How Does Property Location Influence Investment Risk and Return?*

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Abstract

A property's location is often considered to be the ultimate determinant of its investment performance. But how exactly does a property's location influence its risk and return? We focus on the effects of location density on the risk and return of commercial real estate investments. We do this by studying the geographical characteristics of the property portfolios of U.S. equity REITs. We show that REITs with property holdings in high-density locations experience higher NOI growth and carry higher systematic risk than their otherwise comparable peers in low-density locations. Consistent with higher NOI growth rates, high-density REITs also have lower implied cap rates. Our results suggest that location density is an important determinant of REIT performance outcomes, implying that geographical characteristics can drive investment risk and return across commercial real estate markets.

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1 Introduction

Real estate is traditionally divided into several asset classes that depend on the usage of the property. These property types, which include retail, office, multi-family, and industrial, exhibit unique patterns of risk and return. For example, retail generally has higher volatility and systematic risk than multifamily.[1] However, regardless of these property types, real estate professionals are quick to point out that the ultimate determinant of a property's risk and return is its location.

While there are a number of ways to characterize a property's location, this paper focuses on density, and the relationship between the risk of a property and the density of its location. Our analysis is based on the idea that the supply of new space in denser more urban locations is less elastic than the supply in less dense suburban locations, i.e., the supply of property in dense locations grows less in response to positive demand shocks. This is intuitive — in less dense, suburban locations, there tends to be "green field" space that can be relatively inexpensively developed when the demand for space grows. In contrast, adding supply in more urban locations may require the demolition of existing buildings, which, of course, is much costlier. As a result, rents rise more during economic booms in denser locations. It should be emphasized that this difference in the supply elasticities of more and less dense locations is likely to be much weaker during downturns. Because existing buildings are only demolished during extreme downturns, we expect to see almost no new supply during such periods, regardless of location density.[2]

The different supply responses in dense and less dense locations generate a number of empirically testable implications, which we explore in this paper. The first implication is that rents in denser locations benefit more from positive demand shocks but may not be hurt more during downturns. Therefore, rental growth in denser locations should be higher on average. If we hold operating costs and discount rates constant, this in turn implies that capitalization rates should be higher in less dense, suburban locations. However, discount rates may also be related to density, which is our second implication. Specifically, because rents in denser locations are more sensitive to fluctuations in the business cycle, properties in these locations are likely to be exposed to more systematic risk, which

[1] Data from Nareit suggest that, over the 1994–2017 period, the standard deviation of monthly total returns of retail REITs in the U.S. was 6.33%, compared to 5.58% for multifamily REITs. The CAPM beta for retail REITs over that period was 0.71, compared to 0.63 for multifamily REITs.

[2] Density can potentially for a number of reasons. For example, in less dense locations the spread between rents and operating costs tends to be lower, since rents tend to increase more with density than operating costs. If we hold the volatility of rents constant across locations with different densities, this implies that the net operating income of properties should be more volatile in less dense locations. However, the greater supply elasticity in less dense locations suggests that at least in the long run, rents will fluctuate more in denser locations.

implies that they should have higher discount rates. These higher discount rates may offset the effect of higher expected growth. As a result, the effect of density on cap rates, which is the final implication we explore, can in theory go either way.

Real Estate Investment Trusts (REITs) provide an ideal laboratory for testing these hypotheses. Because REITs are publicly traded portfolios of real estate, it is straightforward to estimate their systematic risk exposures. In addition, since they tend to be relatively transparent organizations, it is also straightforward to characterize the locations of their properties. Our focus is on multi-family and office REITs, as their properties tend to be relatively homogeneous across locations. As we show, multi-family and office REITs tend to focus on either suburban (less dense) or CBD (denser) locations, providing us with significant cross-sectional dispersion to test our hypotheses.

The average densities of the locations where the sample REITs own properties can be calculated by combining two granular data sets. The first data set provides detailed information on the acquisition and disposition dates, as well as the addresses and acquisition prices, of the commercial real estate assets held by the REITs in our sample. We use this data set to construct the REITs' property holdings in each U.S. zip code over the study period. The second data set provides information on the employment density in each U.S. zip code, which we combine with the REIT property holdings data to generate the weighted average density across the property locations of each REIT in our sample. For example, we can see in our data that Corporate Office Properties owns several office buildings on Columbia Gateway Drive in Columbia (MD) in the less dense zip code 21046, which has approximately 4,000 workers per square mile. By contrast, SL Green Realty owns properties like The News Building on East 42nd Street in Manhattan (NY), located in the denser zip code 10017, which has more than 450,000 workers per square mile.

As we show, REITs with properties in denser locations exhibit higher quarterly NOI growth rates during our sample period. This evidence is consistent with our idea that, on average, rents grow faster in supply-constrained locations. Using the quarterly growth rate of real GDP as a proxy for aggregate demand, we also document that the NOIs of high-density REITs grow faster when GDP growth is stronger. This finding is consistent with our hypothesis that location density amplifies the response of real estate rents to positive demand shocks.

Next, we turn to the relationship between location density and real estate systematic risk. Our conjecture is that the returns of REITs with properties in denser locations will co-vary more with the returns of the overall REIT market than those of REITs with properties in less dense locations. We first estimate rolling annual regressions of the weekly total returns earned by equal-weighted indices of high- versus low-density multifamily and office REITs on the weekly total return on the broader REIT market. From these regressions, we compile an annual time series of systematic risk estimates for multifamily and office REITs by density exposure category. We find that the systematic risk estimates of high-density multifamily and office REITs are indeed higher than the systematic risk of their low-density counterparts.

There are, however, fundamental differences between the high- and low-density REITs that can potentially have an independent influence on their systematic risk exposure. In particular, we find that the REITs in the densest locations tend to be larger on average than the REITs in less dense locations, and perhaps because of this, REITs in denser locations also tend to have higher credit ratings. To account for these potentially confounding factors, we estimate regressions for REIT systematic risk that control for REIT size and REIT credit ratings. We also include the average betas of the firms headquartered in the cities to proxy for the fundamental risks of the locations. We find that the positive relation between density and systematic risk continues to hold after including these controls.

We conclude our empirical tests by assessing the relationship between location density and real estate cap rates. As we discussed above, the supply restrictions in denser locations are likely to lead to greater rental growth in economic upturns, which should in turn lead to lower cap rates. To examine this possibility empirically, we estimate the cross-sectional relationship between implied cap rates and location densities. Our estimates suggest that implied cap rates for high-density REITs are significantly lower than those of otherwise comparable low-density REITs. For instance, we estimate that a one-standard deviation increase in density exposure is associated with a nearly 25 basis points drop in the implied cap rate for multifamily REITs. For office REITs, the effect is even larger, with a drop in implied cap rates of nearly 40 basis points for a one-standard deviation increase in density exposure. Our results are consistent with denser locations being subject to tighter supply constraints, which raise property values and, all else equal, are associated with lower cap rates.

This paper, of course, is not the first to examine the systematic risk of real estate. Starting with Brueggeman et al. (1984), researchers have tried to estimate the systematic risk of real estate using appraisal-based returns, but note that the smoothed nature of appraised values may result in betas that are too low. Geltner (1989) provides a way to de-smooth appraised real estate returns, but also estimates betas that are quite low. More recently, Peng (2016) introduces a more powerful cross-sectional approach, which estimates betas that are significantly positive. Titman and Warga

(1986) and Gyourko and Linneman (1988) estimate the systematic risk of REITs. These authors find that, because REITs do not have the same appraisal smoothing problems of appraisal-based real estate indexes, REIT betas exceed appraisal-based betas estimated using traditional time-series methods, but they are much closer to the betas estimated with the cross-sectional approach suggested by Peng (2016).

Peng (2016) does note that the systematic risk estimates for different property types are systematically different. However, he does not propose a rationale for what is generating those differences. In contrast, we suggest a rationale for why properties in different locations may have different betas, and provide evidence consistent with that conjecture. We believe that we are the first to explore the relationship between a property's location characteristics and its systematic risk.

There is also a large prior literature that examines the cross-sectional variation in cap rates.[3] Our evidence is consistent with contemporaneous international evidence in (Bialkowski et al. (2019)), which finds that cap rates in the central business district (CBD) of a city are almost always lower than cap rates suburban locations.[4] However, the fundamental drivers of cap rates for investment properties in different locations are still largely unknown, and we believe our work adds to this literature by documenting the empirical association between location density and property cap rates, and by providing evidence for the underlying economic rationale as it relates to the effect of local supply constraints on growth in real estate rents.

2 Data and Sample Selection

2.1 REIT Property Holdings

We start the sample selection process with a comprehensive database on the commercial real estate holdings of public U.S. equity REITs. The information is taken from the "Real Estate Properties" section of S&P Global, the leading provider of firm- and property-level financial data for the REIT industry. The S&P Global database is unique in that it provides, for each property either currently or historically owned by any public U.S. equity REIT, the start and end dates of the period during which a given REIT held the property in its portfolio. The database further provides extensive information

[3]See Duranton and Puga (2014) for a review of the related theoretical and empirical literature.

[4]Other studies documenting cross-sectional and time-series variation in cap rates include, Sivitanidou and Sivitanides (1999), Sivitanides et al. (2001), Chervachidze et al. (2009), McDonald and Dermisi (2009), and Chervachidze and Wheaton (2013).

on each property's physical and financial characteristics, including its property type, exact location coordinates, and property value. The S&P Global data cover all major REIT property types. From this database, we obtain the set of all properties owned by public U.S. multifamily and office equity REITs between 1994 and 2017. We focus on those two property types because multifamily and office products tend to be relatively homogeneous across location types. By contrast, CBD-retail properties for example are structurally quite different from suburban retail properties.

