Disentangling Bubbles in Equity REITs

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Abstract
This paper examines the occurrence of price bubbles in equity real estate investment trusts (REITs) classified by property type focus. We employ the generalized suprema augmented Dickey–Fuller (GSADF) methodology to a sample spanning January 1980 to December 2017. The analysis considers the overall equity REIT index and seven major property sectors including Diversified, Healthcare, Industrial/Office, Lodging/Resorts, Residential, Retail, and Self-Storage. Our results reveal significant bubble periods in the overall equity REIT index and all property sectors except for Lodging/Resorts. Interestingly, we observe independent patterns in the price bubbles for all remaining six property sectors. Our results confirm that each property sector represents a unique line of business. These findings have important implications for REIT investors, portfolio managers and policymakers.

Keywords: Generalized suprema ADF; Equity REITs; Price bubbles; Property sectors

1. Introduction
There is significant debate over whether price bubbles in asset pricing exist and whether they can be properly detected and quantified. Diba and Grossman (1988) define price bubbles as periods of unsustainable price deviation from fundamental value. These persistent pricing errors may arise as a result of investors trading on noise or irrational expectations rather than on relevant information (Phillips et al., 2015). However, Brauers et al. (2014) demonstrate that bubbles can be driven by rational expectations if investors are compensated with higher returns for the growing risk in a potential price collapse. In addition, they explain that bubbles can form under rational expectations if the collapse of the bubble is not a deterministic outcome. As a response to this debate, a wealth of time series methods has been developed to detect rational price bubbles including integration and cointegration tests, variance bound tests, specification tests, and Chow and cumulative sum (CUSUM) type tests. In aggregation, these methods provide evidence that price bubbles do exist and can exist even within a framework of rational expectations.

We extend the literature on price bubbles in equity REITs by testing for the existence of multiple speculative bubble periods in their property type investment focus using the generalized suprema augmented Dickey–Fuller (GSADF) methodology proposed in Phillips et al. (2015). Equity REITs, which
typically invest in income-producing real estate, have become a very important asset class for many investors. The market capitalization of equity REITs was approximately $1 trillion as the end of 2018, creating employment for over 80 million Americans\textsuperscript{1}. The $1 trillion market capitalization is a substantial expansion from $9 billion in 1992 (see e.g., Geltner et al., 2014). An equity REIT may focus its investment in one property type or have a portfolio of multiple property types. Yet, most studies on REIT price bubbles often treat equity REITs as a single asset class, failing to distinguish among property submarkets. The few studies that attempt to differentiate bubbles for REITs that specialize in different property classes often produce inconclusive results or do not provide a thorough investigation of the various property type classifications (e.g., Brauers et al. 2014; Payne and Waters 2007). This paper addresses this limitation by testing bubbles in equity REITs based on their asset holdings. This distinction is important for a number of reasons. First, Ro and Ziobrowski (2011) posit that about 90\% of equity REITs focus their investment in one property type or in two property classes that are closely related. Second, each asset class is affected by different economic forces. For instance, Giambona et al. (2008) examine leverage and debt maturity in equity REITs specialized in five different property categories including industrial, retail, office, multi-family and office. They document that the various property types signify five distinct business lines with unique economic sensitivities. For the authors, the underlying property characteristics affect REITs’ capital structure differently. Finally, property specialized REITs have different risk-return characteristics. Yavas and Yildirim (2009) find statistically significant variations in the correlations between REIT price returns and net asset value returns across different property categories. Figure 1 shows that the various property sectors of equity REITs have very distinct historical total annual returns. Given these reasons, we expect varied bubble patterns in the various property categories in our sample.

\[\text{Figure 1 about here}\]

Results from our analysis reveal statically significant bubble periods in the equity REIT index and all property sectors except for the Lodging/Resorts index. Interestingly, we observe independent patterns in the price bubbles for the six remaining property sectors. While the overall equity REIT index experienced seven bubble periods, the Healthcare index experienced nine and all other indices witnessed five independent bubble occurrences with durations between 3 to 70 months. Notably, we document bubble episodes that coincide with the period prior to the 2007-2009 financial crisis. We also show REIT specific bubbles in the late 1990s fueled by growth in institutional ownership in the industry. Our findings have important implications for investors, portfolio managers and policymakers. The key advantage of the GSADF methodology is the ability to date stamp the episodes of speculative bubble. In other words, it shows when prices begin to rise and when they start to fall. Additionally, the technique has the ability to detect bubbles over a long period of time. This is important because investors and portfolio managers can utilize this price bubble detection methodology to adopt a risk-averting strategy by avoiding over-priced assets or implement a risk-seeking strategy by exploiting the over-priced assets. Similarly, policymakers or regulators can use it to formulate policies to mitigate the negative impact of a sudden decline in prices if a bubble is detected. Cecchetti et al. (2000) suggest that central banks should sometimes respond to stock prices in order to prevent bubbles from getting out of control.

