**How Different Is Real Estate? A Story of Factors**

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**Abstract**

How different is real estate from stocks and bonds? This paper sheds light on this question with new data and new methods. Analyzing 10,848 commercial properties from 1977 to 2017, we find that properties' risk premiums contain systematic components that are orthogonal to a comprehensive list of stock and bond factors. We call these components real estate factors. We also find that properties in each region and property type have their own factors. The real estate factors have substantial incremental explanatory power for individual properties' risk premiums, and properties' attributes are related to their loadings of the real estate factors.

Key words: Real estate, risk premium, factors

JEL classification: G12, R33

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## 1. Introduction

This paper aims to use new data and new methods to shed light on a basic question in real estate asset pricing, which is how different real estate is from stocks and bonds. The importance of real estate as an asset class depends on answers to a few questions. First, is real estate large enough in the economy and does it have significant enough effects on the economy? The answers are yes. Real estate, including housing and commercial real estate, is the largest asset class in the U.S. (see, e.g. Chetty and Szeidl (2007), and Chetty, Sandor and Szeidl (2017)), and its impact on the economy has been substantiated in many scenarios, including the 2008 economic recession. Second, is real estate different enough from other assets to warrant its own literature? It is a commonly accepted notion that real estate is different and the literature has documented many unique features of real estate returns (see e.g. Pivo and Fisher (2011), Ikramov and Yavas (2012), and Sagi (2017)), but little has been done to directly test and quantify the differences between returns of real estate and those of stocks and bonds in a conventional framework such as factor models.

The lack of direct and quantitative analyses seems to be due to two reasons. First, high-quality data of real estate returns are rarely available. In fact, up to now, capital expenditures of owner-occupied housing are still largely unavailable, so it is difficult to accurately measure housing investment returns. Fortunately, the National Council of Real Estate Investment Fiduciaries (NCREIF) recently made its database available to some researchers, which contains detailed cash flow information and thus makes it possible to accurately calculate investment returns. Second, traditional asset pricing frameworks are often not suitable to simultaneously analyze returns of real estate and stocks and bonds, as stocks and bonds are liquid but real estate is not (see, e.g. Riddiough, Moriarty and Yeatman (2005)). This has been changed over the past decade as economists have developed and refined a holding-period factor framework that relates low-frequency real estate returns to high-frequency factors (see, e.g. Cochrane (2005), Driessen, Lin and Phalippou (2012), Franzoni, Nowak and Phalippou (2012) and Peng (2016)). This paper brings together the recently available high-quality commercial real estate data and the holding-period factor framework to shed new light on the differences between returns of real estate and those of stocks and bonds.

Specifically, this paper aims to answer the following questions. First, do individual properties' risk premiums contain systematic components that are orthogonal to a comprehensive list of stock and bond factors? We call these orthogonal components the real estate factors. Second, can we construct indices to track real estate factors' effects on properties' risk premiums across time? Third, how much additional explanatory power can the real estate factors provide for individual properties' risk premiums? Fourth, does there exist a hierarchy of real estate factors at the levels of the whole market, regions, and property types? Finally, is there heterogeneity in properties' loadings of the real estate factors?

The holding-period factor framework suits our research. First, they allow us to explicitly control for stock and bond factors and formally test the existence of additional systematic components of real estate risk premiums. Second, they allow us to extract information from properties' risk premiums to construct indices to track the pricing effects of real estate factors. Third, including both the stock and bond factors and indices of the real estate factors in the same models allows us to directly quantify the incremental explanatory power of the real estate factors for properties' risk premiums. Fourth, they allow us to easily test possible heterogeneity in individual properties' loadings of the real estate factors.

We conduct our analysis using the proprietary dataset of commercial real estate from the National Council of Real Estate Investment Fiduciaries (NCREIF). This dataset has a few big advantages. First and foremost, this dataset contains complete cash flow information, particularly capital expenditures, that allows us to accurately measure properties' investment returns. Second, its sample size is large. The dataset consists of the entire population of properties invested by all NCREIF members, including about 37,000 properties located in all 50 states of the U.S. and the Columbia District, with a total acquisition value of over 1 trillion dollars. The clean final sample we use consists of 10,848 properties with a total value of 354 billion dollars. Finally, the sample period the dataset covers is perhaps the longest of any U.S. real estate datasets. The period is from 1977 to 2017, which covers multiple economic cycles.

We use a novel two-step approach in the holding-period factor framework to formally test the existence of the real estate factors. In the first step, we regress the cross section of individual properties' holding period risk premiums against a comprehensive list of stock and bond factors during their respective holding periods. Apparently, residuals from this regression are orthogonal to the stock and bond factors. In the second step, we regress residuals from the first step against time dummies for periods when properties were held. The coefficient of each time dummy is essentially an index value of the pricing effects of the real estate factors in that period. Should residuals contain pure noise, coefficients of all the time dummies (all index values) should be zero, which is a hypothesis that we are able to directly test. Rejecting the hypothesis would suggest that residuals contain systematic components, which indicates the existence of real estate factors.

We find very strong evidence for the existence of the real estate factors. We reject the null hypothesis that the index of real estate factors is zero in all periods at the 1% level for (1) the clean sample of 10,848 properties, (2) properties located in each of four regions, the East, Midwest, South, and West regions, and (3) properties belonging to each of the four main property types: apartment, industrial, office, and retail properties. We also find that properties have region- and type-specific factors after we control away the whole-market index of real estate factors.

To evaluate the explanatory power of the real estate factors, we bootstrap an out-of-sample predicting regression for 3,000 rounds. In each round we randomly split residuals from the first step of the two-step procedure into two groups with equal size. We then (1) estimate the index of the pricing effects of the real estate factors using one group of residuals, and (2) regress residuals of the other group against the index values during each property's holding period. We find strong evidence that the index of the real estate factors has out of sample explanatory power. To validate this bootstrapping approach, using artificial data generated from a factor model that is consistent with the estimated factors and the distribution of residuals, we demonstrate that the bootstrapping procedure will not generate the observed results should properties' risk premiums not contain real estate factors.

We further quantify the explanatory power of the real estate factors for individual properties' risk premiums in holding-period factor models. After including the index of the real estate factors in models that already include the stock and bond factors, the adjusted R squared of fitting properties' risk premiums to the factor models can increase by up to 68%. This shows substantial explanatory power of the real estate factors. Since the index is only the aggregate of the pricing effects of many real estate factors, the improvement in the adjusted R squared should be considered as the lower bound of the explanatory power that can be gained by treating real estate differently from stocks and bonds.

We then construct a hierarchy of indices of the real estate factors at the levels of the whole market, regions, and property types. The regional indices are orthogonal to the whole market index, and the type indices are orthogonal to both the whole market and the regional indices. We include these indices subsequently in models and find strong evidence that the regional and type indices have statistically significant incremental explanatory power for properties' risk premiums over the whole market index. The explanatory power of the type indices is also significant economically.

Finally, we test possible heterogeneity in properties' loadings of the real estate factors. Specifically, we test whether a property's loading of the whole-market index of the real estate factors is related to three attributes: its capital size (acquisition price), physical size (square footage), and profitability (net operating income per square foot). We estimate holding period factor models for properties in four quartiles of each attribute, and also for the whole sample in models including interaction terms between each attribute and the index. The results show that properties' loadings are decreasing with each of the three attributes.

This paper makes a few novel contributions to the literature. First, it seems the first to bring together a high-quality property level dataset and a new two-step approach developed in the holding-period factor framework to directly test the existence of real estate factors. This two-step approach can also be used for other illiquid assets, such as private equity.

Second, this paper estimates a variety of indices of real estate factors, which economists, investors, and policy makers could use in their research. Third, this paper provides strong evidence for significant incremental explanatory power of the real estate factors for properties' risk premiums. This suggests that research that treats real estate as a different asset class has a great potential to better explain real estate returns. Finally, we provide very strong evidence for heterogeneity in properties loadings for real estate factors, which highlights the importance of analyzing asset level risk and returns of real estate.

The rest of this paper is organized as follows. The second section reviews the literature. The third section describes the data. The fourth section describes the two-step approach and reports the results. The fifth section analyzes the explanatory power of the real estate factors. The sixth section constructs a hierarchy of indices of real estate factors and investigates their incremental explanatory power. It also tests heterogeneity in properties loadings. The last section concludes.

## 2. Literature review

This paper is directly related to the literature on risk and returns of privately-owned commercial real estate. Earlier research in the literature often uses fund level data and focuses on real estate's market betas and correlations with other variables. Brueggeman, Chen and Thihodeau (1984) analyze comingled real estate funds (CREFs) in the 1972 to 1983 period and find real estate returns have an insignificant market beta and are positively correlated with the inflation rate. Hartzell, Hekman and Miles (1986) analyze returns of 403 properties in the 1973 to 1983 period and find that they have an insignificant correlation with the S&P returns, a negative correlation with bond returns, and a positive correlation with the inflation rate. Geltner (1989) un-smooths appraisal-based indices and finds a zero stock market beta and a positive correlation with national consumption. Gyourko and Linneman (1988) find that returns of commercial real estate are positively related to inflation, while REIT returns are negatively related to inflation. Goetzmann and Ibbotson (1990) study returns of CREFs and find that real estate returns are not related to stock returns but related to interest rates. Ling and Naranjo (1997) analyze the NCREIF national and regional indices and find a positive loading on consumption growth, and negative loadings on the real T-bill rate, the term spread, and unanticipated inflation. Shilling (2003) finds that investors' ex ante expected risk premiums on real estate are too large to be explained by standard economic models. Further, ex ante expected returns are higher than average realized equity returns over a 15-year period.

Recently available property level data allow researchers to answer more questions about the risk and returns of commercial real estate. Fisher and Goetzmann (2005) bootstrap cash flows of properties in the NCREIF database over the 1977 to 2004 period and find that the median IRR differs significantly from the compound time-weighted rate of return from the quarterly NCREIF index. Plazzi, Torous and Valkanov (2008) construct the cross-sectional dispersion of real estate returns across Metropolitan Statistic Ares (MSAs) in the 1986 to 2002 period and find that macroeconomic variables help explain the time-series fluctuation of the dispersion, and find a positive correlation between returns and the cross-sectional dispersion. Plazzi, Torous and Valkanov (2010) analyze metro-level cap rates and property returns and find that cap rates predict returns for some but not all property types. Bond and Mitchell (2010) analyze commercial real estate funds in the United Kingdom over the period 1981 to 2006 and find very few managers being able to generate excess risk-adjusted returns, and find little evidence of performance persistence in either fund returns or risk-adjusted fund returns. Plazzi, Torous and Valkanov (2012) use property level data from NCREIF and find that a property's characteristics provide information that improves property portfolio performance. Bond, Hwang and Marcato (2012) make a methodological contribution by analyzing a large sample of appraisal data at the individual property level. They find that commonly used unsmoothing estimates at the index level overstate the extent of smoothing at the individual property level. Wiley (2013) finds that corporate investors value commercial property differently than noninstitutional investors, and valuation differences contribute to their overpayment during periods of expansion and liquidation during contraction. Wiley (2017) finds that credit policies and buyer composition, mostly the market share of highly active investors, help predict commercial real estate price appreciation.

Aiming to capture unique features in real estate returns, Sagi (2017) derives an equilibrium search-based illiquid asset-pricing model which provides an excellent fit to the data of asset level returns and explains why commercial real estate idiosyncratic return means and variances do not scale with the holding period. Using a large sample of individual commercial property holdings, Ling, Naranjo and Scheick (2019) find property portfolio managers concentrate an economically significant portion of their portfolios in their headquarter location. They further document a positive relation between local concentration and portfolio returns in markets where information asymmetry is most severe. Duca and Ling (2020) analyze short-run and long-run movements in capitalization rates and risk premia for offices and apartments during the 2000s. They successfully relate the boom, the bust, and the subsequent recovery in CRE prices to time variation of components of cap rates. Pagliari (2020) compares returns of core, non-core, and opportunistic funds over a 17-year period. He finds that non-core funds substantially underperform core funds, and the performance of opportunistic funds approximately equals that of core funds. Gang, Peng and Thibodeau (2020) use property level returns and find that core properties have lower systematic risk but higher returns than non-core properties both before and after adjusting for risk. Liu, Nowak and Smith (2020) provide a new framework for using text as data in empirical models. They show that, in real estate markets, the agent-owned premiums reported in the literature are likely due to omitted variables, because they dissipate when the salient textual information is included.

This paper is also related to Pai and Geltner (2007), which finds that real estate factors constructed similarly to the Fama-French three factors can well explain the cross-section of real estate index returns. This paper differs from their work in a few important ways. First, we define real estate factors differently. Their factors are mimicking the Fama-French factors, while we have a generic definition of the real estate factors as systematic components of properties' risk premiums that are *orthogonal* to stock and bond factors. Second, we ask different research questions. Our first and foremost research question is whether there exist real estate factors at all. Third, they mostly work with indices, while we focus on property level risk premiums. Finally, when analyzing the explanatory power of real estate factors, we control away stock and bond factors and they don't.

This paper is also closely related to Peng (2016), which uses the holding-period factor model to analyze individual properties' loadings of stock and bond factors. Our two-step approach is based on the same framework, but our research question is different. While Peng (2016) focuses on factor loadings, we focus on the components of properties risk premiums that are not explained by stock and bond factors.

