	Yes	Yes
1st stage F-stat	3948.92	869.78	380.60	434.18	N/A
Prop FEs	No	No	No	No	No
Firm FEs	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes
R-squared	0.364	0.406	0.372	0.399	0.365
# Obs	3,423	3,423	3,423	3,423	3,423

Appendix 1: Variable Definition

Variable	Source	Definition
MSA-level (Quarterly)		
NCREIF	NCREIF	Returns on the aggregate NCREIF Property Index (NPI) by MSA.
NCREIF_INC	NCREIF	The income components of the aggregate NCREIF NPI return by MSA.
NCREIF_PRC	NCREIF	The appreciation components of the aggregate NCREIF NPI return by MSA.
NCREIF(I/A/O/R)	NCREIF	Returns on the NCREIF property-MSA sub-indices for core property types in each MSA. Core property types include industrial (*I*), residential (*A*), office (*O*), and retail (*R*).
GTW (NGTW)	NCREIF	An indicator variable for gateway (non-gateway) markets in the U.S. Gateway markets include Boston, Chicago, Los Angeles, New York, San Francisco and Washington, D.C.
GMP growth	BEA	Changes in real gross domestic product for all industry total by MSA.
Inc growth	BEA	Changes in personal income for all industry total by MSA.
Unemp	BLS	The quarterly average of the monthly unemployment rate in MSA *z* in period *t*.
$ listed firms	Compustat	The number of listed firms headquartered in MSA *z* in period *t*.
PropTO	NCREIF	Property market turnover in MSA *z* in period *t*.
MktSize	NCREIF	The logarithm of the market value of properties in MSA *z* in period *t*.
Firm-level (Quarterly)		
RetRf	CRSP	The chain-linked monthly stock returns of firm *i* in period *t+1* in excess of the rate of return of 30-day Treasury bills.
GPS	NCREIF, S&P Global	The granular property shocks of firm *i* in period *t*, defined as the average of MSA-level idiosyncratic property market shocks, weighted by the percentage allocations of each REIT to each MSA.
GPS(+)		The positive component of GPS. i.e., GPS in which the property market shocks are above zero.
GPS(-)		The negative component of GPS. i.e., GPS in which the property market shocks are below zero.
GPS(GTW)		GPS calculated based on *NCREIF* in the gateway markets.
GPS(NGTW)		GPS calculated based on *NCREIF* in the non-gateway markets.
GPS(PRC)		GPS calculated based on *NCREIF_PRC*.
GPS(INC)		GPS calculated based on *NCREIF_INC*.
GIV	NCREIF, S&P Global	The granular instrumental variable of firm *i* in period *t*, defined as the time-varying difference between geographically-weighted MSA-level shocks and equally-weighted MSA-level shocks aggregated to the firm level.
GIV_even		GIV for MSAs with an even rank based on the market value of NCREIF properties in the MSA (MktSize).
GIV_odd		GIV for MSAs with an old rank based on the market value of NCREIF properties in the MSA (MktSize).
GIV(+)		The positive component of GIV. i.e., GIV in which the market shock is above zero.
GIV(-)		The negative component of GIV. i.e., GIV in which the market shock is below zero.
IV_GPS		GIV-instrumented GPS.

Appendix 1 (cont')

Variable	Source	Definition
GPS_liquidity	NCREIF S&P Global	The average of MSA-level idiosyncratic property market liquidity shocks, weighted by the percentage allocations of each REIT to each MSA. It is calculated in the same way as GPS except that we replace NCREIF NPI returns with NCREIF NPI property turnover in the first step of the analysis (equation (1)). Quarterly property turnover in each MSA is calculated as the transaction value (in dollar terms) of all properties in the NCREIF NPI index that were sold in a quarter divided by the total market value of all properties in the NCREIF NPI database in that MSA at the beginning of the quarter.
Size	Compustat	The logarithm of the product of stock price and shares outstanding.
B/M	Compustat	The ratio of book equity to market equity.
Momentum	CSRP	Cumulative stock returns over the past twelve months (in percentage).
Leverage	Compustat	Sum of total long-term debt and debt in current liabilities divided by total assets.
Profitability	Compustat	Revenues minus revenues minus cost of goods sold, interest expense, and selling, general, and administrative expense divided by the sum of book equity and minority interest at the end of the previous period (in percentage).
Investment	Compustat	The percentage growth rate in non-cash assets of firm *i* during period *t*.
ILLIQ	CRSP	The logarithm of the average Amihud (2002) daily volume price impact firm *i* during period *t*.
IVOL	CRSP	The standard deviation of residuals of monthly Fama-French 3-factor-model regressions of daily stock returns (in percentage).
γ_z		MSA fixed effects.
α_i		Property type focus of the REIT or firm fixed effects.
δ_t		Time (year-quarter) fixed effects.