The sample contains 15,682 unique mainland U.S. properties, held by 30 multifamily REITs and 44 office REITs during the study period. Figure 1 shows that the property holdings of the REITs in the sample are geographically dispersed across all 48 contiguous states and Washington, D.C. The top 20 CBSAs by total REIT property holdings contain 10,188 (65%) of all sample properties.[5] Those CBSAs are characterized by sustained economic growth over the last two decades. Data from the U.S. Census Bureau's annual County Business Patterns survey show that the mean rate of five-year employment growth for the top 20 REIT property CBSAs is 7% during that period, above the overall national average of 6.5%. Moreover, the mean rates of five-year employment growth for those top 20 CBSAs over the study period fall into a narrow interval of between 5% and 10%. These statistics suggest that the property holdings of multifamily and office REITs tend to be located in growth markets.

FIGURE 1 ABOUT HERE.

2.2 REIT Density

Our empirical analysis requires location-specific, time-varying measures of urban density relevant to both, multifamily and office REITs. The choice of suitable density measures is intuitive for those two property types. For multifamily REITs, the natural measure is population density; for office REITs, it is employment density. Location density can be measured at different geographical levels, such as a location's zip code, CBSA, county, or state. However, density may vary significantly across areas situated in close physical proximity to one another; for instance, across the central business district (CBD) and the suburban areas of the same city. To capture the granular nature of location density, we measure this variable at the zip code-level.

[5] CBSA stands for core-based statistical area and is a collective term for metropolitan and micropolitan statistical areas. The top 20 CBSAs by total REIT property holdings are: Atlanta, Austin, Baltimore, Boston, Charlotte, Chicago, Dallas, Denver, Houston, Los Angeles, New York, Orlando, Philadelphia, Phoenix, Raleigh/Durham, San Diego, San Francisco, Seattle, Tampa, and Washington, D.C.

We begin by collecting annual data on zip code-level total employment from the U.S. Census Bureau's County Business Patterns survey. We compute employment density in zip code l at time t, denoted *Location Density*$_{l,t}$, by scaling total employment in zip code l at time t (in thousands of employees) by zip code size (in square miles). Similar annual data on zip code-level total population aren't easily available. Thus, we use zip code-level employment density as a proxy for population density and apply the same location density measure to both, multifamily and office REITs.[6]

We estimate *Density* for REIT i at time t as the weighted average employment density across all L zip codes to which that REIT is exposed through its property holdings at time t:

$$Density_{i,t} = \sum_{l=1}^{L} \omega_{i,l,t} \times Location\ Density_{l,t} \tag{1}$$

where *Location Density*$_{l,t}$ is zip code-level employment density, as defined above, and $\omega_{i,l,t}$ is the weight assigned to each zip code, measured as the exposure of REIT i to zip code l at time t. We compute this exposure as the total market value of properties held by REIT i in zip code l at time t, divided by the total market value of all properties held by REIT i at time t across all L zip codes.

For the computation of the weights, $\omega_{i,l,t}$, we estimate the market value of the properties in each REIT's portfolio at the end of a given week based on the asset-level information from S&P Global. In S&P Global, we observe the exact start and end dates of the holding period for each property in the sample REITs' portfolios. For each property owned by the sample REITs, we observe at least one of the following property value metrics periodically over the course of the holding period: acquisition price, sale price, initial cost, historic cost, or net book value. We estimate the market value of a REIT's properties on dates other than when we observe one of those five value metrics by assuming that time-series variation in the market value of a given property tracks the Real Capital Analytics (RCA) quarterly commercial property price index (CPPI) in that property's region (East, West, Midwest, and South). We compute *Density* on a weekly basis, using the most recent data available on the market value of a REIT's properties and location density. Given the lower frequency at which we observe variation in RCA's

[6]The focus of our investigation is the scope for a location to adjust its supply of real estate to demand shocks, proxied by higher location density. Location density may be elevated due to higher numbers of employees per square mile, or higher numbers of residents. As a result, although higher numbers of employees may not coincide perfectly with higher population numbers (the unconditional correlation between zip code-level population and employment across all U.S. zip codes is 59% over the study period), higher values of either one of those variables likely imply lower local supply elasticity.

CPPI (quarterly) and zip code-level employment density (annual), weekly fluctuations in *Density* are predominantly driven by changes in the composition of the sample REITs' property portfolio holdings.

2.3 REIT Location Beta

Our primary research objective is to document the relationship between REIT density and systematic risk exposure. In doing so, it is important to isolate the impact of density on REIT systematic risk exposure from the potentially confounding influence of the local industry composition in high- versus low-density locations. In other words, one might ask whether REITs with large property portfolio shares located in dense locations; for example, New York and San Francisco, are more exposed to systematic risk because they are in high-density locations — or because these locations have large exposures to highly pro-cyclical industries (in this example, finance and technology, respectively). In that case, it might be the underlying exposure of different locations to certain industries that is the real driver of any observed relationship between REIT density and systematic risk exposure, rather than density itself. We address this possibility by including in our analysis an additional REIT-level variable, denoted *Location Beta*.

To construct the variable *Location Beta*, we first identify, for each CBSA k, the publicly listed firms headquartered in that CBSA. We obtain information on the headquarter locations of the universe of publicly listed firms in the U.S. from Compustat. We then form market capitalization-weighted CBSA portfolios comprising the stock of all publicly listed firms headquartered in a given CBSA. We compute the weekly total return on those CBSA portfolios, in excess of the risk-free rate, denoted $CBSA\ Return_{k,t}$. We regress that return on the weekly excess return on the stock market, denoted $Market\ Return_t$, separately for each CBSA k, as shown below.[7]

$$CBSA\ Return_{k,t} = \alpha + \beta Market\ Return_t + \epsilon_t \tag{2}$$

where α is a constant, β measures the sensitivity of the weekly excess return on a given CBSA portfolio to variation in the excess return on the stock market, and ϵ is the residual. We estimate Eq. (2) on a rolling quarterly basis. Each quarterly regression uses weekly return observations from the previous

[7] As outlined in Section 2.5, we use the value-weighted return on all U.S. firms listed on a major stock exchange as the stock market benchmark, and we use the return on the one-month Treasury bill rate as the risk-free rate.

four quarters. From those regressions, we collect, for each CBSA k in each quarter t, the coefficient β. We denote the resulting CBSA×quarter-level variable *CBSA Systematic Risk*.

We then estimate *Location Beta* for REIT i at time t as the average *CBSA Systematic Risk* exposure across all K CBSAs in which REIT i holds properties at time t, weighted by REIT i's exposure to each of those K CBSAs through its property portfolio holdings at time t:

$$Location\ Beta_{i,t} = \sum_{k=1}^{K} \omega_{i,k,t} \times CBSA\ Systematic\ Risk_{k,t} \tag{3}$$

where $CBSA\ Systematic\ Risk_{k,t}$ is CBSA-level systematic risk, as defined above, and $\omega_{i,k,t}$ is the weight assigned to each CBSA, measured as the exposure of REIT i to CBSA k at time t. We compute this exposure as the total market value of properties held by REIT i in CBSA k at time t, divided by the total market value of all properties held by REIT i at time t across all K CBSAs. The variable *Location Beta* captures a given REIT's exposure to the pro-cyclicality of the local economies in the different CBSAs in which that REIT holds commercial property investments. By including this variable in our analysis, we are able to separate its effect on the systematic risk exposure of REITs with property holdings across different CBSAs from the effect of the density of those CBSAs on REIT systematic risk exposure.

2.4 REIT-Level Financial Variables

We include a number of REIT-level stock market performance measures and financial characteristics in our analyses. We compute the weekly *Total Return* for each of the sample REITs based on daily total return data from the CRSP Daily Stock File. We construct the weekly equity market capitalization of each sample REIT, denoted *Size* and expressed in $ billion, as the product of the stock's closing price and the number of shares outstanding at week-end, both also obtained from the CRSP Daily Stock File.

For each sample REIT, we compute two capital structure characteristics on a quarterly frequency (respectively, annual frequency). We define an indicator variable that takes the value of one if REIT i at time t has an investment-grade credit rating outstanding by S&P or Moody's, and zero otherwise. *Investment-Grade Rating* is defined as a long-term issuer rating better than BBB- for S&P, or better than Baa3 for Moody's. Quarterly data on REIT credit ratings are from S&P Global. Based on Compustat data, we compute each REIT's exposure to *Short-Term Debt* as the total amount of long-term debt due within one year (Compustat item DD1), scaled by the total amount of all long-term debt (item DLTT). This variable is observed annually. To match quarterly and annual data on capital structure characteristics to weekly return data, we carry forward the most recent observations of those characteristics until updated values become available with the next financial reporting cycle. This procedure allows us to avoid any look-ahead bias in our results.

Lastly, we obtain quarterly estimates on each sample REIT's *Implied Cap Rate*, measured as the ratio of long-term property net operating income to the implied market valuation of real estate, from S&P Global. Again, we carry forward the most recent observations of this variable until the next financial reporting period.

2.5 Market-Level Financial Variables

We compute two weekly market-level return measures. The *REIT Market Return* is the value-weighted return on all public U.S. equity REITs, based on daily total return data from the CRSP Daily Stock File.[8,9] The return on the risk-free rate is proxied by the return on the one-month Treasury bill rate, denoted *1-Month T-Bill Return*, from Ibbotson Associates.[10]

2.6 Location-Level Variables

In addition to the zip code-level density data discussed in Section 2.2, we also compute employment density on an annual basis for all major metropolitan areas among the U.S. CBSAs. The CBSA-level employment data are also obtained from the U.S. Census Bureau's County Business Patterns Survey.

[8] We compute the *REIT Market Return* as the value-weighted average return for all U.S. traded securities whose industry classification corresponds to equity REITs. The relevant industry classification codes vary over time due to periodic revisions of the underlying industry classification systems. Specifically, we include securities belonging to SIC code 6798 (classification used from the start of the study period until November 1995), GICS industry code 404010 and sub-industry 40401010 (used between December 1995 and April 2006), GICS industry code 404020 (except sub-industry 40402030 — denoting Mortgage REITs — used between May 2006 and August 2016), and GICS industry code 601010 (used from September 2016 until the end of the study period). For robustness, we repeat our analyses with the overall stock market return as benchmark. In those robustness tests, *Stock Market Return* is the value-weighted return on all CRSP firms incorporated in the U.S. and listed on the NYSE, AMEX, or NASDAQ stock exchanges, with CRSP share codes 10 or 11. The findings from those additional analyses are qualitatively similar to our main results, and are available upon request.