The remainder of the paper is organized as follows. In Section 2 we present a review of the related literature. Section 3 describes the dataset. Section 4 explains our methodology. Section 5 presents our empirical results. Section 6 concludes.

2. Related Literature

There is an expanding literature on price bubbles in REITs that use various econometric techniques but provide evidence that is inconclusive. Clayton and MacKinnon (2003) suggest that the significant link between financial asset, REIT and real estate returns allows for the possibility of the formation of bubbles in REIT prices. However, Jirasakuldech et al. (2006) apply unit root test and cointegration approaches to the National Association of Real Estate Investment Trusts (NAREIT) equity price index from 1973 to 2003.
and find no bubbles for their sample period. Given that Nneji et al. (2013) find a spillover of speculative bubbles from real estate to REITs using a multivariate bubble model, it is possible that bubbles in REITs do exist but were not captured by the methodology employed by Jirasakuldech et al. (2006).

Bohl (2003) uses the momentum threshold autoregressive (MTAR) model to detect periodically collapsing bubbles during the sample period 1871–2001 for the overall U.S. stock market and finds evidence of bubble formation. Payne and Waters (2007) build on their findings and argue that since REITs are integrated with other stocks and share similar risk characteristics, bubbles are to be expected in REITs as well. The authors apply the MTAR model and the residuals-augmented Dickey–Fuller (RADF) methodology to examine for the possibility of price bubbles and document that only the RADF test indicates periodically collapsing bubbles in equity REITs. Although the authors test for bubbles in REIT sub-sectors, only the Lodging sub-sector produces consistent results of periodically collapsing bubbles for both the MTAR and RADF methodologies.

Anderson et al. (2011) study bubbles in mortgage, hybrid and equity REITs using a Markov regime-switching technique. They find evidence of price bubbles in the Mortgage REIT price series but no significant evidence of bubbles in equity and hybrid REITs. Similarly, Paskelian et al. (2011) provide some evidence of rational bubbles in Mortgage and Hybrid REITs with a regime-switching approach. Anderson et al. (2011) and Paskelian et al. (2011), however, did not consider for the possibility of bubbles in equity REITs classified by property sectors. We argue that equity REITs must not be considered as single asset class and further scrutiny based on property focus is relevant.

Brauers et al. (2014) suggest that REITs are susceptible to bubbles because, among other reasons, investors have inadequate short selling abilities compared to other stocks. Employing a complex systems test to equity REITs, they find bubbles in the overall equity REIT price series and the Residential REIT submarket but not for Office property type REITs. A limitation is that their work only looks at two property sectors: Residential and Office which provides the opportunity to further investigate the formation of price bubbles in the REIT industry by dissecting REITs into several other property categories.
Escobari and Jafarinejad (2016) test for the existence of inflation-adjusted REIT price bubbles utilizing CUSUM type tests employing SADF and GSDAF methodologies. They explain that these methodologies allow for the estimation of the beginning and end of bubble periods as well as the detection of multiple bubbles in a single time series. These techniques test for explosive autoregressive behavior that can be interpreted as the existence of bubbles without the need to observe fundamentals. While they find significant evidence of price bubbles in the REIT index and its three components (equity, mortgage and hybrid REITs), they treat REITs as a single asset class and fail to distinguish between different property types.

Our paper builds on these studies to examine for the existence of bubbles in the equity REIT index and seven major property sectors including Diversified, Healthcare, Industrial/Office, Lodging/Resorts, Residential, Retail, and Self-Storage.

3. Data

We obtain value-weighted REIT price indices from the CRSP/Ziman Real Estate Database and the Consumer Price Index (CPI) from the Federal Reserve Bank of St. Louis. We divide REIT prices by the CPI to adjust for inflation. The sample spans from January 1980 to December 2017 comprising 456 monthly observations for each index. For Healthcare and Self-Storage REITs, our sample starts from March 1984 and November 1982, respectively. Figure 2 shows the inflation-adjusted equity REIT index and our seven property type indices: Diversified, Healthcare, Industrial/Office, Lodging/Resorts, Residential, Retail, and Self-Storage. REIT prices exhibit a slight decline in 1997 followed by a steady increase that peaks in late 2006 and collapses in 2008, losing all value gains from 2003 to 2006 by 2009. However, REIT prices recover shortly after with most indices reaching new peaks in 2016. The most notable increases are observed for Self-Storage, Healthcare, and Apartment REITs.