Appendix 2: First-stage -- Instrumental Variables Regression Results of Excess Returns on Granular Property Shocks

This table shows the first-stage regression results for instrumental variables regression results of excess returns on granular property shocks. Control variables are the same as Table 4 and suppressed for brevity. Firm fixed effects and time fixed effects are included. See Appendix 1 for variable descriptions. The *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Table 4

GPS	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GIV	0.480***	0.490***	0.403***	0.471***				
	(12.94)	(11.87)	(9.31)	(11.53)				
GIV (even)					0.285***	0.055	0.117**	0.338***
					(5.97)	(1.09)	(2.24)	(6.97)
GIV (odd)					0.661***	0.477***	0.821***	0.663***
					(12.97)	(8.78)	(14.57)	(12.06)

Panel B: Tables 6-8

GPS	Table 6, Column (5) *IV: GPS (+)*	Table 6, Column (6) *IV: GPS (-)*	Table 7, Column (5) *IV: GPS (GTW)*	Table 7, Column (6) *IV: GPS (NGTW)*	Table 8, Column (5) *IV: GPS (INC)*	Table 8, Column (6) *IV: GPS (PRC)*
	(1)	(2)	(3)	(4)	(5)	(6)
GIV	0.795***	1.316***	1.275***	0.337***	0.601***	1.170***
	(29.07)	(40.03)	(112.40)	(11.22)	(28.35)	(32.75)

Appendix 3: Instrumental Variables Estimator Implemented Using the Generalized Method of Moments (GMM), Excess Returns on Granular Property Shocks

This table shows instrumental variables estimator implemented using the Generalized Method of Moments (GMM) for Table 4. See Appendix 1 for variable descriptions. The *t*-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

RetRf	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IV_GPS	1.905*	2.193**	2.140**	2.296**	2.701**	2.939***	2.795***	2.944***
	(1.76)	(2.03)	(2.08)	(2.06)	(2.55)	(2.78)	(2.79)	(2.71)
B/M	16.037***	16.976***	21.958***	17.359***	16.011***	16.953***	21.942***	17.371***
	(22.87)	(23.84)	(26.13)	(25.95)	(22.84)	(23.80)	(26.10)	(25.97)
Size	0.275	0.399**	-7.609***	-9.909***	0.276	0.400**	-7.572***	-9.882***
	(1.38)	(2.01)	(-9.51)	(-13.45)	(1.39)	(2.01)	(-9.46)	(-13.41)
Momentum	-0.042***	-0.044***	-0.036***	-0.006	-0.043***	-0.045***	-0.037***	-0.007
	(-3.63)	(-3.89)	(-3.20)	(-0.66)	(-3.72)	(-3.98)	(-3.29)	(-0.74)
Leverage	14.124***	12.619***	3.038	2.486	14.267***	12.732***	3.148	2.575
	(7.83)	(6.93)	(0.87)	(0.78)	(7.92)	(6.99)	(0.90)	(0.81)
Profitability	0.174***	0.159***	0.151***	0.073*	0.171***	0.157***	0.149***	0.072*
	(5.61)	(5.13)	(3.63)	(1.95)	(5.54)	(5.06)	(3.58)	(1.92)
Investment	0.035*	0.031	0.032	0.017	0.034*	0.030	0.031	0.016
	(1.80)	(1.58)	(1.61)	(0.81)	(1.74)	(1.52)	(1.56)	(0.77)
ILLIQ	10.369***	10.591***	11.935***	2.555	10.455***	10.662***	11.943***	2.540
	(6.40)	(6.56)	(5.64)	(1.61)	(6.46)	(6.60)	(5.64)	(1.60)
IVOL	-8.616***	-8.906***	-11.071***	-9.683***	-8.596***	-8.887***	-11.048***	-9.654***
	(-21.73)	(-22.40)	(-27.73)	(-25.16)	(-21.69)	(-22.35)	(-27.67)	(-25.10)
Constant	-3.084	-1.962	28.566***	47.876***	-3.078	-1.951	28.754***	48.107***
	(-1.52)	(-0.97)	(4.20)	(7.70)	(-1.52)	(-0.96)	(4.23)	(7.74)
1st stage F-stat	394.54	393.52	380.59	462.00	207.56	207.01	200.27	245.61
Prop FEs	No	Yes	No	No	No	Yes	No	No
Firm FEs	No	No	Yes	Yes	No	No	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.276	0.285	0.372	0.336	0.276	0.285	0.372	0.336
# Obs	3,423	3,423	3,423	4,269	3,423	3,423	3,423	4,269