[9] It should be noted that we are calculating REIT betas with respect to the value weighted portfolio of REITs rather than a value-weighted portfolio of all stocks. To understand this, note that the tests are based on the idea that real estate returns in denser locations fluctuate more with the overall real estate market than the returns of real estate in low density markets. A focused real estate index better captures this idea much better than an overall market index. Moreover, given that REIT returns are much more highly correlated with the REIT index than the overall market index, we can more precisely measure differences in REIT betas calculated relative to REIT indexes.

[10] Weekly return data on the risk-free rate are taken from Kenneth French's Data Library.

To those CBSA–year observations of employment density we match annual CBSA-level data on new construction of commercial real estate. The data on new non-residential construction (total square footage of new construction starts) are obtained from Dodge Data and Analytics. The information on CBSA-level commercial real estate stock is from Costar.

3 Descriptive Statistics

The final sample contains 21,279 weekly observations from 30 unique multifamily REITs, and 27,243 weekly observations from 44 office REITs, over the 1994–2017 period. Figure 2 presents the number of multifamily and office REITs represented in the sample during each year of the study period. The figure shows that the number of multifamily REITs is stable at around 20 between 1994 and 2005, drops to 13 in the aftermath of the financial crisis in 2009 and 2010, and slightly increases during the subsequent recovery but fails to reach its prior peak. The figure further shows that the number of office REITs increases significantly after the introduction of the UPREIT regime in the early 1990s, reaches a maximum value of 31 in 2005, then drops to 18 at the height of the financial crisis in 2008 and 2009, and slowly recovers in the final years of the study period. Overall, the figure suggests a pro-cyclical pattern in the number of active multifamily and office REITs in the U.S.

FIGURE 2 ABOUT HERE.

Table 1 presents descriptive statistics on the sample REITs and the market-level financial variables used in our empirical analysis. All variables, except indicator variables, are winsorized at 1^{st} and 99^{th} percentiles. *Density* for multifamily (office) REITs averages 7,857 (44,426) employees per square mile. These statistics suggest that office REITs, on average, hold properties in locations with higher density than do multifamily REITs. Both multifamily and office REITs on average have a *Location Beta* of close to 1, implying that the stock returns of the firms headquartered in the CBSAs in which those REITs' property holdings are located vary in proportion with the overall U.S. stock market. The mean weekly *Total Return* is comparable across multifamily and office REITs, with 0.27% and 0.25%, respectively. Mean *Size* is also similar across the two types of REITs, with $2.51 billion and $2.42 billion, respectively. However, the median office REIT is substantially larger ($1.29 billion) than the median multifamily REIT ($0.84 billion). Multifamily REITs on average are more likely to have an active *Investment-Grade*

Rating, as the mean value of that indicator equals 42.86% for those REITs, compared to 34.59% for office REITs. On the other hand, those former REITs carry lower levels of *Short-Term Debt* (7.20% compared to 10.86%). The mean *Implied Cap Rate* of multifamily REITs (7.44%) falls below that of office REITs (8.42%) by a significant margin of approximately 100 basis points.

The descriptive statistics on the market-level financial variables presented in Table 1 suggest that both, multifamily and office REITs, deliver higher weekly total returns than the overall REIT market (0.20%) over the study period. During that period, the weekly return on the risk-free rate averages 0.05%.

Table 1 about here.

In Figure 3 we plot histograms for the distributions of mean *Density* across the multifamily REITs (Panel A) and office REITs (Panel B) in the sample. For the purposes of this figure, we compute mean *Density* for each REIT over its life in the sample. The figure shows a discernible difference between the two mean *Density* distributions. Consistent with the statistics reported in Table 1, the average density exposure of office REITs exceeds that of multifamily REITs. The difference in mean *Density* between the two REIT types is often substantial, as evidenced by the difference in the range of mean *Density* across the two distributions. Notably, mean *Density* for multifamily REITs ranges up to 25,000 employees per square mile, whereas it ranges up to over 250,000 employees per square mile for office REITs. The figure also shows significant cross-sectional variation in mean *Density* across individual multifamily REITs. The most heavily populated mean *Density* bucket in that distribution — the bucket for multifamily REITs with a weighted average density exposure of up to 5,000 employees per square mile — contains two thirds of all multifamily REITs in the sample (20 out of 30). The remaining third of multifamily REITs falls into higher density buckets. For office REITs, the mean *Density* distribution is more concentrated. Over 80% of those REITs (33 out of 40) fall into the density bucket representing firms with weighted average density exposure of up to approximately 50,000 employees per square mile. A small number of office REITs focus on very high-density locations. For instance, the office REIT with the highest mean *Density* exposure is SL Green Realty (mean density exposure of approximately 250,000 employees per square mile), whose property portfolio holdings are concentrated in New York City. In sum, the histograms depicted in Panels A and B of Figure 3 suggest that there is significant cross-sectional dispersion in exposure to high-density locations across the sample REITs, especially in the multifamily REIT sector.

Figure 3 about here.

Panel C (Panel D) cross-reference REIT density exposure (by *Density* quartile) and REIT size, measured as market capitalization, for multifamily (office) REITs. The figure suggests a positive correlation between REIT size and density exposure across both property types. The patterns shown also suggest that large REITs operate across the most and least dense locations, whereas small REITs are concentrated in the bottom density quartile.

Table 2 presents pairwise correlation coefficients between the main variables used in this study. The statistics reported indicate a positive correlation between *Density* and *Location Beta* for multifamily REITs. This result suggests that the stock market performance of firms headquartered in denser locations is more sensitive to variation in the return on the stock market, making those local economies more pro-cyclical. Further, *Density* of multifamily REITs is positively correlated with REIT *Size* and the presence of an *Investment-Grade Rating*, while it is inversely correlated with the *Implied Cap Rate*. These patterns suggest that REITs in denser locations are larger, more likely to hold active debt ratings, and that their properties are more expensive than those of REITs in less dense locations. We document similar correlation patterns for office REITs. The correlation patterns discussed here reinforce the need to separate the influence of urban density on REIT financial outcomes from that of the local industry composition and key REIT characteristics.

TABLE 2 ABOUT HERE.

4 Density and Real Estate Supply

We argue that patterns of real estate risk and return are driven by the density of the locations in which the investment properties are located. Our argument rests on the assumption that real estate supply is less elastic in denser locations. To test this assumption empirically, we estimate the following linear regression model relating new commercial real estate construction in a given CBSA–year to location density:

$$\begin{aligned} New\ Construction_{l,t} = \alpha + \beta_1 High\ Density_{l,t-1} + \beta_2 Aggregate\ New\ Construction_t + \\ \beta_3 High\ Density_{l,t-1} \times Aggregate\ New\ Construction_t + \epsilon_{l,t} \end{aligned} \quad (4)$$

where $New\ Construction_{l,t}$ measures unexpected shocks to the total square footage of new commercial construction for CBSA l in year t, scaled by lagged total stock. Those shocks are obtained as the residuals from CBSA-specific AR(1) models through which we filter the raw data on local new construction to account for the sticky nature of these time series. α is a constant term, and $High\ Density_{i,t-1}$ is an indicator that takes the value of one if CBSA l's *Density* at time $t-1$ was in the top 50% of the *Density* distribution across all CBSAs at time $t-1$. $Aggregate\ New\ Construction_t$ is the total square footage of new commercial construction across all U.S. CBSAs at time t, scaled by lagged aggregate stock. $\epsilon_{i,t}$ is the residual. We estimate Eq. (4) with standard errors clustered by CBSA. In alternative specifications, we first replace the main effect of $High\ Density_{i,t-1}$ with CBSA-fixed effects; then we replace the main effect of $Aggregate\ New\ Construction_t$ with year-fixed effects; lastly, we replace both sets of main effects with CBSA- and year- fixed effects, respectively.

Table 3 presents the estimation results for the CBSAs in our sample over the 1994–2017 period. The estimates in column (1) show that the coefficient on the interaction term between the*High Density* indicator and *Aggregate New Construction* is negative. This result implies that, given an increase in aggregate commercial real estate construction, locations with higher density experience a more sluggish response in new supply. The results reported in columns (2) through (4) suggest that this finding is qualitatively similar when replace the main effects of *High Density* and *Aggregate New Construction* with CBSA and year fixed effects, respectively. In sum, the findings presented in Table 3 are consistent with our hypothesis that new real estate supply is less elastic in locations with higher density. In the next section, we explore the implications of this finding for real estate rental growth across locations with different densities.

TABLE 3 ABOUT HERE.

5 Density and Real Estate Rents

The results presented in Section 4 indicate that the supply of real estate is less elastic in denser locations compared to less dense locations. This finding implies greater rental growth in denser locations on average. We expect this to be the case because a given positive demand shock has a greater impact on the rents generated by real estate investment properties situated in denser locations with less elastic supply.[11] In this section, we provide empirical support for both hypotheses. First, we analyze the

[11]Note that the reverse is not necessarily true for the response in local rental growth to negative demand shocks. That is because, as we argue in Section 1, the elasticity of supply to negative demand shocks is likely to be similarly low in denser and less dense locations.

relationship between location density and local rental growth. Then, we assess the response in real estate rents across locations with different density to aggregate demand shocks.