[Figure 2 about here]
Table 1 reports the descriptive statistics. The inflation-adjusted equity REIT index is on average 294.80 over the sample with a minimum of 17.40 and a maximum of 1101.28. Among our seven property type indices, Self-storage has the highest average index level (643.58) followed by Healthcare (389.27) and Residential (374.32) sub-sectors. These three indices also have the highest volatility as measured by standard deviation. Lodging/Resorts has the lowest mean (224.13) and volatility (96.14) in our sample. Jain et al. (2017) note that Hotel REITs witnessed lower volatility during the 2007/2008 crisis and post-crisis.

4. Methodology

We follow the methodological framework introduced in Phillips et al. (2011) and further developed in Phillips et al. (2015) to test for the presence of bubbles and to date stamp the beginning and end of each independent bubble period. This methodology recursively implements the following augmented Dickey-Fuller (ADF) regression equation using a rolling window:

\[
\Delta y_t = \alpha_{r_1,r_2} + \beta_{r_1,r_2} y_{t-1} + \sum_{i=1}^{n} \delta_{r_1,r_2} \beta_{r_1,r_2} \Delta y_{t-i} + \varepsilon_t
\]  

(1)

where \(y_t\) is the corresponding inflation-adjusted REIT prices, \(r_1\) and \(r_2\) are the beginning and the ending points of a rolling period based on the fractions of the total sample size, and \(\varepsilon_t\) is the normally distributed error term. We test the unit root null hypothesis \((H_0: \beta_{r_1,r_2} = 1)\) against the alternative of mildly explosive behavior \((H_1: \beta_{r_1,r_2} > 1)\) in \(y_t\) using the corresponding ADF\(_{r_1}^{T^2}\) = \(\hat{\beta}_{r_1,r_2} / s. e. (\hat{\beta}_{r_1,r_2})\).\(^2\) Phillips et al. (2011) propose supremum ADF (SADF) statistic as a recursive procedure on the estimation of ADF\(_{r_1}^{T^2}\) using different subsamples,

\(^2\)ADF\(_{\hat{\beta}}\) is the standard ADF test statistic.
\[ SADF(r_0) = \sup_{r_2 \in [r_0, 1]} \text{ADF}_{r_2}^{r_0} \] (2)

when the SADF statistic exceeds the right tail critical value, the unit root null hypothesis is rejected, pointing out to the existence of explosive behavior in the series. Phillips et al. (2015) argue that the Phillips et al. (2011) SADF statistic performs well for a single episode of explosive behavior but lacks the power to consistently identify multiple episodes of boom and bust in a series. Phillips et al. (2015) develop the generalized SADF (GSADF) statistic using a rolling and recursive sample in order to test a larger number of subsamples than the SADF where both initial point \((r_1)\) and ending point \((r_2)\) are allowed to change,

\[ GSADF(r_0) = \sup_{r_2 \in [r_0, 1]} \text{BSADF}_{r_2}(r_0) \] (3)

where Backward SADF (BSADF) statistic is obtained by,

\[ \text{BSADF}_{r_2}(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} \text{ADF}_{r_1}^{r_2} \] (4)

to mark the beginning of the bubble when BSADF exceeds its critical value,

\[ \hat{\epsilon} = \inf_{r_2 \in [r_0, 1]} \{ r_2 : BSADF_{r_2}(r_0) > scv_{r_2}^{\alpha} \} \] (5)

and to mark the end of the corresponding bubble after \(\hat{\epsilon} + 3/T\) when BSADF falls below its critical value.\(^3\)

\(^3\) We use \(3/T\) to identify bubbles that lasts three months or longer.
where \( scv^\alpha_2 \) denotes the 100\((1 - \alpha)\)% critical value of the SADF based on \( \lfloor r_2 T \rfloor \) observations and at the \( \alpha \) level of significance. Given the non-standard distributions of \( GSADF(r_0) \) and \( BSADF_{r_2}(r_0) \) statistics in equations 3 and 4, we obtain the critical values using Monte Carlo simulations with 2000 replications. When \( GSADF(r_0) \) exceeds the right tail critical value, we reject the null hypothesis, suggesting the existence of explosive behavior.\(^4\)