## 3. Data

### *3.1. Database*

This paper uses the proprietary dataset of the National Council of Real Estate Investment Fiduciaries (NCREIF). NCREIF is a real estate industry association, and its members are institutional investors, including investment companies, pension funds, and life insurance companies.[1] NCREIF collects, processes, and disseminates information on the operation and transactions of commercial real estate invested or managed by its members, and its database contains information on property attributes, such as property type, street address, square footage, etc., as well as quarterly cash flow information for each property. This dataset has been used by researchers including Pivo and Fisher (2011), Plazzi, Torous and Valkanov (2012), Peng (2016), Gang, Peng and Thibodeau (2020), and Sagi (2017). This paper uses the 2017:Q2 release of the database, which consists of 36,718 properties from the third quarter of 1977 to the second quarter of 2017. The cleaned final sample used in this paper consists of 10,848 properties.

The NCREIF dataset of commercial real estate has three important advantages. First, the NCREIF dataset seems to be the only dataset containing all cash flow information to allow accurate calculation of investment returns. Particularly, it has information on capital expenditures, which is crucial for return calculation but rarely available in other real estate datasets. Second, the dataset is very comprehensive in terms of geographic areas and economic cycles it covers. It consists of the whole population of properties invested or managed by the NCREIF members over about 40 years, which are located in all 50 states

[1] Examples of NCREIF members are Blackrock, Citi group, TIAA, New York Life, Invesco, Heitman/JMB, and Cornerstone real estate advisers.

of the U.S. and the District of Columbia. Third, properties in the dataset themselves constitute a large component of the real estate market. The total value of the 36,718 properties when acquired is about 1.01 trillion dollars. The total value of the 10,848 properties in the clean sample used in this paper is about 354 billion dollars.

Despite the above advantages, it is worth noting that properties in this dataset may not be random samples from of all commercial properties in the U.S., as NCREIF members may systematically prefer properties with certain attributes such as high liquidity (see, e.g. , Ghent (2020)). Therefore, it is important to understand that results in this paper are conditional and apply to institutional grade real estate.

*3.2. Holding-period returns*

This paper analyzes each property's investment return during its holding period. If a property was eventually sold, we calculate its return over the actual holding period. Otherwise, we calculate its return for a 5-year period since acquisition, using its appraised value (minus estimated selling cost) at the end of year 5 as the net sale proceeds. Including unsold properties helps mitigate a possible sample selection problem that sold properties can be selected samples (see, e.g. Gatzlaff and Haurin (1997), Gatzlaff and Haurin (1998), Fisher, Gartzlaff, Geltner and Haurin (2003), Goetzmann and Peng (2006), Korteweg and Sorensen (2010), Geltner and Bokhari (2011), and Sagi (2017)).

For each property $i$, we calculate its quarterly Modified IRR, which is denoted by $MIRR_i$. The cash flows used for this calculation consist of the acquisition cost,[2] net operating income (NOI) plus possible proceeds from partial sales minus capital expenditures in each quarter since acquisition, and the net sale proceeds plus NOI minus capital expenditures in the disposition quarter. We also calculate quarterly series of equally weighted average total returns for each property type, and then use them as finance and reinvestment rates for the calculation of MIRRs. Note that MIRRs seem superior to IRRs in measuring real estate

[2] We assume that all acquisitions and dispositions take place at the end of quarters. For a small number of properties, the database shows positive net operating income in the recorded acquisition quarters, possibly because their acquisitions took place in the middle of those quarters. For these properties, we assume the acquisitions took place at the end of the previous quarters.

returns, because the IRR calculation often have multiple solutions, due to long holding periods and irregular cash flows. Note that results in this paper are robust when we use IRRs in our analyses.[3]

After calculating MIRRs, we calculate the gross return over the holding period, which is denoted by $R_i$, as

$$R_i = (1 + MIRR_t)^{sell_i - buy_i} \quad (1)$$

where $sell_i$ is the quarter when the property is sold, and $buy_i$ is the quarter when the property is acquired.

We extract two more variables from the dataset to use in our analysis of properties' heterogeneity loadings: purchase prices and net operating income in the first year after acquisition. It is apparent that prices and net operating income are not comparable across properties because properties were acquired in different time. To make these two variables comparable, we inflate each property's purchase price to 2017:Q2 dollars, using a price appreciation index constructed from the data. Specifically, for each period, we first calculate all properties' price appreciation rates in that period using transaction or appraised prices. We remove appreciation rates that are lower than -80% or higher than 100%, which are likely due to data errors, and also outliers, which are the lowest and highest 5% of appreciation rates. We then calculate the across-property equally weighted average price appreciation rate as the index if there are at least 60 properties available for this calculation. We calculate the indices for each property type separately. We follow the same procedure to calculate net operating income (NOI) growth rate indices and use them to inflate NOI to 2017:Q2 dollars and then calculate NOI per square foot.

*3.3. Data cleaning and summary*

We clean the data using the following procedure. First, we discard 4,422 properties with missing inflated purchase prices, 1,206 properties with inflated prices below 1.5 million dollars, and 33 properties with inflated prices in the top 0.1% (1.09 billion dollars). The

[3] When there are multiple solutions for total return IRRs for a property, we select the smallest one from all solutions that are higher than the capital appreciation IRR, which is unique for each property.

sample size reduces from 36,718 to 31,057. Second, we discard properties with missing cash flow information, and the sample size decreases to 11,793. Third, we discard 141 properties with holding periods shorter than 3 quarters. Fourth, we discard properties with annualized holding-period total return MIRRs below -30% or above 40%, and those with total returns and capital appreciation returns differing from each other too much, which indicates possible data errors. Specifically, we run a cross property regression of total return MIRRs against price appreciation return MIRRs, and then discard properties with regression residuals being 3 standard deviations away from 0. The final sample consists of 10,848 properties.

Table 1 reports some statistics of the 10,848 properties. The mean of annualized MIRRs across properties is 3.99%, and the standard deviation is 11.54%. The mean of holding period duration is 23.57 quarters (about 6 years) and the standard deviation of duration is 11.84 quarters. The mean of inflated purchase price is 32.59 million dollars, and the standard deviation is 52.14 million dollars. The mean of the gross square feet is 0.26 million square feet, and the standard deviation is 0.27 million square feet. The net operating income (NOI) per square foot is 8.20 dollars, and the standard deviation is 6.79 dollars. The same statistics are also reported for properties located in each of the four regions, East, Midwest, South, and West, and each of the four main property types: apartment, industrial, office, and retail.

This table reveals some interesting variations. For example, the average purchase prices are higher for the East and West regions, so are the average NOI per square foot. Office properties have higher acquisition prices and higher NOI per square foot than the other three types. In addition to reporting these statistics, we plot the histogram of annualized MIRRs for the 10,848 properties in Figure 1.

### *3.4. Stock and bond factors*

The asset pricing literature has generated numerous factors. We choose to use 10 stock market factors, which are the union of the six factors in Fama and French (2018) and the five factors in Hou, Mo, Xue and Zhang (2018) in our analyses. We include 4 bond market factors: the term spread (the difference between the 10-year treasury annual yield and 1-year treasury annual yield) and the credit spread (the difference between the BAA corporate bond annual yield and AAA corporate bond annual yield) and their first order quarterly differences, which Peng (2016) shows can explain commercial real estate returns.

## 4. Testing existence of real estate factors

### *4.1. A model and the definition of real estate factors*

This section develops a two-step approach to test whether individual properties' risk premiums contain systematic components that are orthogonal to the 10 stock and the 4 bond factors. We call these components the real estate factor.

The finance literature has extended classical factor models to holding-period factor models to facilitate the analysis of illiquid assets' returns. Cochrane (2005) uses such models to estimate the beta of venture capital investments. Korteweg and Sorensen (2010), Driessen, Lin and Phalippou (2012), and Franzoni, Nowak and Phalippou (2012) use similar models to estimate private equity's factor loadings, and Peng (2016) uses such models to estimate factor loadings of private commercial real estate.

We follow the literature and develop the model as follows. Consider a property $i$ that was acquired in period $buy_i$ and sold in period $sell_i$. We assume that the unobserved single-period return for this property in period $t$, $R_{i,t}$ (a gross return), is generated from the following log-linear factor model,

$$log(R_{i,t}) - log(T_t) = \alpha_i + \sum_{k=1}^{K} \beta_i^k F_{k,t} + v_{i,t} \tag{2}$$

where $T_t$ is the risk-free interest rate (a gross return), $\{F_{k,t}\}_{k=1}^{K}$ are $K$ factors, $\alpha_i$ and $\beta_i^k$ are the property's risk adjusted return and its loading on factor $F_{k,t}$, and $v_{i,t}$ is an error term.

We categorize factors in equation (2) into two groups. The first $P$ factors are known stock and bond factors in the literature, and the remaining $K - P$ factors are orthogonal to the first $P$ factors, which we call the real estate factors. Note that the real estate factors actually also contain factors that could affect stock and bond risk premiums but have not been identified in the literature. We can rewrite (2) as

$$log(R_{i,t}) - log(T_t) = \alpha_i + \sum_{k=1}^{P} \beta_i^k F_{k,t} + \sum_{k=P+1}^{K} \beta_i^k F_{k,t} + \upsilon_{i,t} \quad (3)$$

The model treats real estate factors as latent, but we can construct an index in time period $t$, denoted by $M_t$, to measure the cross-property mean of the effects of all the unknown factors on the log risk premium.

$$M_t = E\left(\sum_{k=P+1}^{K} \beta_i^k F_{k,t}\right) \quad (4)$$

We simplify the model in (3) in two ways. First, note that the difference between the total effects of the real estate factors and the index $M_t$ has a cross-property mean of zero, so we treat this difference as another component of the error term. Second, since we only observe one holding period return for each property, we do not have enough degrees of freedom to allow each property to have its own alpha and factor loadings. Therefore, we let all properties have identical alphas and identical loadings for each factor. Since the differences between each property's alpha and loadings with their cross-property averages have means of zero, we consider these differences additional components of the error term. After these two simplifications, equation (3) becomes the following.

$$log(R_{i,t}) - log(T_t) = \alpha + \sum_{k=1}^{P} \beta^k F_{k,t} + M_t + \upsilon_{i,t} \quad (5)$$

We aggregate both sides of (5) across periods within the property's holding period and have the following.

$$\sum_{t=buy_i+1}^{sell_i} log(R_{i,t}) - \sum_{t=buy_i+1}^{sell_i} log(T_t) \quad (6)$$

$$= \alpha(sell_i - buy_i) + \sum_{k=1}^{P} \left(\beta^k \sum_{t=buy_i+1}^{sell_i} F_{k,t}\right)$$

$$+ \sum_{t=buy_i+1}^{sell_i} M_t + \sum_{t=buy_i+1}^{sell_i} \upsilon_{i,t}$$

We simplify equation (6) by denoting the duration of the holding period by $U_i$,

$$U_i = sell_i - buy_i \quad (7)$$

denoting the gross risk premium over the holding period by $R_i$,

$$R_i = \sum_{t=buy_i+1}^{sell_i} log(R_{i,t}) - \sum_{t=buy_i+1}^{sell_i} log(T_t) \tag{8}$$

and denoting the total error term by $\varepsilon_i$.

$$\varepsilon_i = \sum_{t=buy_i+1}^{sell_i} v_{i,t} \tag{9}$$

The model becomes

$$R_i = \alpha U_i + \sum_{k=1}^{K} \left( \beta^k \sum_{t=buy_i+1}^{sell_i} F_{k,t} \right) + \sum_{t=buy_i+1}^{sell_i} M_t + \varepsilon_i \tag{10}$$

Since Goetzmann and Spiegel (1995)) find that real estate returns have a non-temporal component, we add a non-temporal term $z_i$ to the model.

$$R_i = z_i + \alpha U_i + \sum_{k=1}^{K} \left( \beta^k \sum_{t=buy_i+1}^{sell_i} F_{k,t} \right) + \sum_{t=buy_i+1}^{sell_i} M_t + \varepsilon_i \tag{11}$$

The model in (11) is the framework in which we analyze real estate factors.

*4.2. Testing hypothesis regarding the existence of real estate factors*

We investigate whether real estate factors exist by testing the null hypothesis that $M_t = 0$ for all $t$. Note that, the existence of real estate factors is a necessary condition for $M_t \neq 0$ because noise cannot have non-zero expected effects on properties' risk premiums. Therefore, if we reject the null hypothesis, we can conclude that real estate factors exist.

It is important to note that, mathematically, we are unable to estimate (11) and test the hypothesis directly. The reason is simple. $M_t$ in (11) are essentially coefficients of time dummies. When time dummies are included in a factor model, they will capture the effects of all factors, including all known and unknown ones, because factors are identical across properties in the same period. As a result, there is perfect multicollinearity between factors and time dummies.