Since rents from a broad cross-section of real estate investment properties are difficult to observe, we use REIT net operating income (NOI) as a proxy for those rents.[12] To test the first hypothesis stated above, we estimate the following linear regression model relating NOI growth to density exposure:

$$\begin{aligned} NOI_{i,t} = \alpha + \beta_1 High\ Density_{i,t-1} + \beta_2 High\ Location\ Beta_{i,t-1} + \beta_3 Large\ Size_{i,t-1} + \\ \beta_4 Total\ Portfolio\ Area_{i,t} + \gamma_t + \epsilon_{i,t} \end{aligned} \tag{5}$$

where $NOI_{i,t}$ is the quarterly NOI growth rate for REIT i at time t, α is a constant term, and $High\ Density_{i,t-1}$ is an indicator that takes the value of one if REIT i's *Density* at time $t-1$ was in the top 50% of the *Density* distribution across all REITs of the same property type as REIT i at time $t-1$.[13] $High\ Location\ Beta_{i,t-1}$ is an indicator that takes the value of one if REIT i's *Location Beta* at time $t-1$ was above the median of the *Location Beta* distribution across all REITs of the same property type as REIT i at time $t-1$. We also construct an indicator for $Large\ Size_{i,t-1}$ according to the same cut-off points, based on the REIT property type-specific distributions of *Size* at time $t-1$. $Total\ Portfolio\ Area_{i,t}$ measures the total amount of square feet in a REIT i's portfolio at time t. We control for this variable since growth in total NOI may partly be driven by changes in the property portfolio composition of a given REIT. γ_t are year-fixed effects. $\epsilon_{i,t}$ is the residual. We estimate Eq. (5) with standard errors clustered by firm-year.

To test the second of the hypotheses stated above, we focus on real GDP growth as a proxy for aggregate demand shocks. Using this proxy, we estimate the following linear regression specification relating REIT NOI growth to density and variation in real GDP growth:

$$\begin{aligned} NOI_{i,t} = \alpha + \beta_1 High\ Density_{i,t-1} + \beta_2 High\ Location\ Beta_{i,t-1} + \beta_3 Large\ Size_{i,t-1} \\ + \beta_4 GDP\ Growth_{t-4} + \beta_5 High\ Density_{i,t-1} \times GDP\ Growth_{t-4} + \gamma_t + \epsilon_{i,t} \end{aligned} \tag{6}$$

[12] Our results are qualitatively similar when we use REIT rental growth as alternative proxy, as quarterly rates of REIT rental growth and NOI growth are 93% correlated in our sample.

[13] All of our results presented throughout the paper are robust to choosing alternative thresholds for the definition of high- versus low-density REITs, such as the top versus bottom 33% or 25% of the *Density* distribution.

where variables and notation follow Eq. (5). *GDP Growth*$_{t-4}$ is the quarterly rate of growth in real U.S. GDP four quarters in the past.[14] We estimate Eq. (6) with standard errors clustered by firm-year.

Table 4 presents the results from estimating the regressions described in Eq. (5) and (6) for the REITs in our sample over the 1994–2017 period. The estimates reported in column (1) suggest that multifamily REITs with high density exposure on average experience significantly higher NOI growth than multifamily REITs with low density exposure. The results presented in column (2) suggest that NOI growth for multifamily REITs with high density exposure also increases relatively more in response to a positive aggregate demand shock than NOI growth for multifamily REITs with low density exposure. The results in columns (3) and (4) show qualitatively similar results for the office REITs in our sample.[15]

Table 4 about here.

Importantly, the results in Table 4 hold after controlling for a REIT's *Location Beta*, implying that they are not due to variation in the pro-cyclicality of the local economies to which a given REIT is exposed through its property portfolio holdings. In all, the estimates presented here are consistent with our assumption that new real estate supply is less elastic in denser locations, resulting in (i) higher rental growth in denser locations on average; and (ii) greater sensitivity of rents to positive demand shocks in high-density locations compared to low-density locations.

6 Density and Real Estate Risk and Return

6.1 Time-Series Patterns of Systematic Risk

Our finding that NOI growth of REITs in denser locations responds more strongly to positive aggregate demand shocks suggests that those REITs should have higher systematic risk exposures. In this section, we assess the relationship between location density and real estate systematic risk in the time-series. To

[14]We choose a longer lag for GDP growth to account for the fact that leasing activity, which drives NOI growth, is sluggish given typical lease terms of at least one year in the property types we include in this study. Our results are robust to various alternative lag choices.

[15]The coefficient estimate on the *High Density* indicator in column (3), pertaining to the office REIT sub-sample, is numerically positive but statistically insignificant. We note that the coefficient on *Total Portfolio Area* in the same regression specification is significantly negative. In combination, those results suggest that office REITs may have expanded into lower-growth, high-density locations during our study period, reducing the magnitude of the coefficient on the *High Density* indicator compared to the magnitude of the corresponding coefficient in the multifamily REIT sub-sample.

do so, we first regress the weekly total return of the REITs belonging to a given property type on the weekly total return of the REIT market benchmark index. We estimate the following regression model:

$$R_t^p = \alpha + \beta_t Market_t + \epsilon_t \tag{7}$$

where R_t^p is the equal-weighted average return at time t of all REITs in a given property type p, with $p \in \{\text{multifamily, office}\}$.[16] α is a constant term. β_t captures the time-varying sensitivity of the REIT property-type average return to variation in the return on the REIT market benchmark index, which is denoted $Market_t$. ϵ_t is the residual. The weekly returns on REITs, R_t^p, and the returns on the REIT market benchmark index, $Market_t$, are measured in excess of the weekly *1-Month T-Bill Return*. Using those weekly excess return data, we estimate Eq. (7) by REIT property type on a rolling annual basis for each calendar year in the 1994-2017 period. We then collect the estimated values of the coefficient β_t from each of those non-overlapping, annual regressions. In this way, we compile an annual series of time-varying REIT systematic risk exposures by REIT property type. We then break the estimation of Eq. (7) down further by considering different density exposures (high versus low *Density*) within each of the REIT property types in the sample. In those annual regressions by density exposure type, high (low) density REITs are those that fall into the top (bottom) 50% of the property type-specific *Density* distribution in a given year.

We summarize the estimation results for the time-varying REIT systematic risk exposures by REIT property and density type in Figure 4. Panel A depicts annual estimates of REIT property type-specific systematic risk exposures relative to the *REIT Market Return* benchmark. The figure shows that the systematic risk exposures of multifamily and office REITs are close to one, reflecting the weights of those two REIT types in the overall equity REIT universe. The time-series patterns shown in this figure also indicate that the systematic risk exposure of office REITs exceeds that for multifamily REITs in most sample years.

FIGURE 4 ABOUT HERE.

[16]The number of active REITs in each property type included in our analysis is small in some years of the study period. If we computed value-weighted average returns across the REITs in a given property type, instead of equal-weighted average returns, those value-weighted returns would be proportionately more influenced by the performance of the largest REITs, and wouldn't necessarily reflect the performance of the typical REIT in a given property type. For this reason, we focus our analyses on equal-weighted average returns. We provide separate results on REIT-level return and systematic risk measures, controlling for REIT size, in Section 6.2.

Panel B depicts the time-series of annual systematic risk exposures broken down by REIT property type and density type (above- versus below-median *Density* in a given year) against the *REIT Market Return* as benchmark. The figure shows that, within multifamily REITs and office REITs, respectively, the systematic risk exposures for REITs with high density generally exceed those for REITs with low density. High-density office (multifamily) REITs exhibit greater systematic risk exposure than their low-density counterparts in 22 (20) out of 24 sample years. The estimates depicted suggest that the magnitude of the difference in systematic risk exposures between REITs in the high- versus low-density categories is also significant for both, multifamily and office REITs. The time-series patterns shown in this figure provide evidence consistent with our hypothesis that the returns of high-density REITs respond more strongly to systematic demand shocks, proxied by variation in the return on the overall REIT market, than those of low-density REITs.

6.2 Cross-Sectional Patterns of Systematic Risk

We dig deeper into our results pertaining to location density and real estate systematic risk by estimating REIT-level systematic risk exposures in the cross-section as a function of REIT-level *Density*. In this step of our empirical analysis, we control for a set of firm-characteristic covariates that capture other important determinants of REIT systematic risk identified in the prior literature.[17] Specifically, we employ the following regression specification:

$$\begin{aligned} R_{i,t} = \alpha + \beta_1 High\ Density_{i,t-1} + \beta_2 Market_t + \beta_3 High\ Density_{i,t-1} \times Market_t \\ \beta_4 High\ Location\ Beta_{i,t-1} + \beta_5 High\ Location\ Beta_{i,t-1} \times Market_t \\ \beta_6 Investment\text{-}Grade\ Rating_{i,t-1} + \beta_7 Investment\text{-}Grade\ Rating_{i,t-1} \times Market_t \\ \beta_8 High\ Short\text{-}Term\ Debt_{i,t-1} + \beta_9 High\ Short\text{-}Term\ Debt_{i,t-1} \times Market_t \\ \beta_{10} Large\ Size_{i,t-1} + \beta_{11} Large\ Size_{i,t-1} \times Market_t + \gamma_t + \epsilon_{i,t} \end{aligned} \tag{8}$$

where $R_{i,t}$ is the weekly excess return over the *1-Month T-Bill Return* on REIT i at time t, α is a constant term, and $High\ Density_{i,t-1}$ is an indicator that takes the value of one if REIT i's *Density* at time $t-1$ was in the top 50% of the *Density* distribution across all REITs of the same property type as REIT i at time $t-1$. $Market_t$ is the weekly *REIT Market Return*, measured in excess of the *1-Month*

[17] For a discussion of firm characteristics that determine REIT return performance, see Letdin et al. (2019).

T-Bill Return. *High Location Beta*$_{i,t-1}$ is an indicator that takes the value of one if REIT i's *Location Beta* at time $t-1$ was above the median of the *Location Beta* distribution across all REITs of the same property type as REIT i at time $t-1$. *Investment-Grade Rating* is an indicator that takes the value of one if REIT i has an investment-grade rating by S&P or Moody's outstanding at time $t-1$, and zero otherwise. We construct the indicators for *High Short-Term Debt*$_{i,t-1}$, and *Large Size*$_{i,t-1}$ according to the corresponding cut-off points along the medians of the REIT property type-specific distributions of *Short-Term Debt*, and *Size* at time $t-1$, respectively. γ_t are year-fixed effects. $\epsilon_{i,t}$ is the residual. The value of the coefficient β_3 in Eq. (8) captures the degree to which a REIT's property portfolio's exposure to high-density locations modulates firm-level systematic risk after controlling for the effects of REIT location beta, credit quality, refinancing risk exposure (through short-term debt holdings), and REIT size. We estimate Eq. (8) with standard errors clustered by firm-year. We replicate the estimation of Eq. (8) separately for multifamily and office REITs.