5. Results

We follow equation 3 to compute GSADF test statistics for the inflation-adjusted equity REIT index and the seven property type indices: Diversified, Healthcare, Industrial/Office, Lodging/Resorts, Residential, Retail, and Self-Storage. Table 2 reports the estimated test statistics along with the 90%, 95% and 99% critical values.\(^5\) We show significant results for equity REIT at the 5% level (GSADF: 5.308 > 3.977), and six of the seven property types: Diversified at the 5% level (GSADF: 4.164 > 3.977), Healthcare at the 10% level (GSADF: 3.883 > 2.262), Industrial/Office at the 5% level (GSADF: 4.095 > 3.977), Residential at the 1% level (GSADF: 5.942 > 5.627), Retail at the 1% level (GSADF: 7.197 > 5.627), and Self-Storage at the 1% level (GSADF: 7.651 > 6.370). Overall, statistically significant GSADF test statistics suggest the presence of multiple bubbles in Diversified, Healthcare, Industrial/Office, Residential, Retail, and Self-Storage REIT indices.

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\(^4\) We focus on reporting results on the more conservative GSADF for the sake of brevity, however, results for the SADF are available upon request.

\(^5\) We obtain critical values for both tests using Monte Carlo simulations with 2000 replications with 2% of the sample (i.e., 8 or 9 observations) as the smallest window.
Figures 3 to 10 plot the recursive BSADF statistics for GSADF against their corresponding 95% critical values. We mark the beginning and the end of each bubble when the recursive BSADF statistics cross above and below their corresponding 95% critical values. All figures suggest multiple bubble periods in the inflation-adjusted REIT index and in the aforementioned six property type indices.

[Figures 3]

The GSADF graph in Figure 3 shows a number of bubble periods. One of the longest bubble episodes being the period (1996 to early 1998) when REITs became popular with institutional investors. Chan et al. (1998) posit that REIT stocks after 1994 on average attracted more institutional investors than non-REIT stocks. Geltner et al. (2014) state that REITs during that period were priced substantially above their underlying assets because investors perceived them as growth stocks. The other longest bubble documented in Figure 3 is the subprime boom from 2003 to 2007.

[Figure 4] [Figure 5] [Figure 6] [Figure 7]

For the Diversified REIT index, the GSADF graph in Figure 4 indicates bubble periods in the early 1990s mostly driven by acquisition of underlying assets at lower cost due to the overbuilding by private real estate developers in the 1980s. The figure also reveals the REIT boom of 1996 to 1998 and the real estate bubble in the 2000s.

In the case of the Healthcare REIT index, Figure 5 shows that Modern REIT Era starting in 1991 had an impact on Healthcare stock prices. The GSADF graph provides bubble episodes in the early 1990s as well as 1996 to 1998, the peak of the REIT industry’s boom. Aside the bubble presaging the 2007-2009 financial crisis, we also see two bubbles after the crash.

In Figure 6, the bubbles in Industrial/Office REITs are mainly observed for the periods 1996 to 1998 and 2004 to 2007. Surprisingly, the dot-com bubble which led to rising office rents in early the 2000s
in San Francisco did not increase Industrial/Office REIT prices. Geltner et al. (2014) argue that it has been speculated that money was actually pulled from REIT stocks and invested in dot-com stocks during that period.

For the Lodging/Resorts REIT index, Figure 7 suggests periods of price explosiveness, however, we fail to find statistically significant bubbles as shown in Table 2. Interestingly, the Lodging/Resort property type index also displays the smallest volatility among all property type indices in this study with a standard deviation of 96.14. Relatively stable returns for this index may explain why we do not observe significant bubble occurrences since speculative investors are probably inclined to look for more volatile prices in the attempt to reap gains from short-term investing. It is also important to state that the daily leases of hotels allow them to react more quickly to economic change. Our finding is contrary to Payne and Waters (2007) who document evidence of periodically collapsing bubbles in the lodging sub-sector of equity REITs between January 1994 to March 2005 using the momentum threshold autoregressive and the residuals-augmented Dickey-Fuller techniques. The authors however, fail to show the presence of bubbles in the other sectors. We believe our methodology is more robust and the consistency in the results further attest to this. Shi and Kabir (2018) used the approach to show animal spirits in residential real estate data in Auckland, New Zealand. Fabozzi and Xiao (2018) apply a modified version of the technique to provide evidence of the presence of bubbles in residential real estate prices in seven U.S. cities.