We adopt a two-step approach to test our hypothesis. We first estimate a version of the model in (11) that does not contain the real estate factor $M_t$.

$$R_i = z_i + \alpha U_i + \sum_{k=1}^{K} \left( \beta^k \sum_{t=buy_i+1}^{sell_i} F_{k,t} \right) + \epsilon_i \tag{12}$$

Since real estate factors are orthogonal to other factors by definition, it is clear that residuals from (12) contain the index $M_t$ and errors.

$$\epsilon_i = \sum_{t=buy_i+1}^{sell_i} M_t + \varepsilon_i \tag{13}$$

Second, we use regression residuals from (12) $\hat{\epsilon}_i$ as the dependent variable to estimate the following model.

$$\hat{\epsilon}_i = \sum_{t=buy_i+1}^{sell_i} M_t + \varepsilon_i \tag{14}$$

Note that $\hat{\epsilon}_i$ have the cross-property mean of zero. However, if real estate factors exist, $M_t$ in each period may not equal 0. We can test the null hypothesis that $M_t = 0$ for all $t$ by estimating the model in (14), which also provides estimates of the index $M_t$.

Note that the model in (14) is essentially a repeat sales regression (see, e.g. Bailey, Muth and Nourse (1963) and Goetzmann (1992)). When estimating it, should the variance of $\varepsilon_i$ increase with the duration, we can use the weighted least square proposed by Case and Shiller (1989) to estimate the model. However, regressing the squared residuals from estimating the model with OLS against duration does not provide any evidence for increasing variance of the error with duration, which is consistent with Peng (2016) and Sagi (2017). Therefore, we estimate (14) with OLS.

We estimate (12) and then (14) using the 10,848 properties and report results in Table 2. Note that the test for the null hypothesis that $M_t = 0$ for all $t$ is essentially a F test. Using all the 10,848 properties and 157 quarterly dummies, the F statistic is 4.417, which is significant at the 1% level. This is very strong evidence for the existence of the real estate factors. The regression of (14) also generates estimates of $\{M_t\}_{t=1}^{157}$, the index of the effects of the real estate factors on properties' risk premiums, which we plot in Figure 2.

Table 2 also reports results of a few other regressions. Given that the real estate is well known for being segmented (see, e.g. Peng and Thibodeau (2013), Hartman-Glaser and

Mann (2016), and Peng and Thibodeau (2017) for recent evidence from the housing market), it is natural to ask whether properties in each submarket, however defined, have additional systematic components in their risk premiums after we already control the whole-market index of real estate factors.

To shed light on this question, we analyze properties in each of the four regions: East, Midwest, South, and West. In the first step, we use the entire 10,848 properties to estimate the model in (12), and include not only the stock and bond factors but also the whole-market index of real estate factors. In the second step, for each region, we run a separate regression of residuals from the first step of properties in that region against quarter dummies. Coefficients of the quarterly dummies are essentially the index of region-specific real estate factors. Note that due to smaller sample size for each region, some quarters are not covered by properties' holding periods.

We use the F tests of the second step regressions to test whether a regional index equals 0 in each period, which means there are no additional regional factors. Results overwhelmingly strongly reject the null hypothesis and substantiate the existence of regional factors. Reported in Table 2, the F statistic is 2.545 for the East region, 2.008 for the Midwest region, 2.803 for the South region, and 3.302 for the West region. All the F statistics are significant at the 1% level. The adjusted R squared of the second step regression is 0.087, 0.096, 0.080, and 0.090 for the four regions respectively.

Next, we test whether properties in each of the four main types, apartment, industrial, office, and retail properties, respectively have additional type-specific factors after we include the stock, bond, and the whole-market index of real estate factors. We follow the same two-step approach described before. In the first step, we include the stock, bond, and the whole-market index of real estate factors and use the whole sample to estimate the model in (12). In the second step, for each property type, we run separate regressions of residuals from the first step against quarter dummies. Due to smaller sample size for each property type, some quarters are not covered by properties' holding periods. Also, a small number of properties in the first step regression do not belong to these four types, so they are not used in this analysis.

F tests for the four types provide very strong evidence supporting the existence of additional type-specific factors. As reported in Table 2, the F statistic is 2.872 for apartment properties, 5.023 for industrial properties, 2.881 for office properties, and 2.723 for retail properties. All the F statistics are significant at the 1% level. The adjusted R squared of the second step regression is 0.083, 0.151, 0.104, and 0,148 for the four property types respectively.

Appendix A reports the time series of the whole-market index, the regional index, and the property type index of real estate factors we constructed from regressions reported in Table 2. A few things are worth noting. First, the second step regression in the two-step approach is essentially a regression of log gross returns against time dummies. Therefore, the real estate factors, which are coefficients of time dummies, are also in log gross returns. To make them intuitive and easy to understand, we convert them to net returns (not in log) in Appendix A. Second, each of the four regional indices is orthogonal to the whole-market index. Each of the four property type indices is also orthogonal to the whole-market index. But the regional and property type indices are not orthogonal to each other. Third, there are missing index values for some quarters. This is because sample size becomes smaller when we estimate (14) for each region and property type; consequently, some quarters are not covered by properties' holding periods and thus the repeat sale regression is unable to estimate coefficients for those quarters. Lastly, in very rare scenarios, we have multicollinearity between consecutive quarters, due to the fact that there is no transaction in those quarters to distinguish them from each other. In this case, the repeat sale regression estimates the sum of the index values for the consecutive quarters and researchers need to decide how to allocate the sum across the consecutive quarters. In this paper, we allocate the sum to the first of these quarters and give 0 to the other quarters. This does not affect analyses in this paper. Researchers who are interested in using these real estate factors for their own research could choose to do things differently.

## 5. Quantifying the explanatory power of real estate factors

*5.1. Bootstrapping*

This section first analyzes real estate factors' *out-of-sample* explanatory power for properties' risk premiums, with a bootstrapping approach using residuals of all 10,848 properties from estimating the model in (12) that includes the stock and bond factors. In each round of bootstrapping, we first randomly split all residuals into two groups with equal size, say groups $A$ and $B$. Second, we use residuals in group $A$ to construct an index of real estate factors by estimating (14), which is denoted by $M_t^A$. Finally, we test whether $M_t^A$ explains residuals in group $B$, $\hat{\epsilon}_i^B$, using the following regression.

$$\hat{\epsilon}_i^B = \tau + \lambda \sum_{t=buy_i+1}^{sell_i} M_t^A + e_i^B \tag{15}$$

A significant and positive $\hat{\lambda}$ would indicate that $M_t^A$ has out-of-sample explanatory power for properties' risk premiums.

We conduct 3,000 rounds of the above bootstrapping analyses and plot the histogram of the 3,000 $\hat{\lambda}$ in Figure 3. The average of $\hat{\lambda}$ is 0.608, and the standard error is 0.055. It is apparent that $\hat{\lambda}$ is positive and significantly different from 0, which is also confirmed by a formal t-test. This is strong evidence that real estate factors help capture and thus explain the systematic components of properties' risk premiums. The average of the adjusted R squared of the 3,000 rounds is 0.032, and the standard error is 0.004.

To validate the bootstrapping approach above, we conduct a counterfactual analysis using simulated data generating from a factor model that does not contain any factors other than the 10 stock and the 4 bond factors. The counterfactual analysis also consists of 3,000 rounds. In each round, first, we generate an artificial dataset of 10,848 holding period risk premiums. Second, we estimate the model in (12) using the artificial data to obtain residuals. Third, we randomly split the residuals into two groups with equal size. We use residuals in one group to construct an index of real estate factors, and then test whether this index explains residuals in the other group using the model in (15).

We use the following procedure to generate artificial data. First, we generate the acquisition period from a Uniform distribution between 1 and 153 (there are 158 periods in total). Second, we generate the holding period duration from a Normal distribution with the mean and standard deviation equal the actual mean and standard deviation of actual duration in the data. If the generated duration is shorter than 3 quarters, we change it to 3 quarters. The combination of the acquisition period and the duration uniquely determines a property's disposition period. If the disposition period is later than the 158$^{th}$ quarter, we discard this property. As a result, the final sample size is slightly smaller than 10,848. Third, we generate each property's loading of each factor from a Normal distribution with the mean and standard deviation equal the estimate and its standard error from estimating the model in (12) using actual data. Finally, to generate random error $\epsilon_i$, we regress the squared actual residuals from estimating (12) using actual data against actual duration $D_i$.

$$\hat{\epsilon}_i^2 = \gamma + \rho D_i + \eta_i \tag{16}$$

We generate the artificial error from a Normal distribution with the mean being 0, and the standard error being the fitted value from estimating (16).

We plot the histogram of $\hat{\lambda}$ from the 3,000 rounds of counterfactual analysis in Figure 4. It is apparent that $\hat{\lambda}$ is not significantly different from 0. This counterfactual analysis shows that, should there be no real estate factors, the bootstrapping approach would not generate a significantly positive $\hat{\lambda}$. Therefore, we conclude that the bootstrapping approach is valid, and the significant and positive $\hat{\lambda}$ indicates that the real estate factors have out-of-sample explanatory power for properties' risk premiums.

### *5.2. Explanatory power in factor models*

We now analyze whether real estate factors help explain individual properties' holding period risk premiums in the model of (12). We first report the result of the baseline regression which includes the stock and bond factors but not the real estate factor. We then construct a few different indices of the real estate factor and include them in (12), and then re-estimate the model.

Table 3 reports the results. The first regression is the baseline case that includes the 10 stock factors and 4 bond factors, but not any indices of real estate factors. Eight out of the ten stock factors have loadings statistically significant at the 1% level. The loading is 0.319 for the Market Risk Premium, -0.625 for SMB, 0.358 for HML, 0.242 for Liquidity, 0.167 for Momentum, 0.618 for Q.ME, 0.474 for Q.IA, -0.374 for Q.ROE. One factor has a loading significant at the 10% level, which is CMA, and the loading is -0.289. RMW is the only factor of which the loading is not significantly different from 0. Three of the four bond factors have loadings statistically significant at the 1% level. The loading is -3.621 for the credit spread, 52.770 for the first order difference of the credit spread, and -5.448 for the first order difference of the term spread. The loading of the term spread is insignificant. These loadings are generally consistent results in Peng (2016).

The second regression includes the whole-market index of real estate factors which we construct from residuals of all 10,848 properties using the model in (14). Results show that loadings of the stock and bond factors are similar with those of the baseline case. The loading of the index is 1 and statistically significant at the 1% level. It is worth noting that, by including the index of real estate factors, the adjusted R squared increases from 0.22 in the baseline case to 0.27. This is a significant improvement, by about 23%. Note that this increase should be considered as the lower bound of the improvements that can be achieved by identifying real estate factors, since the index we construct is just the average effect of real estate factors at the whole market level.

It is possible that similar properties have similar factors and/or loadings. Consequently, indices of real estate factors constructed from residuals of similar properties might have higher explanatory power. To investigate this, we construct indices of real estate factors for the four regions respectively using residuals of properties in each region. We estimate the model in (12) using all 10,848 properties but this time include each property's own regional index, which is the third regression in Table 3. The loading of regional indices is 1 and statistically significant at the 1% level. The adjusted R squared now increases to 0.33, which is about a 50% increase from 0.22 in the baseline model. Similarly, we estimate indices of real estate factors for each of the four property types and include them in the model, which is the fourth regression in Table 3. The loading of type indices is also 1 and statistically significant at the 1% level. Now the adjusted R squared increases further to 0.37, which is a 68% increase from 0.22 in the baseline regression.

To investigate whether the improvement in the adjusted R squared is robust across regions and property types, we re-run the baseline regression and the third regression in Table 3 using only properties in each of the four regions and each of the four main property types separately. We report the results in Table 4. Note that these regressions differ from the third regression in Table 3, which uses all the 10,848 properties. Panel A reports the results of the baseline regression (specification I) and the regressions including regional indices (specification II). The adjusted R squared increases from 0.23 to 0.33 for the East region, from 0.23 to 0.36 for the Midwest region, from 0.19 to 0.28 for the South region, and from 0.26 to 0.34 for the West region. Panel B reports results for the four property types. The adjusted R squared increases from 0.29 to 0.34 for apartment, from 0.26 to 0.38 for industrial, from 0.23 to 0.30 for office, and from 0.35 to 0.45 for retail properties. Overall, Table 4 provides strong evidence showing that real estate factors provides significant additional explanatory power for individual properties' risk premiums across all four regions and the four property types.

### *5.3. Robustness checks*

Note that there is a mechanical relationship between each property's risk premium and indices of real estate factor in regressions in Tables 3 and 4, because each property's residual from the first step regression is used to construct indices of real estate factors, which are then included on the right side of the equation in (12). While this relationship might be weak, we still conduct a series of robustness checks to make sure that the results in Tables 3 and 4 are not entirely driven by it, and report results in Table 5.

In Panel A of Table 5, we estimate the model in (12) with all stock and bond factors as well as indices of real estate factors. However, for each region, the index of real estate factors is constructed from residuals of properties in *other* regions. By doing so, we eliminate the mechanical relationship discussed above as well as the explanatory power of regional specific components in properties' risk premiums. The remaining explanatory power of the index comes from systematic components of properties' risk premiums at the market level. As reported in Table 5, the coefficient of the "other region" index is 0.583 for the East region, 0.663 for the Midwest region, 0.420 for the South region, and 0.493 for the West region. All of them are significant at the 1% level. This is strong evidence that the explanatory power of the real estate factor is not entirely driven by the mechanical relationship discussed above. It is worth noting that the adjusted R squared in each regression in Panel A of Table 5 is higher than the corresponding regression I in Panel A of Table 4.