Table 5 presents the results from estimating the regression described in Eq. (8) for the sample REITs over the 1994–2017 period, focusing on the main predictors of interest only. Table 6 presents the corresponding output from the full specification shown in Eq. (8). In both tables, column (1) presents the regression results for multifamily REITs and column (2) presents output for office REITs.

TABLES 5 AND 6 ABOUT HERE.

The estimates shown in Table 5 suggest that the systematic risk exposure of high-density multifamily and office REITs is significantly greater than that of their peers with lower density exposures. The evidence presented here is consistent with our conjecture that the returns on portfolios of real estate assets located in high-density locations are more sensitive to variation in the return on the market than are the returns on low-density real estate portfolios.

We now turn to the discussion of the results from estimating the full model specified in Eq. (8). The estimates reported in column (1) of Table 6 indicate that the sensitivity of multifamily REITs in less dense locations to variation in the return on the REIT market is 0.59. The results reported also show that the sensitivity to variation in the return on the REIT market for multifamily REITs with property holdings in denser locations is significantly higher. The coefficient estimate on the interaction term between the high density exposure indicator and the excess return on the REIT market (0.11) implies that the systematic risk exposure (with respect to the REIT market benchmark) of multifamily REITs in denser locations is 0.70, or nearly 20% higher than the systematic risk exposure of multifamily REITs with properties in less dense locations. The estimates reported in column (2) show that the sensitivity of low-density office REIT returns to variation in the return on the overall REIT market is 0.84, exceeding that of low-density multifamily REITs by over 20 basis points. The regression results further indicate that the sensitivity of the stock returns on office REITs with greater density exposure to fluctuations in the REIT market return is numerically higher than that of their low-density counterparts (0.88, or 5% higher than for low-density office REITs).[18]

In sum, the evidence presented in Table 6 suggests that both multifamily and office REITs exhibit return performance properties generally associated with defensive stocks, as their systematic risk exposures are less than one. This result is consistent with prior findings; see, for instance, Chan et al. (1990), Glascock and Hughes (1995), and Howe and Shilling (1990). However, our results also imply that office REITs exhibit greater systematic risk exposure than multifamily REITs, suggesting that the return performance of office REITs on average is more sensitive to systematic demand shocks than that of multifamily REITs. When estimating systematic risk exposure by property type and density exposure type, we find that REITs with property portfolio holdings in locations characterized by higher density are exposed to higher systematic risk. Our results are robust to controlling for the potentially confounding influence of other key REIT characteristics that are correlated with REIT density exposure.

In the analysis of the results presented in Table 6, it is noteworthy that multifamily REITs with greater exposures to pro-cyclical local economies — those with higher location betas — also appear to carry higher systematic risk. However, as shown in Table 6, the *Location Beta* variable does not supersede the statistical and economic significance of the *Density* variable, suggesting that density and industry composition represent two separate channels through which location characteristics can affect the performance of real estate investments. Further, REIT investment-grade ratings are also significantly associated with higher REIT-level systematic risk. This finding may reflect the disproportionate concentration of larger REITs (which are more likely to have lower leverage and investment-grade credit ratings) in high-density locations. Our finding speaks to prior results on the

[18]The regression results reported in Table 6 show a noticeable difference in the numerical magnitude and the statistical significance of the marginal effect of higher density exposure on the systematic risk estimates across the two REIT property types in the sample. The greater strength of the empirical association between density exposure and systematic risk in multifamily REITs compared to office REITs is partly driven by the greater cross-sectional dispersion of density exposure among multifamily REITs, and the greater clustering by density exposure among the office REITs in the sample, as illustrated by the histograms in Figure 3.

empirical relationships between REIT performance and leverage (and short-term debt exposure), as established, for instance, in Giacomini et al. (2015), Sun et al. (2015), and Pavlov et al. (2018).

7 Density and Real Estate Financing

7.1 Leverage Levels

Our results on the positive association between location density and systematic risk could be driven by REIT financing choices. As shown in Table 2, higher density exposure is strongly positively correlated with REIT size and the availability of an investment-grade credit rating, which are also strongly correlated amongst each other. While we control for REIT size and the presence of an investment-grade rating in the regression specifications used to document the relationship between location density and systematic risk, we take our analysis one step further. In this section, we test whether there is also an empirical association between location density and the likelihood of a REIT having an investment-grade rating. To implement this test, we estimate the following regression using quarterly data on REIT debt ratings, density exposure, and control variables for the systematic risk exposures of different locations as well as for REIT size:

$$\begin{aligned} \textit{Investment-Grade Rating}_{i,t} = \alpha + \beta_1 \textit{High Density}_{i,t-1} + \beta_2 \textit{High Location Beta}_{i,t-1} + \\ \beta_3 \textit{Large Size}_{i,t-1} + \gamma_t + \epsilon_{i,t} \end{aligned} \tag{9}$$

where $\textit{Investment-Grade Rating}_{i,t}$ is an indicator that takes the value of one if REIT i at time t has an investment-grade credit rating outstanding from S&P or Moody's, α is a constant term, $\textit{High Density}_{i,t-1}$, $\textit{High Location Beta}_{i,t-1}$, and $\textit{Large Size}_{i,t-1}$ are indicators defined as under Eq. (8), γ_t are year-fixed effects, and $\epsilon_{i,t}$ is the residual. We estimate Eq. (9) in logit form, with standard errors clustered by firm-year. We replicate the estimation of Eq. (9) for the underlying REIT characteristics of *Density*, *Location Beta*, and *Size* measured continuously, instead of the *High Density*, *High Location Beta*, and *Large Size* indicators in the original specification shown above.

Table 7 presents the regression results from estimating Eq (9). The estimates shown in column (1) indicate that *High Density* multifamily REITs are significantly more likely to have an active investment-grade rating than are their peers with property portfolio holdings in less dense locations.

The results reported in column (2) are consistent with this inference. The estimates shown in columns (1) and (2) also suggest that multifamily REITs with *High Location Beta* and *Large Size* are more likely than their otherwise comparable peers to have an active investment-grade rating.

Table 7 about here.

The results reported in columns (3) and (4) suggest that *High Density* office REITs are also more likely to have an active investment-grade rating than are their peers with lower density exposure. The estimates reported in column (4) are again consistent with this inference. The estimates shown in columns (3) and (4) further indicate that office REITs with *High Location Beta* and *Large Size* are also more likely to have an active investment-grade credit rating than are their otherwise comparable peers.

To conclude, the results presented here suggest that REITs with property holdings in denser locations generally have better access to corporate credit markets (through the availability of debt ratings) and are perceived to be of higher credit quality, as implied by the availability of investment-grade corporate debt ratings.

8 Density and Real Estate Cap Rates

In the final step of our data analysis, we estimate the empirical association between location density and real estate cap rates. Our conjecture is that properties in high-density locations are more valuable, as local supply is more constrained. If this conjecture is true, then we expect to observe lower cap rates for real estate investment properties in denser locations. To test our hypothesis, we study REIT implied cap rates as a proxy for real estate cap rates. We estimate the following linear regression model using quarterly data on real estate implied cap rates, density exposures, and the familiar set of control variables we employed in our earlier regression models:

$$\begin{aligned} Implied\ Cap\ Rate_{i,t} = \alpha + \beta_1 High\ Density_{i,t-1} + \beta_2 High\ Location\ Beta_{i,t-1} + \\ \beta_3 Large\ Size_{i,t-1} + \gamma_t + \epsilon_{i,t} \end{aligned} \tag{10}$$

where $Implied\ Cap\ Rate_{i,t}$ is the ratio of long-term property net operating income to the implied market valuation of real estate for REIT i at time t, and the remaining variables and notation are defined as outlined under Eq. (9). We estimate Eq. (10) with standard errors clustered by firm-year.

In alternative specifications, we replicate the estimation of Eq. (10) for *Density*, *Location Beta*, and *Size* measured continuously.

Table 8 presents the regression results from estimating Eq. (10) for the multifamily REITs (columns (1) and (2)) and office REITs (columns (3) and (4)) in the sample. The results reported across all four columns of Table 8 indicate that REITs with higher density exposure exhibit lower implied cap rates. The documented results are generally consistent across multifamily and office REITs, and across the dichotomous and continuous measures of REIT density exposure.

TABLE 8 ABOUT HERE.

The coefficient estimates reported in column (1) suggest that the implied cap rate for high-density multifamily REITs — those in the top 50% of the density distribution — is on average 44 basis points lower than that for their low-density counterparts. The estimates shown in column (2) suggest that, for a one-standard deviation increase in density exposure, implied cap rates for multifamily REITs decline by nearly 25 basis points. The results reported in column (3) indicate that implied cap rates for high-density office REITs are 14 basis points below those of their low-density peers, but the coefficient is statistically insignificant. Further, we estimate that a one-standard deviation increase in density exposure for office REITs is associated with a statistically significant decline in implied cap rates of nearly 40 basis points (column (4)). In sum, the estimates presented in Table 8 provide empirical evidence consistent with the conjecture that — all else equal — REIT properties in denser locations are more valuable, due to tighter local supply constraints, leading to lower implied cap rates for high-density REITs relative to low-density REITs.

9 Concluding Remarks

In this study, we characterize the relationship between location density and the patterns of risk and returns in commercial real estate investments. To do so, we use a sample of multifamily and office REITs, which are publicly traded portfolios of real estate investment properties. For those REITs, we can easily observe granular information on asset holdings across denser and less dense locations as well as a broad set of investment performance measures. Using this empirical setting, we first estimate each REIT's weighted average density exposure across the locations in which their real estate investments are situated. We then relate this REIT-specific, time-varying measure of density exposure to a variety of REIT financial outcomes.

In all, we document three main results about the association between location density and REIT performance: (i) high-density REITs experience higher NOI growth — on average and after a positive aggregate demand shock — than their low-density peers; (ii) high-density REITs are more exposed to systematic risk than otherwise similar low-density REITs; (iii) REITs holding properties in high-density locations, where new supply is restricted, experience lower implied cap rates. As we show, these results derive from the differential supply responses to demand shocks in dense versus less dense locations.