The Residential REIT results in Figure 8 show the longest bubble prior to the subprime crisis. This is expected since the boom was mainly driven by the housing market. The figure also shows the reemergence of a bubble after 2014. This is consistent with the work of Fabozzi and Xiao (2018) who find

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6 In the overall equity REIT index and the six property sectors where we find significant bubbles, we show evidence of bubble patterns prior to the subprime mortgage crisis.
the reemergence of a bubble in the U.S. housing market after 2013. Our results however indicate a lag between the private and public markets.

For Retail REITs, the GSADF graph in Figure 9 suggests a long bubble from 1982 to 1987. Mostly caused by favorable tax rules that motivated investments in retail real estate. It is estimated that the number of shopping centers around that period increased by about 57% (Freeman, 1999). The Tax Reform Act of 1986 reduced some of those incentives thus negatively impacting stock prices in the public REIT market. The Retail REIT bubble crash in 1987 also coincides with Black Monday, the stock market crash that started in Hong Kong and spread to the U.S. Similar to the other property sectors, we also reveal a bubble episode before the financial crisis of 2007-2009.

Finally, The Self-Storage GSADF graph in Figure 10 provides evidence of lengthy bubble periods around the REIT boom of 1996 to 1998, the subprime mortgage boom of 2001 to 2007 and surprisingly, a recent bubble episode from 2011 to 2017. Grant (2018) argues the sector saw overvaluation of its stock during that time frame due to the unreasonably higher rent increases caused by scant development.

[Table 3 about here]

6. Conclusion

Prior research on REIT price bubbles often treat equity REITs as a single asset class and do not consider the differing characteristics among REITs that are focused on a single property type. This distinction is important since different property types react differently to macroeconomic conditions and face idiosyncratic submarket risks. We contribute to the literature by testing for the existence of price bubbles in equity REITs disaggregated by property investment focus. We adopt the generalized supremum augmented Dickey–Fuller (GSADF) methodology proposed in Phillips et al. (2015).

We document statically significant periods of multiple bubbles in the equity REIT index and in all property focus indices except for the Lodging/Resorts index. We conjecture that the insignificant bubble statistic in Lodging/Resort REITs is due to their daily lease structure which allows them to react more
quickly to economic conditions. Interestingly, we observe independent patterns in the price bubbles for the other six property sectors with varying durations. This indicates that each REIT category represents a unique line of business.

The key advantage of the GSADF methodology is the ability to date stamp the episodes of speculative bubbles irrespective of the fundamentals. In other words, the method shows when prices begin to rise and when they start to fall. Our results are relevant because investors and portfolio managers can utilize this form of analysis to adopt a risk-averting strategy by avoiding over-priced assets or implement a risk-seeking strategy by exploiting periods of asset over-pricing. Additionally, policymakers and regulators can use it to formulate policies to prevent the bursting of bubbles. According to Cecchetti et al. (2000), central banks need to sometimes act to prevent bubbles from getting out of control. Interestingly, our results clearly show bubble patterns in the various property type REITs during the REIT boom of 1996 to 1998 and the subprime mortgage boom. We also observe very recent bubble episodes unique to only Residential, Healthcare and Self-Storage REITs.
References