Panel B of Table 5 reports regressions for each property type separately with indices of real estate factors constructed from properties of *other* types. The coefficient of the real estate factor is 0.136 for apartment, 0.437 for industrial, 0.394 for office, and 0.178 for retail properties. The coefficients are statistically significant at the 1% level for industrial and office properties, and significant at the 10% level for apartment and retail properties. This also support the notion that the explanatory power is entirely not driven by the mechanical relationship discussed above.

## 6. A hierarchy of factors and heterogeneous loadings

### *6.1. Hierarchy of factors*

Real estate markets are segmented. For example, Ghent (2020) shows that liquidity can vary across cities due to differences in their investor compositions. It is plausible that risk premiums of properties in different regions or property types contain their own special components, in addition to the common components shared by all properties in the whole market. This suggests the existence of factors at the whole market, regional, and property type levels. This section constructs a hierarchy of indices of real estate factors at the three levels, and test whether each of them provides incremental explanatory power for individual properties' risk premiums.

Note that the whole-market index of real estate factors is constructed using all properties' regression residuals from estimating the model in (12) that includes both the stock and bond factors. It is clear that this index is orthogonal to all the stock and bond factors. Following the same idea, we construct regional indices that are orthogonal to the stock, bond, and the whole-market index of real estate factors using the following procedure. First, we estimate the model in (12) using all properties, including the stock, bond factors, *and* the whole-market index of real estate factors. Second, we us residuals from the first step to estimate the model in (14) for each of the four regions separately and obtain four regional indices. It is clear that the four regional indices are (1) constructed from properties in each of the four regions respectively, and (2) orthogonal to all the stock, bond, and the whole-market index of real estate factors.

We test whether the regional indices provide additional explanatory power for individual properties' risk premiums by estimating the model in (12) that includes the stock, bond, the whole market and the regional indices. Table 6 reports the results of five regressions. The first uses all 10,848 properties. The other four use properties in the four regions separately. It is clear that, first, coefficients of regional indices in all the five regressions are statistically significant at the 1% level. Second, the coefficients are all close to 1, which is expected because the regional indices essentially capture the average of residuals in each period for each region. Third, the adjusted R squared does not seem to increase much from corresponding regressions in Table 3 and Panel A of Table 4 that include the whole-market index but not the regional indices. This seems to indicate that, the regional factors provide statistically significant incremental explanatory power for individual properties' risk premiums, which, however, does not seem to be economically strong.

We further construct property type indices of real estate factors for the four main types using a similar two step procedure. First, we estimate the model in (12) using all properties and including the stock, bond, the whole-market index, and each property's regional index of real estate factors. Second, we us residuals from the first step to estimate the model in (14) for each of the four property types separately and obtain the property type indices of real estate factors. It is clear that the property type factors are orthogonal to all the stock, bond, the whole-market *and* the regional indices. Note that a small number of properties do not belong to the four main types.

We test whether the property type indices provide additional explanatory power for properties' risk premiums by estimating the model in (12) that includes the stock, bond, the whole market, the regional, and the property type indices. Table 7 reports the results of five regressions. The first one uses 9,907 properties that belong to the four main types. The other four regressions are for the four types separately. Across all regressions, it is clear that property type indices are significant at the 1% level except for apartment properties, for which the type index is significant at the 5% level. Second, the adjusted R squared increases from 0.33 (the first regression in Table 6) to 0.41 for all properties, from 0.34 (the second specification in Table 4 for apartment properties) to 0.37 apartment, from 0.38 (the second specification in Table 4 for industrial properties) to 0.44 for industrial, from 0.30 (the second specification in Table 4 for office properties) to 0.35 for office, and from 0.45 (the second specification in Table 4 for retail properties) to 0.48 for retail properties. These results indicate that the property type indices have both statistically and economically significant additional explanatory power for properties' risk premiums.

*6.2. Heterogeneous loadings*

As the literature suggests (see, e.g. Plazzi, Torous and Valkanov (2012)), property level attributes may be related to real estate's risk and returns. This section hopes to shed light on this by analyzing whether individual properties have heterogeneous loadings of the real estate factors. To simplify our analysis, we use the whole-market index of real estate factors as the proxy for real estate factors, and assume properties have identical loadings of the stock and bond factors. We focus on three attributes of each property: its capital size (acquisition price in 2017:Q2 value), its physical size (gross square feet), and its profitability (net operating income in the first year after acquisition per square foot in 2017:Q2 value). While the three attributes are commonly observed, little is known about their possible relationships with loadings of real estate factors.

To make it easier to interpret results, we normalize each attribute using the following two steps. First, we calculate the log value of an attribute variable. We the normalize the log value by first subtracting its across-property average and then dividing by the across-property standard error. After these two steps, 0 means that the log value equals the across-property average, and 1 means the log value is one standard error higher than the across-property average.

We first investigate whether properties with different capital size have different loadings of the index of real estate factors. We estimate the model in (12) by including the stock, bond, and the index for properties in the four quartiles of the normalized log prices respectively. Table 8 reports the results. The coefficient of the index is 1.406 for properties in the lowest quartile, 0.938 for the next quartile, 0.913 for the third quartile, and 0.453 for the highest quartile. The first three coefficients are statistically significant at the 1% level, and the last one is significant at the 10% level. These coefficients seem to indicate that properties' loadings of the index of real estate factors decrease with their capital size. We further estimate a model using all properties that includes an interaction term between their capital size and the index. We find that the interaction term has a negative coefficient, -0.198, which is significant at the 1% level. This indicates that, when the log price increases by 1 standard error, the loading of the index decreases by 0.198. This further confirms that properties' loadings of the whole-market index of real estate factors are decreasing with their capital size.

We then investigate whether properties' loadings of index are related to their physical size. We also estimate the model in (12) by including the stock, bond, and the index of real estate factors for properties in the four quartiles of their physical size separately. Results are in Table 9. The loading of the index is 1.252 for the smallest 25% properties, 1.023 for the next 25%, 0.742 for the next l25%, and 0.847 for the largest 25% properties. All loadings are statistically significant at the 1% level. We use all properties to estimate a model that includes an interaction term between physical size and the index. The coefficient of the interaction term is -0.16 and significant at the 1% level. This means that, when the log value of gross square feet increases by 1 standard error, the property's loading of the index decreases by 0.16. Overall, Table 9 provides strong evidence that larger properties tend to have smaller loadings of the index of real estate factors.

We finally use similar regressions to analyze the relationship between a property's profitability, which is measured with the net operating income per square foot in the first year after acquisition, and its loading of the index of real estate factors. Table 10 reports the results. The loadings are 1.148, 0.985, 0.834, and 0.834 for the four quartiles of properties respectively from the lowest to the highest. All loadings are statistically significant at the 1% level. In a model that includes an interaction term between profitability and the index, the coefficient of the interaction term is -0.073 and statistically significant at the 10% level. Therefore, it seems reasonable to conclude that there is some but not strong evidence for a negative relationship between a property's profitability and its loading on the index of real estate factors.

## 7. Conclusion

Economists often use the enormous size of real estate in the economy to justify the importance of research on real estate asset pricing. Another feature of real estate that also provides crucial justification for such research is the uniqueness of real estate, which is highlighted by some recent work (see, e.g. Sagi (2017). However, there is little research that directly tests and quantifies how different real estate is from some better-studied assets such as stocks and bonds in terms of risk and returns. This paper aims to fill this blank by analyzing new data using new methods.

This paper proposes a novel two-step approach to formally test whether properties' risk premiums contain systematic components that are orthogonal to stock and bond factors. We call these components the real estate factors. Using 10,848 commercial properties valued at 354 billion dollars, we find strong evidence for the existence of the real estate factors. Bootstrapping and counterfactual analyses further substantiate the explanatory power of the real estate factors.

We also find that the real estate factors provide substantial explanatory power for individual properties' risk premiums in factor models. After account for the real estate factors, which we capture using a variety of indices, the adjusted R squared of factor models for properties' risk premiums can increase by up to 68%. Such apparent improvements are merely the lower bound of additional explanatory power models can achieve by treating real estate differently from stocks and bonds.

We construct a hierarchy of indices of real estate factors for the whole market, the four regions, and the four main property types. We find strong evidence that the regional and property type indices provide statistically significant incremental explanatory power for properties' risk premiums. The property type indices' incremental explanatory power is economically significant. The indices we create could help economists, investors, and policy makers control for uniqueness of the real estate market in their analyses.

Finally, we find strong evidence for heterogeneity in individual properties' loadings of the real estate factors. Particularly, we find that properties with larger capital size (purchase price) and physical size and those with higher profitability (net operating income per square foot in the first year after acquisition) have lower loadings of the whole-market index of real estate factors. These results complement the literature and highlight the importance of property level heterogeneity in real estate risk and returns.

Appendix A: Indices of real estate factors

This table reports indices of real estate factors for the whole market, four regions (East, Midwest, South, and West), and four main property types (apartment, industrial, office, and retail). The whole market index is constructed by running a repeat sales regression using residuals of a cross-sectional regressions of properties' holding-period risk premiums against an intercept term, duration (quarters), and stock and bond factors. The regional indices are constructed by running repeat sales regressions separately for the four regions, using residuals of properties in each region. The property type indices are constructed by running repeat sales regressions separately for the four types using residuals of properties in each type. Original indices are in log gross returns. Numbers reported in this table are net returns and not in log.