Our findings suggest that location density is a significant driver of real estate investment risk and return. The evidence we present in this paper is consistent with geographical characteristics playing an important role in determining local rates of return in commercial real estate by modulating the sensitivity of local real estate investment performance to systematic demand shocks.

We believe that our analysis of the link between property locations and systematic risk is the first study that examines the fundamental spatial determinants of the systematic risk of real estate. This is important for at least two practical reasons: The first is that it helps us better understand the link between the fundamental nature of the real estate held by REITs and the observed return patterns of REITs. To what extent do REIT investors appreciate these relatively subtle location-level differences? The second is that by learning more about the determinants of systematic risk, we can help REIT portfolio managers, as well as investors in physical real estate, better optimize their portfolios.

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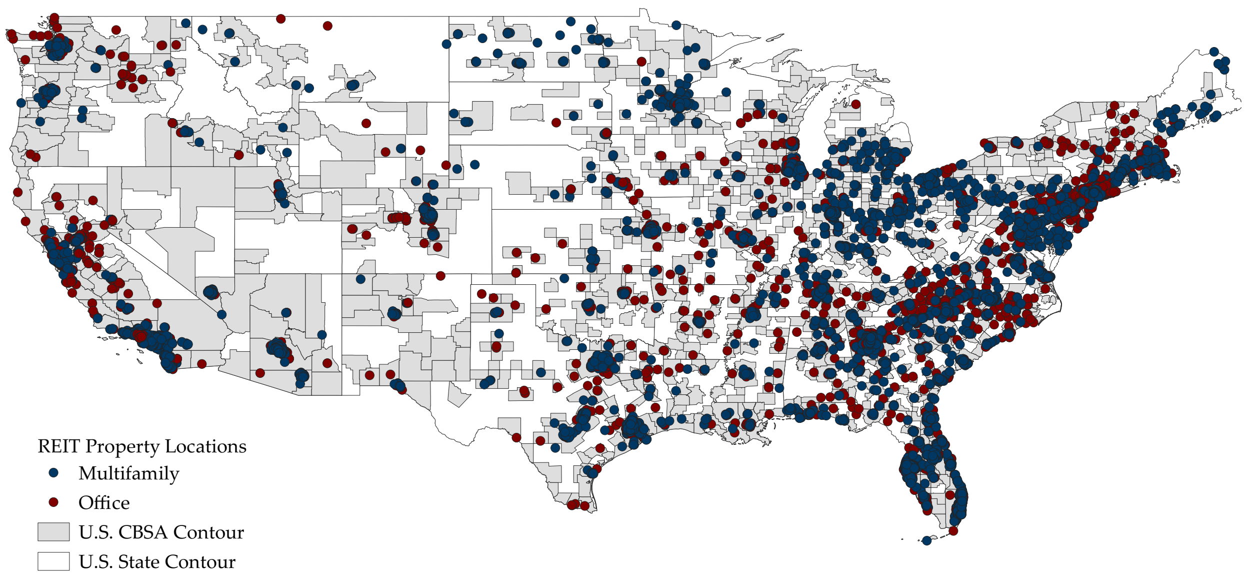


Figure 1. Real Estate Holdings Locations of Sample REITs by Property Type. The figure shows the geographical distribution across U.S. CBSAs of the commercial real estate assets held by the multifamily REITs (blue circles) and office REITs (red circles) in our sample. Sources: S&P Global and U.S. Census.

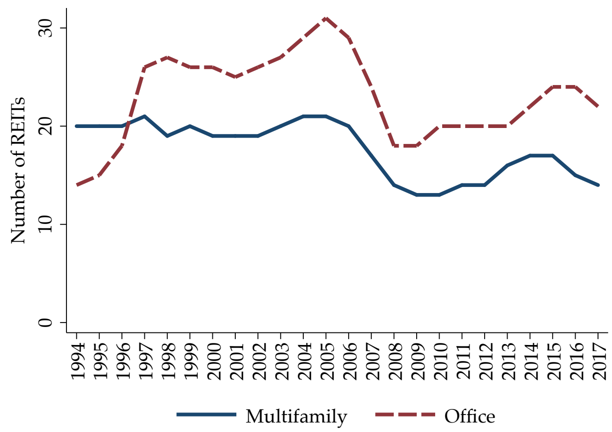
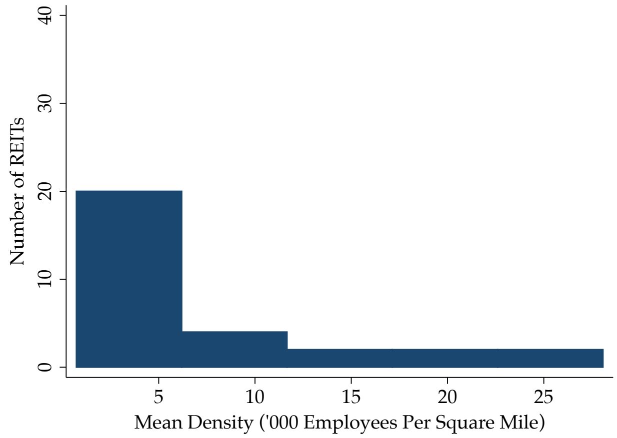
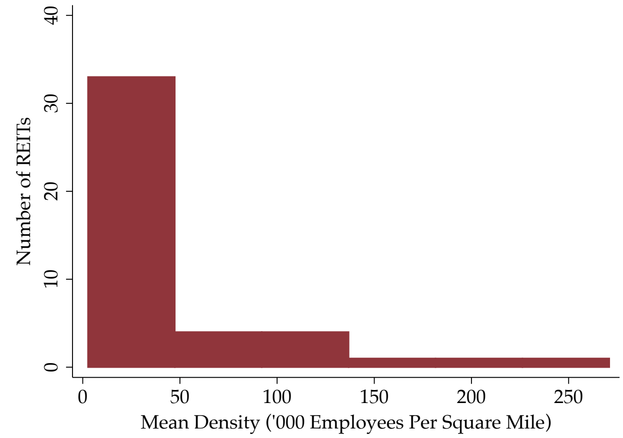


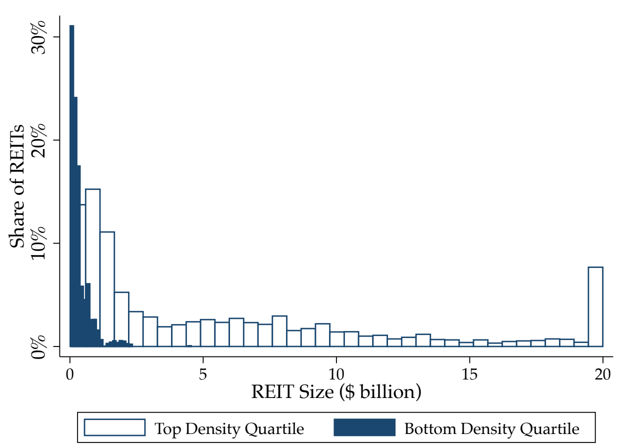
Figure 2. Annual Numbers of Sample REITs by Property Type. The figure shows the number of unique multifamily and office REITs in our final sample in each year of the 1994–2017 period.



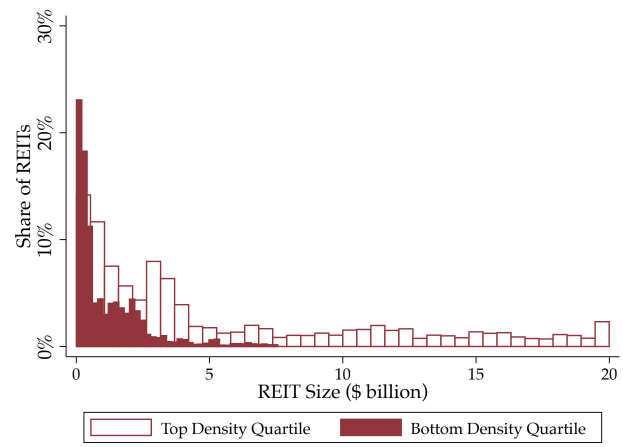
(A) Multifamily REITs Mean Density



(B) Office REITs Mean Density

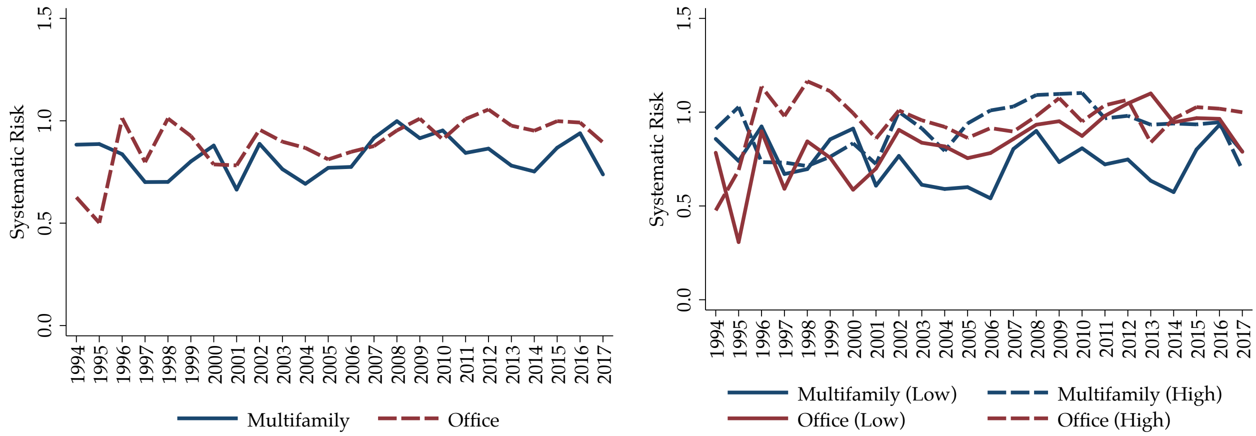


(C) Multifamily REITs Density and Size



(D) Office REITs Density and Size

Figure 3. Density Distribution by REIT Property Type and Size. Panel A (Panel B) shows the number of REITs in each bucket of mean *Density* for the multifamily (office) REITs in the sample. *Density* is the property market value-weighted average of zip code-level employment density (in thousands of employees per square mile) to which a REIT is exposed through its property portfolio holdings across different zip codes. These panels depict the mean values of *Density*, computed for each REIT over its life in the sample. Panel C (Panel D) shows the size distribution (measured as REIT market capitalization in $ billion) in the top and bottom *Density* quartiles across all REITs in a given property type in each sample year.