| Time | Market | East | Midwest | South | West | Apartment | Industrial | Office | Retail |
|---|---|---|---|---|---|---|---|---|---|
| 1977.75 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1978 | -0.1624499 | -0.1652849 | -0.5977398 | 1.09721545 | 0.28711612 | NA | -0.0160458 | NA | NA |
| 1978.25 | -0.1047166 | -0.0744993 | 0.18638161 | 0 | 0.99382081 | NA | -0.0099328 | NA | NA |
| 1978.5 | 0.11896031 | -0.0957287 | 0.50143307 | -0.562606 | 0 | NA | 0.0125664 | NA | NA |
| 1978.75 | 0.27634742 | 0 | -0.1333866 | 0.34658943 | -0.5529751 | NA | -0.0920296 | NA | NA |
| 1979 | -0.2004645 | 0.14377299 | -0.1463892 | 0.51477226 | 0.11721047 | NA | 0.08243671 | NA | NA |
| 1979.25 | 0.01802706 | -0.585818 | 0.075934 | -0.2683267 | 0.26498164 | NA | 0.0431668 | NA | NA |
| 1979.5 | 0.14591675 | 1.64331424 | 0.04504726 | 0.27089579 | -0.0775451 | NA | -0.2369169 | NA | NA |
| 1979.75 | -0.0353068 | 0 | 0 | -0.19313 | 0.00678678 | NA | 0.2998056 | NA | -0.4951344 |
| 1980 | -0.067041 | -0.3463309 | 0.24727997 | -0.1141354 | -0.2641973 | NA | -0.0834173 | -0.0897296 | -0.0353388 |
| 1980.25 | -0.0029811 | 0.32697636 | -0.1389149 | 0.10105781 | 0.49339687 | NA | 0.02152732 | 0.06741904 | 0.03258477 |
| 1980.5 | 0.17673236 | -0.0277834 | 0.05797798 | -0.0789831 | -0.0708914 | NA | 0.01534808 | 0.10976245 | -0.0268449 |
| 1980.75 | 0.05060747 | -0.0727634 | -0.0891805 | -0.0094015 | 0.13335286 | NA | -0.0455563 | -0.0186654 | -0.0262355 |
| 1981 | -0.1206836 | -0.0770933 | -0.1317715 | 0.0717041 | -0.0328295 | NA | 0.00053776 | -0.1503093 | 0.07117729 |
| 1981.25 | 0.00257717 | 0.00807518 | 0.08810407 | 0.27441869 | -0.0840888 | NA | 0.10205592 | -0.1029998 | -0.2425344 |
| 1981.5 | 0.09802865 | -0.0416762 | 0.16361029 | -0.2363027 | 0.08197727 | NA | -0.1296581 | 0.13890798 | 0.21899114 |
| 1981.75 | 0.02741044 | 0.04788696 | -0.3176371 | 0.15716365 | 0.05341144 | NA | -0.2174076 | -0.024647 | 0.15438283 |
| 1982 | -0.1253233 | -0.3081256 | 0.1066276 | 0.08987525 | 0.22110024 | NA | 0.33907942 | 0.04231077 | -0.1594492 |
| 1982.25 | -0.0193733 | 0.81813932 | 0.29111671 | 0.12864339 | -0.3079436 | NA | -0.0037479 | 0.13071451 | -0.2755521 |
| 1982.5 | 0.04632464 | -0.3617436 | 0.06992797 | -0.0918356 | -0.0841798 | NA | -0.3140724 | -0.1022487 | 0.02741916 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1982.75 | -0.163022 | 0.06199561 | -0.3103574 | 0.06863443 | 0.09151344 | NA | 0.42329042 | -0.03282 | 0.51395765 |
| 1983 | 0.34303081 | -0.2845843 | 0.29727766 | -0.1686356 | -0.2270811 | NA | 0.09387288 | 0.03354808 | 0.02832287 |
| 1983.25 | -0.1203372 | 0.52828656 | 0.06563802 | -0.4048741 | 0.73337097 | NA | -0.1297809 | -0.2000566 | 0.20912117 |
| 1983.5 | 0.05678704 | 0 | -0.1380655 | 0.30214878 | -0.0643286 | NA | 0.40477554 | -0.1223316 | -0.2806622 |
| 1983.75 | 0.16644804 | 0.21979867 | -0.0376188 | 0.47798247 | -0.2737022 | NA | -0.2377661 | 0.27673371 | 0.50648744 |
| 1984 | -0.1623319 | -0.063981 | 0.50145749 | -0.1452527 | 0.13148587 | NA | 0.04572159 | -0.1420778 | -0.0466899 |
| 1984.25 | 0.22213632 | -0.2211012 | -0.3524012 | -0.1067739 | 0.01493143 | NA | -0.0470426 | 0.24357331 | -0.2830612 |
| 1984.5 | -0.0904459 | 0.5029333 | 0.17961023 | 0.12409794 | -0.0536696 | NA | 0.03447438 | -0.0996722 | -0.0017552 |
| 1984.75 | 0.00815301 | 0.13659117 | 0.21419435 | -0.1549255 | 0.03770629 | NA | -0.1751884 | 0.13788332 | 0.2240175 |
| 1985 | -0.1448809 | 0.00014433 | -0.2321566 | -0.1949591 | 0.17535145 | NA | 0.32330427 | -0.1916568 | -0.0414224 |
| 1985.25 | 0.00640738 | -0.112651 | -0.3111756 | 0.68478385 | -0.0038489 | NA | -0.0351121 | -0.0117461 | -0.4611993 |
| 1985.5 | 0.18495011 | 0.15460824 | 0.30731708 | -0.1918033 | -0.1788502 | NA | 0.03237863 | 0.00531086 | 0.38007527 |
| 1985.75 | -0.1360442 | -0.1234135 | -0.1264555 | -0.1096868 | 0.14886877 | NA | -0.1871788 | 0.11859807 | 0.58703025 |
| 1986 | -0.0921802 | -0.0645071 | 0.17758587 | 0.17996362 | -0.124266 | NA | 0.14093516 | -0.0590467 | -0.1597189 |
| 1986.25 | 0.17676255 | 0.05331935 | -0.1035568 | -0.0338155 | -0.0404986 | NA | 0.10823136 | 0.22151697 | -0.3071551 |
| 1986.5 | 0.00586137 | -0.1125757 | 0.2743945 | -0.1977494 | 0.13481396 | NA | 0.00254236 | -0.1412232 | 0.28984501 |
| 1986.75 | -0.0489175 | 0.22452137 | -0.0793622 | 0.52348078 | -0.2153774 | NA | -0.1522531 | -0.0635553 | 0.23100167 |
| 1987 | -0.0938335 | -0.29264 | -0.1836383 | -0.004968 | 0.89479725 | NA | 0.01841222 | 0.15491605 | -0.1173504 |
| 1987.25 | 0.37258788 | 0.31925705 | 0.27420878 | -0.3901611 | -0.2418623 | NA | -0.0487176 | -0.0016711 | 0 |
| 1987.5 | 0.00214763 | -0.023051 | -0.1718061 | 0.39314367 | -0.0029481 | NA | 0.14993653 | -0.1265581 | 0.01030364 |
| 1987.75 | -0.1889436 | -0.1138521 | 0.11037324 | 0.08393772 | -0.1829445 | 3.45134832 | 0.09608125 | -0.1090525 | 0.22426972 |
| 1988 | 0.25097763 | 0.21901897 | 0.1320128 | -0.2099528 | 0.06957555 | 0.0958662 | -0.0389112 | 0.03348884 | -0.0139226 |
| 1988.25 | -0.1282636 | 0.2373744 | -0.3593733 | -0.1266226 | 0.22483712 | 0.05936047 | 0.01363473 | 0.06459688 | -0.1960267 |
| 1988.5 | -0.0457986 | -0.3123267 | 0.61237295 | -0.1130858 | 0.04906068 | 0.03936971 | -0.001536 | -0.1610503 | 0.19031315 |
| 1988.75 | -0.0870061 | 0.27786799 | -0.1064573 | 0.23639591 | -0.2686355 | 0.07623277 | -0.0379601 | 0.4397409 | -0.048785 |
| 1989 | 0.00217386 | -0.2560284 | -0.0324802 | 0.23890098 | 0.32127272 | -0.0864019 | -0.1366089 | -0.0291941 | 0.54258748 |
| 1989.25 | 0.06222639 | 0.02792287 | -0.0326371 | -0.3894853 | 0.06080996 | 0.20005229 | 0.13544148 | -0.1647712 | -0.4100574 |

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| 1989.5 | -0.056757 | 0.06673216 | 0.10465983 | -0.0041562 | -0.0709936 | 0.15623424 | -0.1170287 | 0.04214251 | 0.0906372 |
| 1989.75 | -0.0666768 | 0.05432731 | 0.15894299 | 0.10342005 | -0.1193968 | -0.1683621 | 0.06286888 | 0.20766702 | -0.1647689 |
| 1990 | -0.0466252 | -0.0004915 | -0.2083826 | 0.07859541 | 0.05258206 | 0.15231795 | 0.09346486 | -0.1174293 | 0.28973684 |
| 1990.25 | 0.13699671 | -0.1069839 | -0.0380543 | 0.02803113 | 0.1023333 | 0.00873385 | -0.0314891 | -0.0449026 | -0.0620157 |
| 1990.5 | -0.0012839 | -0.0150768 | 0.02433948 | 0.10069301 | -0.0807796 | -0.1152567 | 0.05799592 | -0.1751603 | -0.0231791 |
| 1990.75 | -0.0083543 | 0.46330817 | 0.02004432 | -0.0989818 | -0.1095451 | 0.01540657 | -0.1442866 | 0.22040186 | 0.18309834 |
| 1991 | 0.10505129 | -0.0532284 | 0.06083754 | 0.14830497 | -0.0799929 | -0.2227204 | 0.12257532 | 0.03446558 | -0.2584183 |
| 1991.25 | -0.1411063 | -0.0246321 | 0.19483882 | 0.08791081 | 0.10679675 | 0.5440236 | -0.0162438 | -0.0845706 | 0.50397589 |
| 1991.5 | 0.17486866 | 0.09131581 | -0.1266766 | 0.16038527 | -0.0949583 | -0.3949526 | 0.19927471 | -0.0935263 | -0.1165922 |
| 1991.75 | -0.1218745 | -0.2194652 | -0.1089993 | -0.0651064 | 0.03454744 | 0.229397 | -0.1398526 | -0.019242 | 0.13167571 |
| 1992 | -0.0067416 | -0.2216299 | -0.1681901 | -0.4876186 | 0.31935269 | 0.03020606 | 0.04876917 | 0.17298467 | -0.2820993 |
| 1992.25 | 0.12642743 | -0.0109462 | 0.77795622 | 0.3443291 | 0.05312318 | -0.2135126 | 0.09218232 | -0.0208649 | 0.07751354 |
| 1992.5 | -0.1103434 | 0.11459875 | -0.2238979 | 0.22534536 | -0.3125082 | 0.1557738 | -0.1292695 | -0.0618577 | 0.48793049 |
| 1992.75 | 0.02291179 | 0.2704368 | -0.2005118 | -0.4260364 | 0.33355281 | 0.35026934 | 0.01794559 | -0.1910346 | -0.1924433 |
| 1993 | 0.02625532 | 0.26690508 | 0.42009906 | 0.78451456 | -0.3663019 | -0.1056165 | -0.0169403 | 0.1775446 | 0.17898097 |
| 1993.25 | -0.0299256 | 0.0328801 | -0.2668776 | 0.41672649 | 0.06909764 | -0.0183972 | -0.0376252 | 0.13524603 | -0.2605891 |
| 1993.5 | -0.1195084 | -0.4979873 | 0.25286979 | -0.2945531 | 0.18267435 | -0.0033657 | -0.0110237 | -0.035161 | 0.14544923 |
| 1993.75 | -0.1139062 | 0.28211371 | -0.1428521 | 0.10437234 | -0.1544021 | 0.03195736 | 0.10009709 | -0.0918632 | 0.13640629 |
| 1994 | 0.23839405 | 0.16416722 | 0.15421791 | -0.1368054 | 0.1866315 | 0.31352085 | -0.2248476 | -0.0085552 | -0.0554292 |
| 1994.25 | -0.0475719 | -0.262081 | 0.07899779 | -0.1283054 | 0.38013347 | -0.1629254 | 0.0576199 | 0.0471956 | -0.3176337 |
| 1994.5 | 0.05002193 | -0.0461225 | -0.113454 | 0.03299306 | -0.0797498 | -0.1211936 | 0.09377905 | -0.1932277 | 0.20264885 |
| 1994.75 | 0.01956841 | -0.0233611 | 0.08815009 | 0.23803417 | -0.2829777 | 0.22473172 | -0.0607 | 0.06831645 | 0.21227124 |
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| 1995.5 | 0.20591567 | -0.0672872 | 0.14830031 | 0.23891969 | -0.1703227 | -0.1989332 | -0.0124761 | -0.0323382 | 0.33358351 |
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| 1996 | 0.03900522 | -0.0596276 | 0.10635182 | 0.0108146 | -0.012263 | 0.21674683 | -0.0937956 | 0.09975721 | -0.267779 |

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|---|---|---|---|---|---|---|---|---|---|
| 1996.25 | 0.0477403 | -0.1902202 | 0.05068452 | -0.1620095 | 0.23278149 | -0.0021046 | -0.0373647 | 0.04214407 | 0.19262901 |
| 1996.5 | 0.06053824 | 0.21893792 | -0.1969225 | 0.06409405 | 0.02655219 | -0.1522927 | 0.1910305 | 0.01656694 | -0.0550405 |
| 1996.75 | -0.1470239 | -0.1241003 | 0.22707763 | 0.18231022 | -0.206475 | 0.14230797 | -0.0911272 | -0.0846094 | 0.21607343 |
| 1997 | 0.128665 | 0.08564084 | 0.14733815 | -0.0855228 | -0.0224151 | 0.13887923 | 0.04635183 | -0.0767062 | -0.1667959 |
| 1997.25 | 0.07360453 | -0.0036642 | -0.1423059 | 0.37200282 | 0.00368822 | -0.1727604 | 0.09717902 | -0.0362375 | -0.0601382 |
| 1997.5 | -0.0307664 | 0.41124747 | -0.1687697 | -0.3108058 | -0.0068866 | -0.0662107 | -0.1379629 | 0.30058039 | 0.06094672 |
| 1997.75 | -0.1272927 | -0.1623829 | 0.12718559 | 0.06568562 | -0.0395007 | 0.06427026 | 0.11787045 | -0.1622427 | -0.0080631 |
| 1998 | 0.03264968 | -0.1837581 | 0.05103335 | 0.0088016 | 0.1318794 | 0.11702847 | -0.0584514 | 0.0254384 | -0.0976789 |
| 1998.25 | 0.06628644 | 0.08361089 | -0.0352893 | -0.0137615 | 0.05921018 | -0.1133337 | 0.02756287 | 0.14478571 | -0.1537718 |
| 1998.5 | 0.07364981 | 0.14136516 | 0.10926343 | 0.00065991 | -0.1297188 | -0.0707628 | 0.01383 | -0.200585 | 0.46864212 |
| 1998.75 | -0.135161 | -0.1822005 | -0.0452104 | 0.09079183 | 0.08738586 | 0.20560239 | -0.1215959 | 0.01289048 | -0.0366032 |
| 1999 | 0.11839763 | -0.0946138 | -0.2542877 | -0.0211431 | 0.1135657 | -0.1081306 | 0.10899148 | 0.1135295 | -0.086253 |
| 1999.25 | 0.00840921 | 0.04999527 | 0.55209227 | -0.0419171 | -0.1360695 | 0.12922202 | -0.1398322 | -0.0130561 | -0.2164174 |
| 1999.5 | 0.09468448 | 0.30388215 | -0.2069718 | -0.0408035 | 0.04249695 | -0.1299015 | 0.28681577 | -0.0831361 | 0.19579239 |
| 1999.75 | -0.1613244 | 0.02645356 | -0.0588753 | -0.035995 | -0.0342729 | 0.13479627 | -0.100432 | -0.0630265 | 0.21822018 |
| 2000 | 0.00022341 | -0.1535214 | -0.115485 | 0.05750257 | 0.1543544 | -0.22092 | 0.12239483 | 0.20300307 | -0.1477153 |
| 2000.25 | 0.08173602 | -0.2059888 | 0.36380632 | 0.02176354 | 0.00890682 | 0.34294566 | -0.0673024 | -0.1709363 | -0.0383633 |
| 2000.5 | 0.00212762 | 0.47072981 | -0.1198234 | -0.0928335 | -0.0760074 | -0.0616284 | -0.1625467 | 0.18409838 | 0.26509849 |
| 2000.75 | -0.1083561 | -0.085515 | 0.07754425 | 0.07115752 | -0.0760421 | -0.0150693 | 0.08795711 | -0.0063382 | -0.1212747 |
| 2001 | -0.0498918 | 0.06661976 | -0.1632258 | 0.15304951 | -0.1158284 | -0.0118099 | -0.0772689 | 0.20760381 | 0.18142671 |
| 2001.25 | 0.10975131 | 0.09589857 | -0.1126797 | -0.0250795 | 0.07763617 | 0.09424376 | 0.20695261 | -0.3036766 | -0.2151714 |
| 2001.5 | 0.14766542 | -0.2319623 | 0.00591645 | 0.01299277 | 0.14538925 | 0.00284508 | -0.123057 | 0.05341575 | 0.10104231 |
| 2001.75 | -0.2750745 | 0.05662277 | 0.13592705 | 0.03109091 | -0.0138138 | 0.10657292 | -0.010127 | 0.21530047 | 0.21803339 |
| 2002 | 0.22054117 | 0.03803325 | 0.05462145 | -0.2643973 | 0.09741811 | -0.2513116 | 0.14413026 | -0.17899 | -0.1483918 |
| 2002.25 | -0.0485293 | -0.136019 | 0.15208784 | 0.28417696 | -0.0697261 | 0.02882251 | 0.02688096 | 0.02932294 | -0.0436241 |
| 2002.5 | 0.10792586 | 0.36516964 | -0.2237972 | -0.114141 | -0.1023498 | 0.04636593 | -0.090293 | 0.00799493 | 0.04348515 |
| 2002.75 | -0.1636717 | -0.1259656 | 0.08655532 | 0.00987098 | 0.08504675 | 0.00193387 | 0.03872352 | -0.0394702 | 0.03041702 |