(A) Property Types

(B) Density Exposures

Figure 4. REIT Systematic Risk Exposures by Property Type and Density. Panel A depicts the time-series of annual REIT systematic risk exposures by property type. Panel B depicts the time-series of annual REIT systematic risk exposures by property type and *Density* exposure. Systematic risk is measured against the *REIT Market Return* as benchmark. The annual estimates of systematic risk exposures are derived from the estimation of Eq. (7).

Table 1. Descriptive Statistics

This table presents descriptive statistics for the main variables used in our empirical analyses over the 1994–2017 period. *Density* is based on annual zip code-level employment density data from the Census Bureau's County Business Patterns survey, measured in thousands of employees per square mile, and weighted by a given REIT's exposure to different zip codes through its property portfolio holdings. *Location Beta* is the average systematic risk exposure of the CBSAs where the sample REITs hold properties at the end of a given quarter, weighted by each REIT's exposure to different CBSAs through its property portfolio holdings. *Total Return* is the weekly total return on a given REIT's stock. *Size* is a REIT's stock price, multiplied by the number of shares outstanding, both measured at week-end. Data on stock returns, stock prices, and the number of shares outstanding are from the CRSP Daily Stock File. *Investment-Grade Rating* is an indicator that takes the value of one if a REIT has an investment-grade rating by S&P or Moody's outstanding in a given quarter, and zero otherwise. Data on REIT credit ratings are from S&P Global. *Short-Term Debt*, computed from Compustat data, is the principal amount of long-term debt outstanding that matures within one year (Compustat item DD1), scaled by total long-term debt outstanding (item DLTT). This variable is observed annually. *Implied Cap Rate* is long-term property net operating income, scaled by the implied market valuation of real estate. This variable is observed quarterly, and data are from S&P Global. *REIT Market Return* is the value-weighted return on all REITs in the CRSP universe. *1-Month T-Bill Return* proxies for the risk-free rate. Data on the stock market return and the return on the risk-free rate are taken from Kenneth French's Data Library. All variable definitions are provided in Section 2.

	N	Mean	SD	Median	Min	Max
Multifamily						
Density	21,279	7.8572	10.3513	3.8109	0.6931	65.5359
Location Beta	21,279	0.9446	0.1584	0.9776	0.4839	1.4227
Total Return	21,279	0.0027	0.0319	0.0021	-0.1027	0.1089
Size	21,279	2.5057	4.0428	0.8435	0.0111	19.9937
Investment-Grade Rating	21,279	0.4286	0.4949	0.0000	0.0000	1.0000
Short-Term Debt	16,708	0.0720	0.0858	0.0496	0.0000	0.8339
Implied Cap Rate	13,271	7.4418	1.5844	7.4368	4.5608	11.7213
Office						
Density	27,243	44.4262	65.6687	18.8915	0.6931	290.9172
Location Beta	27,243	0.9995	0.1438	0.9996	0.4839	1.4227
Total Return	27,243	0.0025	0.0348	0.0023	-0.1027	0.1089
Size	27,243	2.4154	3.5781	1.2938	0.0080	19.9937
Investment-Grade Rating	27,243	0.3459	0.4757	0.0000	0.0000	1.0000
Short-Term Debt	18,492	0.1086	0.1636	0.0458	0.0000	0.8339
Implied Cap Rate	17,148	8.4230	1.8748	8.3828	4.5608	12.6487
Market-Level Variables						
REIT Market Return	1,252	0.0020	0.0243	0.0030	-0.0768	0.0708
1-Month T-Bill Return	1,252	0.0005	0.0005	0.0004	0.0000	0.0013

Table 2. Pairwise Correlation Coefficients

This table presents pairwise correlation coefficients between the main variables used in our empirical analyses over the 1994–2017 period. *Density* is based on annual zip code-level employment density data from the Census Bureau's County Business Patterns survey, measured in thousands of employees per square mile, and weighted by a given REIT's exposure to different zip codes through its property portfolio holdings. *Location Beta* is the average systematic risk exposure of the CBSAs where the sample REITs hold properties at the end of a given quarter, weighted by each REIT's exposure to different CBSAs through its property portfolio holdings. *Total Return* is the weekly total return on a given REIT's stock. *Size* is a REIT's stock price, multiplied by the number of shares outstanding, both measured at week-end. Data on stock returns, stock prices, and the number of shares outstanding are from the CRSP Daily Stock File. *Investment-Grade Rating* is an indicator that takes the value of one if a REIT has an investment-grade rating by S&P or Moody's outstanding in a given quarter, and zero otherwise. Data on REIT credit ratings are from S&P Global. *Short-Term Debt*, computed from Compustat data, is the principal amount of long-term debt outstanding that matures within one year (Compustat item DD1), scaled by total long-term debt outstanding (item DLTT). This variable is observed annually. *Implied Cap Rate* is long-term property net operating income, scaled by the implied market valuation of real estate. This variable is observed quarterly, and data are from S&P Global. All variable definitions are provided in Section 2.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Multifamily							
(1) Density	1.0000						
(2) Location Beta	0.1945	1.0000					
(3) Total Return	-0.0015	0.0067	1.0000				
(4) Size	0.5904	0.2385	0.0106	1.0000			
(5) Investment-Grade Rating	0.4830	0.2621	-0.0038	0.5290	1.0000		
(6) Short-Term Debt	0.0653	0.0911	-0.0012	0.0182	0.0169	1.0000	
(7) Implied Cap Rate	-0.3822	-0.3530	0.0205	-0.5714	-0.4064	-0.0659	1.0000
Office							
(1) Density	1.0000						
(2) Location Beta	-0.0276	1.0000					
(3) Total Return	-0.0025	0.0011	1.0000				
(4) Size	0.7559	0.0578	0.0106	1.0000			
(5) Investment-Grade Rating	0.3269	-0.0194	-0.0023	0.4909	1.0000		
(6) Short-Term Debt	-0.0417	0.2215	0.0072	-0.0886	-0.0847	1.0000	
(7) Implied Cap Rate	-0.3819	-0.1402	0.0273	-0.5049	0.0059	0.0932	1.0000

Table 3. Real Estate Supply Elasticity as a Function of Location Density

This table reports output from Eq. (4). The dependent variable is unexpected shocks to the total square footage of new commercial real estate construction in CBSA l at time t, scaled by lagged total commercial real estate stock. We obtain those unexpected shocks by filtering local new construction through an AR(1) model and collecting the residuals. *High Density* is an indicator that takes the value of one if CBSA l's *Density* at time $t-1$ was in the top 50% of the underlying distribution. *Density* is based on annual CBSA-level employment density data from the Census Bureau's County Business Patterns survey, measured in thousands of employees per square mile. *Aggregate New Construction* is the total square footage of new commercial construction across all U.S. CBSAs at time t, scaled by lagged aggregate stock. Data on new construction are from Dodge Data and Analytics. Data on commercial real estate stock are from Costar. All regressions are estimated over the 1994–2017 period. CBSA- and time-fixed effects are included as indicated. Robust standard errors, clustered by CBSA, are reported in parentheses.

	(1)	(2)	(3)	(4)
High Density	0.003**		0.003**	
	(0.001)		(0.001)	
Aggregate New Construction	0.723***	0.684***		
	(0.065)	(0.049)		
High Density × *Aggregate New Construction*	-0.135**	-0.093*	-0.135**	-0.085*
	(0.068)	(0.048)	(0.068)	(0.048)
Constant	-0.015***	-0.012***	0.000	0.001*
	(0.001)	(0.000)	(0.000)	(0.001)
Observations	7,875	7,875	7,875	7,875
R-squared	0.10	0.11	0.11	0.12
CBSA-Fixed Effects	No	Yes	No	Yes
Year-Fixed Effects	No	No	Yes	Yes
Standard Errors Clustered By	CBSA	CBSA	CBSA	CBSA

Statistical significance is indicated as follows: *** p <0.01, ** p <0.05, * p <0.1.

Table 4. REIT NOI Growth as a Function of Density

This table reports output from Eq. (5) and (6). The specifications reported in columns (1) and (2) ((3) and (4)) refer to the estimation of *NOI Growth* for multifamily (office) REITs, respectively. Odd (even) columns present the results from estimating Eq. (5) (Eq. (6)), respectively. *NOI Growth* is the quarterly rate of growth in REIT-level net operating income (NOI). *High Density* is an indicator that takes the value of one if REIT i's *Density* at time $t-1$ was in the top 50% of the underlying distribution. *Density* is based on annual zip code-level employment density data from the Census Bureau's County Business Patterns survey, measured in thousands of employees per square mile, and weighted by a given REIT's exposure to different zip codes through its property portfolio holdings. *High Location Beta* is an indicator that takes the value of one if REIT i's *Location Beta* at time $t-1$ was in the top 50% of the underlying distribution. *Location Beta* is the average systematic risk exposure of the CBSAs where the sample REITs hold properties at the end of a given quarter, weighted by each REIT's exposure to different CBSAs through its property portfolio holdings. *Large Size* is an indicator that takes the value of one if REIT i's *Size* at time $t-1$ was in the top 50% of the underlying distribution. *Size* is a REIT's market capitalization, measured as its stock price multiplied by the number of shares outstanding. *Total Portfolio Area* is the quarterly total amount of square feet in REIT i's portfolio at time t. *GDP Growth* is the quarterly rate of growth in real U.S. GDP, measured four quarters in the past and obtained from the Federal Reserve Bank of St. Louis's Economic Database. Data on stock prices and the number of shares outstanding are from the CRSP Daily Stock File. All regressions are estimated over the 1994–2017 period. Time-fixed effects are included as indicated. Robust standard errors, clustered by firm-year, are reported in parentheses.

	Multifamily		Office	
	(1)	(2)	(3)	(4)
High Density	0.025**	-0.004	0.008	-0.011
	(0.011)	(0.005)	(0.007)	(0.007)
High Location Beta	0.017	0.000	0.004	0.001
	(0.013)	(0.005)	(0.007)	(0.006)
Large Size	-0.007	-0.008	0.001	-0.019***
	(0.011)	(0.006)	(0.007)	(0.007)
Total Portfolio Area	-0.008		-0.024***	
	(0.007)		(0.006)	
GDP Growth		-0.224		0.197
		(0.151)		(0.247)
High Density × *GDP Growth*		0.308**		0.413*
		(0.153)		(0.230)
Constant	0.004	0.003	0.061***	0.137***
	(0.027)	(0.010)	(0.014)	(0.039)
Observations	280	1,325	992	1,772
R-squared	0.09	0.13	0.04	0.12
Year-Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors Clustered By	Firm-Year	Firm-Year	Firm-Year	Firm-Year

Statistical significance is indicated as follows: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5. REIT-Level Systematic Risk as a Function of Density (Simple Specification)

This table reports output from Eq. (8), focusing on the main predictors of interest only. Column (1) (Column (2)) refers to the estimation results for multifamily (office) REITs. *High Density* is an indicator that takes the value of one if REIT i's *Density* at time $t-1$ was in the top 50% of the underlying distribution. *Density* is based on annual zip code-level employment density data from the Census Bureau's County Business Patterns survey, measured in thousands of employees per square mile, and weighted by a given REIT's exposure to different zip codes through its property portfolio holdings. *Benchmark Return* is the return on the overall REIT market. All regressions are estimated based on weekly return data over the 1994–2017 period. Time-fixed effects are included as indicated. Robust standard errors, clustered by firm-year, are reported in parentheses.

	Multifamily (1)	Office (2)
High Density	0.000	0.000
	(0.000)	(0.000)
Benchmark Return	0.748***	0.884***
	(0.028)	(0.025)
High Density × *Benchmark Return*	0.225***	0.099***
	(0.034)	(0.031)
Constant	0.001	0.002*
	(0.001)	(0.001)
Observations	21,249	27,199
R-squared	0.399	0.407
Year-Fixed Effects	Yes	Yes
Standard Errors Clustered By	Firm-Year	Firm-Year

Statistical significance is indicated as follows:
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6. REIT-Level Systematic Risk as a Function of Density (Full Specification)

This table reports output from Eq. (8). Column (1) (Column (2)) refers to the estimation results for multifamily (office) REITs. *High Density* is an indicator that takes the value of one if REIT i's *Density* at time $t-1$ was in the top 50% of the underlying distribution. *Density* is based on annual zip code-level employment density data from the Census Bureau's County Business Patterns survey, measured in thousands of employees per square mile, and weighted by a given REIT's exposure to different zip codes through its property portfolio holdings. *Benchmark Return* is the return on the overall REIT market. *High Location Beta* is an indicator that takes the value of one if REIT i's *Location Beta* at time $t-1$ was in the top 50% of the underlying distribution. *Location Beta* is the average systematic risk exposure of the CBSAs where the sample REITs hold properties at the end of a given quarter, weighted by each REIT's exposure to different CBSAs through its property portfolio holdings. *Investment-Grade Rating* is an indicator that takes the value of one if a REIT has an investment-grade rating by S&P or Moody's outstanding at time $t-1$, and zero otherwise. *High Short-Term Debt* is an indicator that takes the value of one if REIT i's ratio of long-term debt due within one year to total long-term debt at time $t-1$ was in the top 50% of the underlying distribution. *Large Size* is an indicator that takes the value of one if REIT i's market capitalization at time $t-1$ was in the top 50% of the underlying distribution. All regressions are estimated based on weekly return data over the 1994–2017 period. Time-fixed effects are included as indicated. Robust standard errors, clustered by firm-year, are reported in parentheses.

	Multifamily (1)	Office (2)
High Density	0.000	0.000
	(0.000)	(0.000)
Benchmark Return	0.593***	0.838***
	(0.034)	(0.034)
High Density × *Benchmark Return*	0.108***	0.040
	(0.033)	(0.033)
High Location Beta	0.001*	0.001***
	(0.000)	(0.000)
High Location Beta × *Benchmark Return*	0.142***	-0.006
	(0.029)	(0.029)
Investment-Grade Rating	0.000	0.000
	(0.000)	(0.000)
Investment-Grade Rating × *Benchmark Return*	0.211***	0.089***
	(0.041)	(0.034)
High Short-Term Debt	0.000	0.000
	(0.000)	(0.000)
High Short-Term Debt × *Benchmark Return*	0.036	-0.017
	(0.029)	(0.032)
Large Size	-0.001**	-0.001
	(0.000)	(0.000)
Large Size × *Benchmark Return*	0.044	0.146***
	(0.033)	(0.033)
Constant	0.001	0.000
	(0.001)	(0.001)
Observations	16,699	18,464
R-squared	0.440	0.429
Year-Fixed Effects	Yes	Yes
Standard Errors Clustered By	Firm-Year	Firm-Year

Statistical significance is indicated as follows:
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 7. REIT Investment-Grade Ratings as a Function of Density

This table reports output from Eq. (9). The specifications reported in columns (1) and (2) ((3) and (4)) refer to the estimation of the presence of an *Investment-Grade Rating* for multifamily (office) REITs, respectively. *Investment-Grade Rating* is an indicator that takes the value of one if a REIT has an investment-grade rating by S&P or Moody's outstanding at time t, and zero otherwise. *High Density* is an indicator that takes the value of one if REIT i's *Density* at time $t-1$ was in the top 50% of the underlying distribution. *Density* is based on annual zip code-level employment density data from the Census Bureau's County Business Patterns survey, measured in thousands of employees per square mile, and weighted by a given REIT's exposure to different zip codes through its property portfolio holdings. *High Location Beta* is an indicator that takes the value of one if REIT i's *Location Beta* at time $t-1$ was in the top 50% of the underlying distribution. *Location Beta* is the average systematic risk exposure of the CBSAs where the sample REITs hold properties at the end of a given quarter, weighted by each REIT's exposure to different CBSAs through its property portfolio holdings. *Large Size* is an indicator that takes the value of one if REIT i's *Size* at time $t-1$ was in the top 50% of the underlying distribution. *Size* is a REIT's market capitalization, measured as its stock price multiplied by the number of shares outstanding. Data on stock prices and the number of shares outstanding are from the CRSP Daily Stock File. All regressions are estimated over the 1994–2017 period. Time-fixed effects are included as indicated. Robust standard errors, clustered by firm-year, are reported in parentheses.

	Multifamily		Office	
	(1)	(2)	(3)	(4)
High Density	1.697**		1.457*	
	(0.431)		(0.287)	
High Location Beta	0.619**		1.240	
	(0.129)		(0.203)	
Large Size	17.817***		5.497***	
	(4.459)		(1.091)	
Density		1.072***		0.988***
		(0.024)		(0.002)
Location Beta		0.076***		0.068***
		(0.071)		(0.067)
Size		5.810***		8.788***
		(1.091)		(1.733)
Constant	0.156***	0.000***	0.159***	0.000***
	(0.032)	0.000	(0.030)	0.000
Observations	1,513	1,511	2,036	2,035
Pseudo R-squared	0.31	0.49	0.13	0.40
Year-Fixed Effects	No	No	No	No
Standard Errors Clustered By	Firm-Year	Firm-Year	Firm-Year	Firm-Year

Statistical significance is indicated as follows: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8. REIT Implied Cap Rates as a Function of Density

This table reports output from Eq. (10). The specifications reported in columns (1) and (2) ((3) and (4)) present the results for multifamily (office) REITs. *Implied Cap Rate* is the ratio of long-term property net operating income to the implied market valuation of real estate observed for REIT i at time t. Data on implied cap rates are from S&P Global. *High Density* is an indicator that takes the value of one if REIT i's *Density* at time $t-1$ was in the top 50% of the underlying distribution. *Density* is based on annual zip code-level employment density data from the Census Bureau's County Business Patterns survey, measured in thousands of employees per square mile, and weighted by a given REIT's exposure to different zip codes through its property portfolio holdings. *High Location Beta* is an indicator that takes the value of one if REIT i's *Location Beta* at time $t-1$ was in the top 50% of the underlying distribution. *Location Beta* is the average systematic risk exposure of the CBSAs where the sample REITs hold properties at the end of a given quarter, weighted by each REIT's exposure to different CBSAs through its property portfolio holdings. *Large Size* is an indicator that takes the value of one if REIT i's *Size* at time $t-1$ was in the top 50% of the underlying distribution. *Size* is a REIT's market capitalization, measured as its stock price multiplied by the number of shares outstanding. Data on stock prices and the number of shares outstanding are from the CRSP Daily Stock File. All regressions are estimated over the 1994–2017 period. Time-fixed effects are included as indicated. Robust standard errors, clustered by firm-year, are reported in parentheses.

	Multifamily		Office	
	(1)	(2)	(3)	(4)
High Density	-0.436***		-0.141	
	(0.110)		(0.141)	
High Location Beta	0.009		0.073	
	(0.080)		(0.128)	
Large Size	-0.735***		-0.907***	
	(0.110)		(0.144)	
Density		-0.022***		-0.006***
		(0.004)		(0.001)
Location Beta		-0.885**		-0.446
		(0.402)		(0.513)
Size		-0.229***		-0.339***
		(0.046)		(0.109)
Constant	8.850***	11.956***	8.934***	12.816***
	(0.155)	(0.666)	(0.946)	(1.745)
Observations	964	964	1,277	1,277
R-squared	0.78	0.80	0.43	0.50
Year-Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors Clustered By	Firm-Year	Firm-Year	Firm-Year	Firm-Year

Statistical significance is indicated as follows: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.