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|---|---|---|---|---|---|---|---|---|---|
| 2003 | 0.24426228 | -0.0950045 | -0.019725 | -0.1695886 | 0.22849727 | 0.01338839 | 0.00703822 | -0.0635081 | 0.07285841 |
| 2003.25 | 0.06900818 | 0.19471869 | -0.2175532 | 0.15885677 | -0.1029611 | -0.1467781 | 0.21926396 | -0.1870556 | -0.2631912 |
| 2003.5 | -0.192861 | 0.10069391 | 0.26426681 | -0.0418209 | -0.1151404 | 0.2671011 | -0.2119519 | 0.10295071 | 0.39838336 |
| 2003.75 | -0.1083385 | -0.1788445 | -0.047724 | 0.10376007 | 0.05300806 | -0.0271642 | -0.0255296 | 0.16471496 | -0.0925852 |
| 2004 | 0.18667161 | 0.00496067 | 0.01238558 | -0.031496 | -0.0225333 | -0.0705901 | -0.008173 | 0.01437295 | 0.15140434 |
| 2004.25 | 0.05713061 | -0.0081697 | 0.09566439 | -0.0180057 | -0.0190252 | 0.18749223 | 0.04583414 | -0.1346304 | -0.114358 |
| 2004.5 | 0.00676557 | 0.0774389 | 0.04688855 | 0.00795014 | -0.0135663 | -0.1057883 | -0.0243801 | 0.27861396 | 0.01066876 |
| 2004.75 | -0.1707291 | 0.052902 | -0.0771375 | -0.0190034 | 0.05472038 | 0.09076746 | -0.0142551 | -0.0149376 | 0.02264353 |
| 2005 | 0.20849842 | -0.0876327 | 0.01953455 | 0.05818928 | -0.0465711 | -0.0600241 | -0.0059705 | -0.1022325 | 0.10104207 |
| 2005.25 | -0.0440564 | 0.03357333 | -0.0249789 | -0.0194052 | -0.0722306 | 0.07819884 | -0.0545482 | -0.0005081 | 0.09252449 |
| 2005.5 | 0.03095555 | 0.26473306 | 0.00056491 | -0.1621051 | 0.13548247 | -0.1638145 | 0.11422443 | 0.03292733 | 0.00764105 |
| 2005.75 | -0.0981801 | -0.1149673 | 0.05062047 | -0.0084281 | 0.01501831 | -0.0867583 | 0.01166662 | -0.0150207 | 0.04664693 |
| 2006 | 0.17010452 | -0.1659676 | -0.0779985 | 0.24157297 | -0.1287695 | 0.08594725 | -0.0218523 | 0.09982898 | -0.2041837 |
| 2006.25 | -0.1722384 | 0.15065036 | -0.1547496 | -0.0555954 | 0.13627071 | 0.07643777 | 0.06423572 | 0.00727336 | -0.0043282 |
| 2006.5 | 0.15961983 | -0.1349634 | 0.01446923 | 0.03532671 | 0.02355901 | 0.02105882 | -0.1090475 | -0.0775619 | 0.08000638 |
| 2006.75 | -0.1575676 | 0.03695954 | 0.17947397 | 0.00791218 | -0.0228847 | -0.0076719 | -0.0003923 | 0.00298756 | 0.0419838 |
| 2007 | 0.12574551 | -0.0619519 | 0.01927582 | 0.09988198 | -0.0910538 | -0.1453386 | 0.01006157 | 0.03263164 | -0.0470537 |
| 2007.25 | 0.0350491 | 0.02310445 | 0.00739702 | -0.1303977 | 0.08379505 | 0.05296118 | 0.08343084 | -0.0512408 | -0.1662189 |
| 2007.5 | -0.0204628 | 0.2456364 | -0.0195177 | -0.0867612 | -0.0368877 | 0.06527396 | -0.0162028 | -0.0399523 | 0.07707567 |
| 2007.75 | -0.1501891 | -0.2076388 | -0.0078249 | 0.20621417 | 0.0448197 | 0.00535139 | 0.05006743 | -0.0212457 | 0.17628384 |
| 2008 | 0.16152071 | 0.09371671 | 0.07739981 | -0.0786106 | -0.0903255 | -0.0918791 | 0.06018554 | 0.01257135 | -0.0945988 |
| 2008.25 | -0.0332228 | 0.06306731 | -0.0173304 | -0.0341441 | 0.0513264 | 0.02569333 | -0.0728078 | -0.077929 | -0.0079047 |
| 2008.5 | -0.096278 | -0.0018115 | 0.05196845 | -0.0004949 | -0.0452521 | 0.15816376 | 0.04973649 | -0.0094994 | -0.0656264 |
| 2008.75 | 0.02911368 | -0.0731618 | -0.2716057 | 0.24236323 | 0.13335815 | -0.0630835 | -0.1195148 | 0.04779725 | -0.0420354 |
| 2009 | 0.25979375 | 0.01187962 | 0.06713813 | -0.1063222 | -0.1449474 | -0.1414294 | 0.01098319 | 0.15217469 | 0.21111905 |
| 2009.25 | -0.0646452 | -0.1459481 | 0.2316496 | 0.08429157 | 0.04230573 | 0.11157586 | 0.04356097 | -0.1268353 | -0.0704385 |
| 2009.5 | 0.05594248 | 0.26252158 | -0.090622 | -0.2155133 | 0.11732653 | 0.01453099 | 0.03660004 | -0.0050095 | -0.1021023 |

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|---|---|---|---|---|---|---|---|---|---|
| 2009.75 | -0.1246351 | -0.0251969 | 0.14966696 | 0.10052364 | -0.1026762 | -0.0775758 | 0.01573271 | 0.09267431 | 0.03357401 |
| 2010 | 0.05426627 | 0.08124157 | -0.0522626 | 0.07294409 | -0.123657 | 0.26698008 | -0.1580413 | -0.0770138 | 0.23592603 |
| 2010.25 | -0.013923 | -0.1407439 | -0.1632985 | -0.049064 | 0.19059438 | -0.1887235 | 0.33593164 | 0.05868756 | -0.1233537 |
| 2010.5 | -0.1333418 | 0.11862362 | -0.032875 | 0.05586258 | -0.0874525 | 0.18506693 | -0.1989849 | 0.04530869 | 0.10338599 |
| 2010.75 | 0.12938429 | -0.1704657 | 0.23442209 | -0.1281593 | 0.16567053 | -0.0791877 | 0.18110882 | -0.189243 | -0.194507 |
| 2011 | -0.115437 | 0.08841018 | 0.15515907 | 0.09494593 | -0.1367353 | -0.0490513 | -0.0301284 | 0.10264995 | 0.24441172 |
| 2011.25 | 0.0610402 | 0.15705065 | -0.2439624 | -0.0219137 | 0.02267716 | 0.08186413 | -0.0892598 | 0.04351738 | -0.1787404 |
| 2011.5 | 0.23103235 | -0.2607091 | 0.17502634 | 0.0571057 | 0.02936157 | 0.05845703 | 0.02480554 | -0.0474827 | 0.00406882 |
| 2011.75 | -0.1569426 | 0.23013797 | 0.05223421 | -0.0278496 | -0.0744631 | -0.0750395 | -0.0525795 | 0.0386194 | 0.15535372 |
| 2012 | -0.0638803 | -0.0224038 | -0.0382718 | 0.02783956 | -0.0054816 | -0.015078 | -0.0347257 | 0.04437857 | -0.0536174 |
| 2012.25 | 0.07025295 | -0.0252858 | -0.091755 | -0.1305333 | 0.17870208 | 0.03929552 | 0.03362828 | -0.051647 | 0.02113531 |
| 2012.5 | -0.0552431 | 0.11933554 | 0.14736058 | 0.04187108 | -0.0988496 | 0.01009579 | 0.02301612 | -0.1149319 | 0.24888257 |
| 2012.75 | 0.05998602 | -0.1064616 | -0.0963293 | 0.11186214 | 0.0355477 | 0.02139853 | 0.04020064 | 0.02070795 | -0.2630029 |
| 2013 | 0.00668347 | -0.0656994 | 0.18760557 | -0.086433 | 0.02851165 | -0.1174402 | -0.0823457 | 0.19780988 | 0.22868498 |
| 2013.25 | -0.0828197 | 0.03264984 | -0.1050204 | 0.15845786 | -0.1887425 | 0.14153346 | 0.04258606 | -0.0293223 | -0.1604861 |
| 2013.5 | 0.09828111 | 0.16738812 | 0.02957748 | -0.0686634 | 0.05783228 | -0.1109848 | 0.06995672 | -0.0263068 | -0.1160337 |
| 2013.75 | 0.0257724 | -0.0729414 | 0.01901617 | -0.0033371 | 0.02935863 | 0.01895675 | -0.0581269 | -0.1269358 | 0.14363356 |
| 2014 | -0.0722013 | 0.03222428 | 0.10650913 | -0.0913285 | 0.13469979 | -0.0153959 | 0.11028919 | 0.23774791 | 0.19839386 |
| 2014.25 | 0.08412036 | -0.0196315 | -0.142127 | 0.1610807 | -0.1762995 | 0.18137603 | -0.1027831 | -0.0487522 | -0.2611122 |
| 2014.5 | 0.04381307 | 0.01793474 | 0.06051527 | -0.1623035 | 0.14834726 | -0.1537251 | -0.1647495 | -0.0286318 | 0.15391909 |
| 2014.75 | -0.0148999 | -0.1501312 | -0.176671 | 0.14138985 | 0.04348265 | 0.02967307 | 0.17822408 | -0.0747113 | 0.09695732 |
| 2015 | -0.0534689 | 0.1650083 | 0.12097857 | 0.09020801 | -0.1876484 | 0.08790722 | -0.1369728 | 0.10156002 | -0.0464863 |
| 2015.25 | -0.0594479 | -0.0557014 | -0.1188764 | -0.1465787 | 0.26270768 | -0.0584703 | 0.2005967 | 0.05110829 | 0.13818147 |
| 2015.5 | 0.12143423 | 0.00684141 | 0.1109733 | 0.08501351 | -0.0832432 | -0.0042919 | -0.1127223 | -0.0860139 | -0.1877708 |
| 2015.75 | -0.1308242 | -0.048205 | -0.0405647 | 0.00686912 | 0.03656227 | 0.10485559 | 0.14529004 | -0.02659 | 0.21092947 |
| 2016 | 0.05504018 | -0.0558271 | 0.25014723 | -0.0379228 | 0.09697217 | -0.0440473 | 0.01007881 | -0.1808271 | 0.14608925 |
| 2016.25 | 0.02844056 | 0.20822207 | -0.3577616 | -0.0197911 | -0.0090334 | -0.1079177 | 0.02342082 | 0.1882354 | -0.2500928 |

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|---|---|---|---|---|---|---|---|---|---|
| 2016.5 | -0.012927 | -0.2036139 | 0.38682247 | 0.04983017 | -0.066397 | 0.03802092 | -0.0369456 | 0.01388742 | 0.21762209 |
| 2016.75 | -0.0191246 | 0.27466362 | -0.0954368 | -0.083729 | -0.0655358 | 0.08365349 | -0.1211576 | 0.09345602 | -0.0307948 |
| 2017 | 0.06048634 | -0.1224275 | -0.0215569 | 0.08925105 | 0.07011282 | -0.06806 | -0.0107896 | 0.09117632 | -0.2488334 |

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Table 1. Summary statistics

This table reports the number of properties, and the mean and the standard deviation of the annualized modified IRRs, duration, acquisition prices, gross square feet, and net operating income per square foot of properties in the whole sample, the four regions, and the four main property types respectively. Duration is in quarters. Acquisition price is in million dollars. Gross square foot is in million square feet. Net operating income is in dollars per square foot.

| | All | East | Midwest | South | West | Apartment | Industrial | Office | Retail |
|---|---|---|---|---|---|---|---|---|---|
| Properties | 10,848 | 2,499 | 1,484 | 3,249 | 3,616 | 2,449 | 3,551 | 2,429 | 1,478 |
| Annualized IRR: mean | 3.99% | 3.98% | 5.36% | 3.95% | 3.49% | 3.86% | 4.16% | 3.21% | 5.81% |
| Annualized IRR: s. d. | 11.54% | 11.66% | 10.65% | 11.41% | 11.86% | 11.93% | 11.16% | 11.67% | 11.40% |
| Duration: mean | 23.57 | 23.52 | 25.29 | 23.37 | 23.09 | 22.71 | 23.75 | 24.64 | 24.56 |
| Duration: s. d. | 11.84 | 11.08 | 12.78 | 11.80 | 11.95 | 10.65 | 12.62 | 12.77 | 12.22 |
| Acquisition price: mean | 32.59 | 43.42 | 25.47 | 25.49 | 34.41 | 36.81 | 15.63 | 54.17 | 38.75 |
| Acquisition price: s. d. | 52.14 | 69.10 | 42.03 | 39.39 | 50.88 | 38.97 | 26.13 | 78.27 | 58.52 |
| Gross square foot: mean | 0.26 | 0.27 | 0.27 | 0.27 | 0.25 | 0.29 | 0.28 | 0.26 | 0.24 |
| Gross square foot: s. d. | 0.27 | 0.28 | 0.28 | 0.27 | 0.26 | 0.20 | 0.31 | 0.26 | 0.28 |
| NOI per s. f.: mean | 8.20 | 10.35 | 6.72 | 6.50 | 8.84 | 6.71 | 4.41 | 12.28 | 11.40 |
| NOI per s. f.: s. d. | 6.79 | 8.01 | 5.41 | 5.26 | 7.09 | 4.74 | 3.58 | 7.19 | 7.48 |

Table 2. Testing the existence of real estate factors
This table reports the F-test results regarding the existence of real estate factors in individual properties' risk premiums. The first step regresses properties' holding period risk premiums against stock and bond factors. The second step regresses residuals from the first step, for the whole sample, each of the four regions, and each of the four main property types, against dummies for quarters when properties were held. Coefficients of quarterly dummies are index values capturing the average effects of real estate factors on properties' risk premiums. The null hypothesis is that the coefficients of all the quarterly dummies are 0, which means there are no real estate factors.

| | Sample size | Quarters | F statistics | P-value | R squared |
|---|---|---|---|---|---|
| Whole sample | | | | | |
| | 10,848 | 157 | 4.417 | <1% | 0.047 |
| Regions | | | | | |
| East | 2,499 | 154 | 2.545 | <1% | 0.087 |
| Midwest | 1,484 | 156 | 2.008 | <1% | 0.096 |
| South | 3,249 | 156 | 2.803 | <1% | 0.080 |
| West | 3,616 | 156 | 3.302 | <1% | 0.090 |
| Property types | | | | | |
| Apartment | 2,449 | 118 | 2.872 | <1% | 0.083 |
| Industrial | 3,551 | 157 | 5.023 | <1% | 0.151 |
| Office | 2,429 | 149 | 2.881 | <1% | 0.104 |
| Retail | 1,478 | 149 | 2.723 | <1% | 0.148 |

Table 3. Explanatory power of real estate factors

This table reports results of cross-sectional regressions of properties' holding-period risk premiums against an intercept term, duration (quarters), stock and bond factors, and indices of real estate factors. The first regression does not contain an index of real estate factors. Regression II contains a whole-market index of real estate factors, which is constructed from residuals from regression I. Regression III contains regional indices of real estate factors, which are constructed from residuals from regression I but for each region separately. Regression IV contains property type indices of real estate factors, which are constructed from residuals from regression I but for each property type separately. Heteroskedasticity robust standard errors are reported in parenthesis. ***, **, and * indicate significant levels of 1%, 5%, and 10% respectively.

| | I | II | III | IV |
|---|---|---|---|---|
| Intercept | -0.110*** | -0.115*** | -0.125*** | -0.129** |
| | (0.011) | (0.011) | (0.010) | (0.010) |
| Duration | 0.009*** | 0.009*** | 0.010*** | 0.010*** |
| | (0.003) | (0.003) | (0.003) | (0.003) |
| Whole market index | | 1.000*** | | |
| | | (0.036) | | |
| Regional indices | | | 1.001*** | |
| | | | (0.024) | |
| Type indices | | | | 1.001*** |
| | | | | (0.022) |
| Market risk premium | 0.319*** | 0.319*** | 0.318*** | 0.318*** |
| | (0.046) | (0.044) | (0.042) | (0.041) |
| SMB | -0.625*** | -0.626*** | -0.627*** | -0.627*** |
| | (0.205) | (0.198) | (0.186) | (0.188) |
| HML | 0.358*** | 0.361*** | 0.365*** | 0.366*** |
| | (0.052) | (0.050) | (0.047) | (0.048) |
| RMW | -0.066 | -0.068 | -0.071 | -0.073 |
| | (0.086) | (0.083) | (0.079) | (0.080) |
| CMA | -0.289* | -0.287 | -0.283 | -0.281 |
| | (0.160) | (0.155) | (0.146) | (0.147) |
| Liquidity | 0.242*** | 0.242*** | 0.241*** | 0.241*** |
| | (0.032) | (0.031) | (0.029) | (0.030) |
| Momentum | 0.167*** | 0.168*** | 0.169*** | 0.168*** |
| | (0.054) | (0.052) | (0.049) | (0.050) |
| Q.ME | 0.618*** | 0.618*** | 0.618*** | 0.618*** |
| | (0.197) | (0.191) | (0.181) | (0.181) |
| Q.IA | 0.474*** | 0.470*** | 0.462*** | 0.459*** |
| | (0.160) | (0.155) | (0.147) | (0.148) |
| Q.ROE | -0.374*** | -0.376*** | -0.380*** | -0.380*** |
| | (0.114) | (0.110) | (0.103) | (0.105) |
| Credit spread | -3.621*** | -3.596*** | -3.552*** | -3.539*** |
| | (0.816) | (0.782) | (0.734) | (0.724) |
| Term spread | 0.226 | 0.239 | 0.261 | 0.266 |
| | (0.418) | (0.401) | (0.375) | (0.375) |
| Credit spread change | 52.770*** | 53.028*** | 53.464*** | 53.582*** |
| | (0.419) | (6.363) | (5.921) | (5.910) |
| Term spread change | -5.448*** | -5.449*** | -5.451*** | -5.474*** |
| | (1.936) | (1.873) | (1.776) | (1.806) |
| Sample size | 10,848 | 10,848 | 10,848 | 9,907 |
| Adjusted R square | 0.22 | 0.27 | 0.33 | 0.37 |

Table 4. Explanatory power of real estate factors by regions and types

This table reports results of cross-sectional regressions of properties' holding-period risk premiums against an intercept term, duration (quarters), stock and bond factors, and regional indices (Panel A) and property type indices of real estate factors (Panel B). The indices are constructed from residuals from a pooled regression (the first one in Table 3) but for each region (Panel A) and type (Panel B) separately. Heteroskedasticity robust standard errors are reported in parenthesis. ***, **, and * indicate significant levels of 1%, 5%, and 10% respectively.

| Panel A | East | | Midwest | | South | | West | |
|---|---|---|---|---|---|---|---|---|
| | I | II | I | II | I | II | I | II |
| Regional index | | 1.011*** | | 0.983*** | | 1.001*** | | 0.999*** |
| | | (0.073) | | (0.051) | | (0.051) | | (0.044) |
| Intercept | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Duration | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Stock factors | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bond factors | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample size | 2,499 | 2,499 | 1,484 | 1,484 | 3,249 | 3,249 | 3,616 | 3,616 |
| Adjusted R square | 0.23 | 0.33 | 0.23 | 0.36 | 0.19 | 0.28 | 0.26 | 0.34 |
| **Panel B** | **Apartment** | | **Industrial** | | **Office** | | **Retail** | |
| | I | II | I | II | I | II | I | II |
| Type index | | 1.012*** | | 0.997*** | | 1.000*** | | 1.006*** |
| | | (0.074) | | (0.037) | | (0.065) | | (0.063) |
| Intercept | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Duration | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Stock factors | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bond factors | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample size | 2,449 | 2,449 | 3,551 | 3,551 | 2,429 | 2,429 | 1,478 | 1,478 |
| Adjusted R square | 0.29 | 0.34 | 0.26 | 0.38 | 0.23 | 0.30 | 0.35 | 0.45 |

Table 5. Explanatory power of indices of real estate factors constructed from out of sample

This table reports results from cross-sectional regressions of properties' holding-period risk premiums against an intercept term, duration (quarters), stock and bond factors, and a whole-market index of real estate factors. Panel A reports regressions for each of the four regions, and Panel B reports regressions for each of the four property types. In each regression, the index of real estate factors is constructed from residuals of properties that are not in the current region/type. Heteroskedasticity robust standard errors are reported in parenthesis. ***, **, and * indicate significant levels of 1%, 5%, and 10% respectively.

| Panel A. Regions | | | | |
|---|---|---|---|---|
| | East | Midwest | South | West |
| Index (from other regions) | 0.583*** | 0.633*** | 0.420*** | 0.493*** |
| | (0.080) | (0.087) | (0.060) | (0.063) |
| Intercept | Yes | Yes | Yes | Yes |
| Duration | Yes | Yes | Yes | Yes |
| Stock factors | Yes | Yes | Yes | Yes |
| Bond factors | Yes | Yes | Yes | Yes |
| Sample size | 2,499 | 1,484 | 3,249 | 3,616 |
| Adjusted R square | 0.25 | 0.26 | 0.20 | 0.27 |

| Panel B. Property types | | | | |
|---|---|---|---|---|
| | Apartment | Industrial | Office | Retail |
| Index (from other types) | 0.136* | 0.437*** | 0.394*** | 0.178* |
| | (0.077) | (0.062) | (0.079) | (0.103) |
| Intercept | Yes | Yes | Yes | Yes |
| Duration | Yes | Yes | Yes | Yes |
| Stock factors | Yes | Yes | Yes | Yes |
| Bond factors | Yes | Yes | Yes | Yes |
| Sample size | 2,449 | 3,551 | 2,429 | 1,478 |
| Adjusted R square | 0.23 | 0.26 | 0.24 | 0.35 |

Table 6. Explanatory power of regional indices of real estate factors

This table reports results from cross-sectional regressions of properties' holding-period risk premiums against an intercept term, duration (quarters), stock and bond factors, and the whole-market index of real estate factors, and regional indices of real estate factors that are orthogonal to the whole market index. Heteroskedasticity robust standard errors are reported in parenthesis. ***, **, and * indicate significant levels of 1%, 5%, and 10% respectively.

| | All | East | Midwest | South | West |
|---|---|---|---|---|---|
| Market index | 1.001*** | 1.014*** | 0.979*** | 1.001*** | 0.999*** |
| | (0.034) | (0.075) | (0.082) | (0.064) | (0.062) |
| Regional index | 1.001*** | 1.007** | 0.984*** | 1.002*** | 1.000*** |
| | (0.033) | (0.075) | (0.067) | (0.071) | (0.069) |
| Intercept | Yes | Yes | Yes | Yes | Yes |
| Duration | Yes | Yes | Yes | Yes | Yes |
| Stock factors | Yes | Yes | Yes | Yes | Yes |
| Bond factors | Yes | Yes | Yes | Yes | Yes |
| Sample size | 10,848 | 2,499 | 1,484 | 3,249 | 3,616 |
| Adjusted R2 | 0.33 | 0.33 | 0.36 | 0.28 | 0.34 |

Table 7. Explanatory power of property type indices of real estate factors

This table reports results from cross-sectional regressions of properties' holding-period risk premiums against an intercept term, duration (quarters), stock and bond factors, and the whole-market index of real estate factors, regional indices of real estate factors that are orthogonal to the whole market index, and property type indices of real estate factors that are orthogonal to both the whole market and regional indices. Heteroskedasticity robust standard errors are reported in parenthesis. ***, **, and * indicate significant levels of 1%, 5%, and 10% respectively.

| | All | Apartment | Industrial | Office | Retail |
|---|---|---|---|---|---|
| Market index | 1.002*** | 0.993*** | 1.002*** | 1.001*** | 1.026*** |
| | (0.033) | (0.095) | (0.050) | (0.079) | (0.089) |
| Regional index | 0.915*** | 0.862*** | 0.970*** | 0.934*** | 0.824*** |
| | (0.031) | (0.067) | (0.046) | (0.070) | (0.075) |
| Type index | 1.007*** | 1.021** | 1.004*** | 1.004*** | 1.014*** |
| | (0.030) | (0.083) | (0.070) | (0.087) | (0.080) |
| Intercept | Yes | Yes | Yes | Yes | Yes |
| Duration | Yes | Yes | Yes | Yes | Yes |
| Stock factors | Yes | Yes | Yes | Yes | Yes |
| Bond factors | Yes | Yes | Yes | Yes | Yes |
| Sample size | 9,907 | 2,449 | 3,551 | 2,429 | 1,478 |
| Adjusted R2 | 0.41 | 0.37 | 0.44 | 0.35 | 0.48 |

Table 8. Heterogeneity in loadings: capital size

This table reports results of regressions of properties' holding period risk premiums against an intercept term, duration (quarters), stock and bond factors, and the whole-market index of real estate factors, for properties in the four quartiles of normalized log prices respectively. The last regression uses all properties and includes an interaction term between the normalized log price and the index of real estate factors. Heteroskedasticity robust standard errors are reported in parenthesis. ***, **, and * indicate significant levels of 1%, 5%, and 10% respectively.

| | 0 - 25% | 25% - 50% | 50% - 75% | 75% - 100% | All |
|---|---|---|---|---|---|
| Index | 1.406*** | 0.938*** | 0.913*** | 0.453* | 0.978*** |
| | (0.214) | (0.134) | (0.159) | (0.275) | (0.037) |
| Price * RE | | | | | -0.198*** |
| | | | | | (0.038) |
| Intercept | Yes | Yes | Yes | Yes | Yes |
| Duration | Yes | Yes | Yes | Yes | Yes |
| Stock factors | Yes | Yes | Yes | Yes | Yes |
| Bond factors | Yes | Yes | Yes | Yes | Yes |
| Sample size | 2,712 | 2,712 | 2,712 | 2,712 | 10,848 |
| Adjusted R2 | 0.26 | 0.24 | 0.29 | 0.28 | 0.27 |

Table 9. Heterogeneity in loadings: physical size

This table reports results of regressions of properties' holding period risk premiums against an intercept term, duration (quarters), stock and bond factors, and the whole-market index of real estate factors, for properties in the four quartiles of normalized log gross square footage respectively. The last regression uses all properties and includes an interaction term between the normalized log gross square footage and the index of real estate factors. Heteroskedasticity robust standard errors are reported in parenthesis. ***, **, and * indicate significant levels of 1%, 5%, and 10% respectively.

| | 0 - 25% | 25% - 50% | 50% - 75% | 75% - 100% | All |
|---|---|---|---|---|---|
| Index | 1.252*** | 1.023*** | 0.742*** | 0.847*** | 0.975*** |
| | (0.066) | (0.073) | (0.075) | (0.078) | (0.036) |
| GSF * RE | | | | | -0.160*** |
| | | | | | (0.036) |
| Intercept | Yes | Yes | Yes | Yes | Yes |
| Duration | Yes | Yes | Yes | Yes | Yes |
| Stock factors | Yes | Yes | Yes | Yes | Yes |
| Bond factors | Yes | Yes | Yes | Yes | Yes |
| Sample size | 2,518 | 2,518 | 2,517 | 2,518 | 10,071 |
| Adjusted R2 | 0.25 | 0.27 | 0.30 | 0.29 | 0.28 |

Table 10. Heterogeneity in loadings: profitability

This table reports results of regressions of properties' holding period risk premiums against an intercept term, duration (quarters), stock and bond factors, and the whole-market index of real estate factors, for properties in the four quartiles of normalized log net operating income (NOI) per square foot respectively. The last regression uses all properties and includes an interaction term between the normalized log NOI per square foot and the index of real estate factors. Heteroskedasticity robust standard errors are reported in parenthesis. ***, **, and * indicate significant levels of 1%, 5%, and 10% respectively.

| | 0 - 25% | 25% - 50% | 50% - 75% | 75% - 100% | All |
|---|---|---|---|---|---|
| Index | 1.148*** | 0.985*** | 0.834*** | 0.834*** | 0.988*** |
| | (0.071) | (0.067) | (0.079) | (0.084) | (0.038) |
| NOI * Index | | | | | -0.073* |
| | | | | | (0.042) |
| Intercept | Yes | Yes | Yes | Yes | Yes |
| Duration | Yes | Yes | Yes | Yes | Yes |
| Stock factors | Yes | Yes | Yes | Yes | Yes |
| Bond factors | Yes | Yes | Yes | Yes | Yes |
| Sample size | 2,315 | 2,315 | 2,314 | 2,315 | 9,259 |
| Adjusted R2 | 0.33 | 0.32 | 0.29 | 0.23 | 0.28 |

Figure 1. Histogram of holding-period annualized IRRs

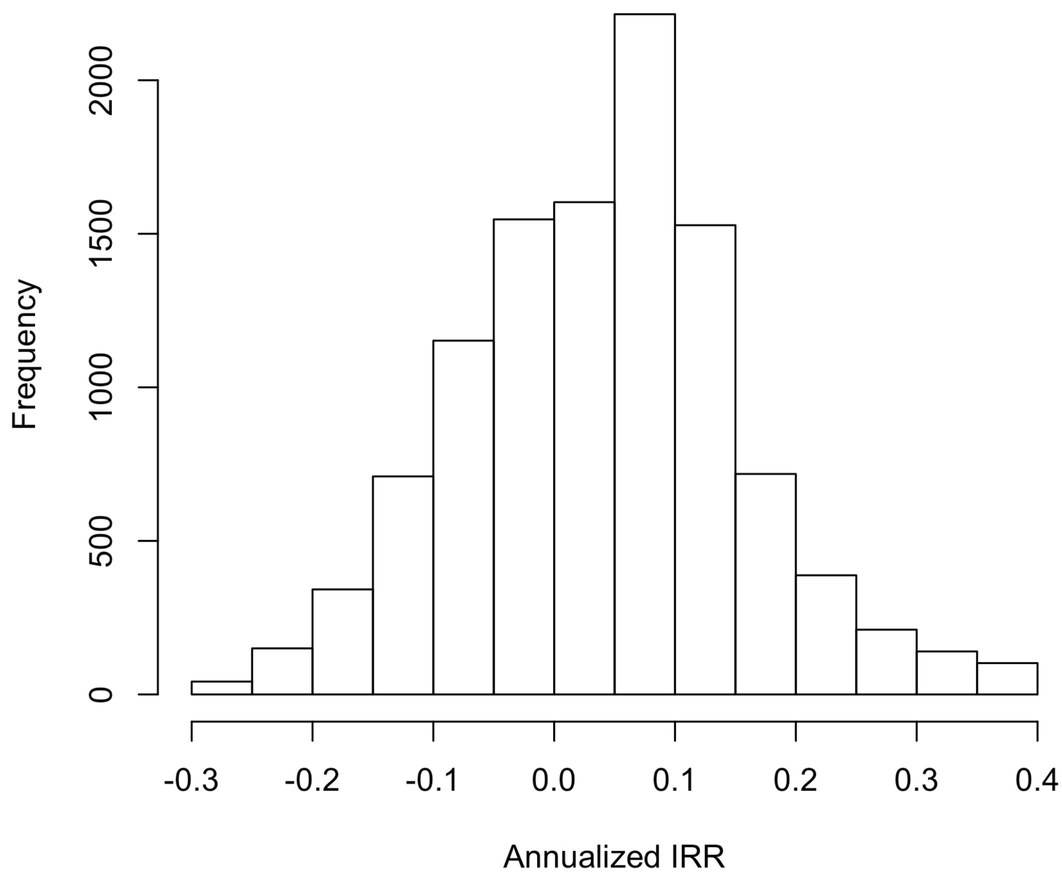

Figure 2. Time series of a whole-market index of real estate factors

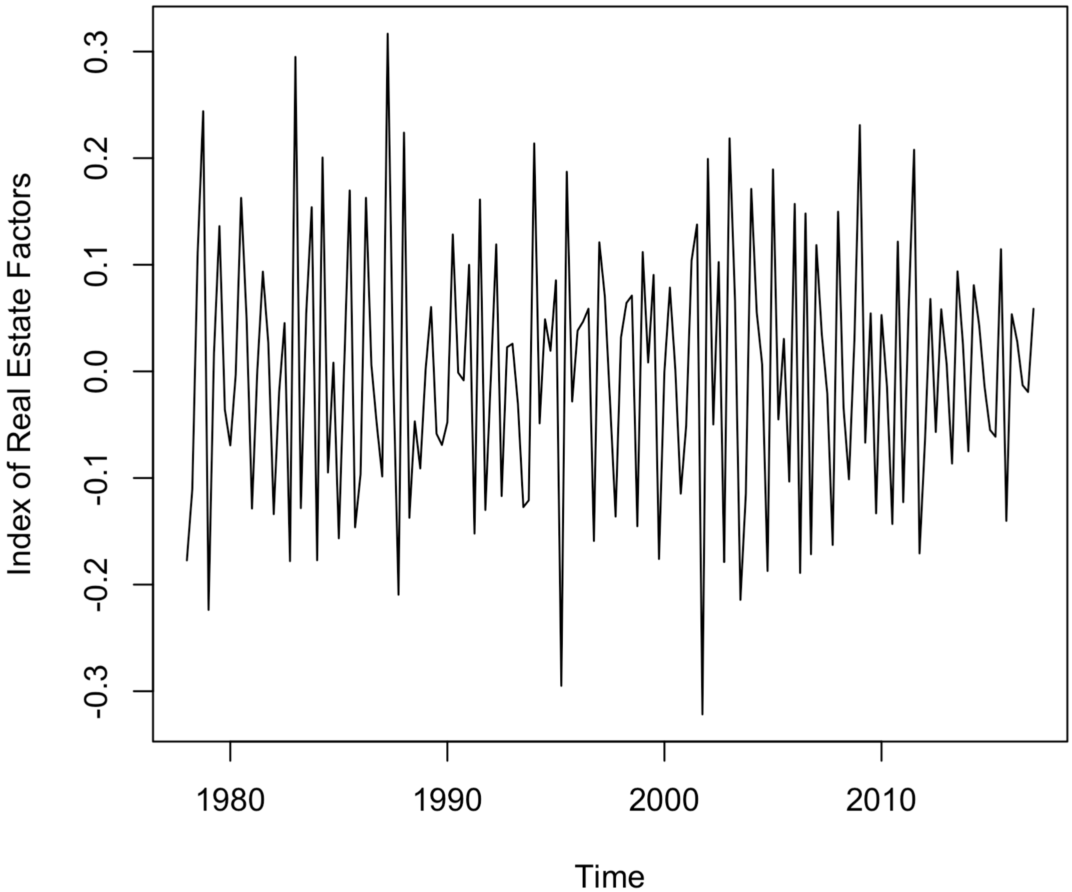

Figure 3. Histogram of coefficients of indices of real estate factors from bootstrapping analysis

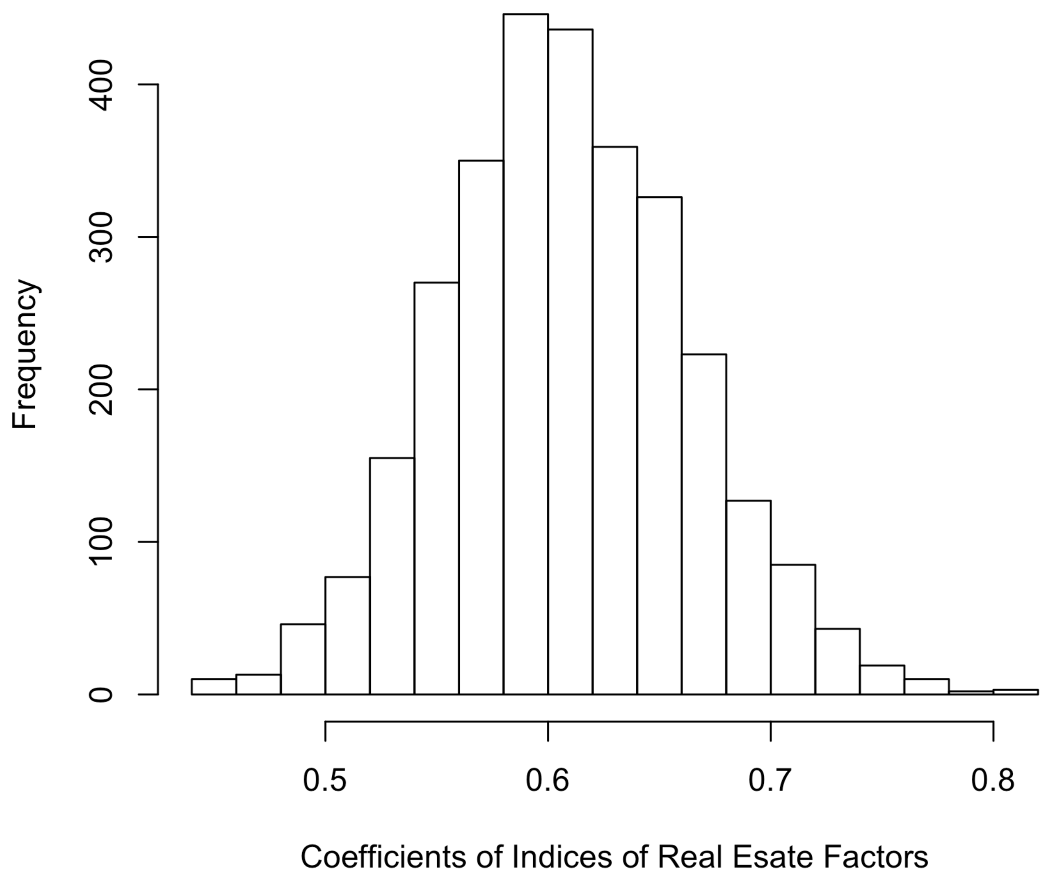

Figure 4. Histogram of coefficients of indices of real estate factors from counterfactual analysis