Figure 1. Long-term property sector returns for equity REITs

This figure shows long-term property sector returns for equity REITs. The data is from the National Association of Real Estate Investment Trusts (NAREIT).
This figure exhibits the monthly inflation-adjusted equity REIT index and seven property-type indices including Diversified, Healthcare, Industrial/Office, Lodging/Resorts, Office, Residential, Retail (right axes), and Self-Storage (left axis) from January 1980 to December 2017. Inflation-adjusted REIT indices are calculated by dividing the monthly indices (obtained from the CRSP/Ziman REITs database) by the Consumer Price Index (CPI, obtained from the Federal Reserve Bank of St. Louis).
Table 1. Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>Equity REIT Index</td>
<td>456</td>
<td>294.80</td>
<td>164.15</td>
<td>295.26</td>
<td>17.40</td>
<td>1101.28</td>
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<td>Diversified REIT Index</td>
<td>456</td>
<td>317.51</td>
<td>196.65</td>
<td>277.80</td>
<td>20.68</td>
<td>944.74</td>
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<td>Healthcare REIT Index</td>
<td>406</td>
<td>389.27</td>
<td>175.87</td>
<td>411.63</td>
<td>15.85</td>
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<td>Industrial/Office REIT Index</td>
<td>456</td>
<td>324.34</td>
<td>198.03</td>
<td>258.48</td>
<td>41.46</td>
<td>1084.59</td>
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<tr>
<td>Lodging/Resorts REIT Index</td>
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<td>224.13</td>
<td>238.10</td>
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<td>45.45</td>
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<td>185.34</td>
<td>423.32</td>
<td>10.52</td>
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<td>Retail REIT Index</td>
<td>456</td>
<td>335.76</td>
<td>152.01</td>
<td>356.20</td>
<td>11.52</td>
<td>1389.29</td>
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<td>Self-Storage REIT Index</td>
<td>422</td>
<td>643.58</td>
<td>195.41</td>
<td>861.93</td>
<td>33.74</td>
<td>3568.63</td>
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<td>Consumer Price Index (Inflation)</td>
<td>456</td>
<td>167.00</td>
<td>164.55</td>
<td>48.54</td>
<td>78.00</td>
<td>247.91</td>
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<td>Inflation-adjusted Equity REIT Index</td>
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<td>0.99</td>
<td>1.17</td>
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<td>Inflation-adjusted Diversified REIT Index</td>
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<td>3.94</td>
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<td>Inflation-adjusted Healthcare REIT Index</td>
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<td>1.19</td>
<td>3.52</td>
<td>0.25</td>
<td>14.99</td>
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This table presents descriptive statistics for the monthly equity REIT index and seven property-type indices: Diversified, Healthcare, Industrial/Office, Lodging/Resorts, Office, Residential, Retail, and Self-Storage from January 1980 to December 2017. For Healthcare and Self-Storage REIT indices, our sample starts from March 1984 and November 1982, respectively. Inflation-adjusted REIT indices are calculated by dividing the REIT monthly indices (obtained from CRSP/Ziman REITs database) by the Consumer Price Index (CPI, obtained from the Federal Reserve Bank of St. Louis).
### Table 2. GSADF test statistics

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<th>Property Types</th>
<th>Equity REITs</th>
<th>Diversified REITs</th>
<th>Healthcare REITs</th>
<th>Industrial/Office REITs</th>
<th>Lodging/Resorts REITs</th>
<th>Residential REITs</th>
<th>Retail REITs</th>
<th>Self-Storage REITs</th>
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</thead>
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<tr>
<td>GSADF</td>
<td>5.308**</td>
<td>4.164**</td>
<td>3.883*</td>
<td>4.095**</td>
<td>3.164</td>
<td>5.942***</td>
<td>7.197***</td>
<td>7.651***</td>
</tr>
</tbody>
</table>

#### Finite Sample Critical Values

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Equity REITs</th>
<th>Diversified REITs</th>
<th>Healthcare REITs</th>
<th>Industrial/Office REITs</th>
<th>Lodging/Resorts REITs</th>
<th>Residential REITs</th>
<th>Retail REITs</th>
<th>Self-Storage REITs</th>
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<tbody>
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<td>90%</td>
<td>3.399</td>
<td>3.399</td>
<td>2.262</td>
<td>3.399</td>
<td>3.399</td>
<td>3.399</td>
<td>3.399</td>
<td>3.733</td>
</tr>
<tr>
<td>95%</td>
<td>3.977</td>
<td>3.977</td>
<td>4.483</td>
<td>3.977</td>
<td>3.977</td>
<td>3.977</td>
<td>3.977</td>
<td>4.532</td>
</tr>
<tr>
<td>99%</td>
<td>5.627</td>
<td>5.627</td>
<td>6.297</td>
<td>5.627</td>
<td>5.627</td>
<td>5.627</td>
<td>5.627</td>
<td>6.370</td>
</tr>
</tbody>
</table>

Inflation-adjusted REIT indices are calculated by dividing the REIT monthly indices (obtained from CRSP/Ziman REITs database) by the Consumer Price Index (CPI, obtained from the Federal Reserve Bank of St. Louis). The sample spans from January 1980 to December 2017 with a total of 456 observations. For Healthcare and Self-Storage REIT indices, our sample starts from March 1984 and November 1982, respectively. GSADF is generalized SADF methodology proposed by Phillips et al. (2015). Critical values of both tests are obtained from Monte Carlo simulations with 2000 replications. The smallest window in the recursive procedures has 9 observations (or 2% of the sample). *, **, *** denote significance at the 10%, 5%, and 1% level, respectively, based on the finite sample critical values.
This graph shows results for the inflation-adjusted equity REIT index. The sample spans from January 1980 to December 2017 with 456 monthly observations. GSADF is the generalized SADF methodology proposed in Phillips et al. (2015). 95% critical values are calculated using Monte Carlo simulations with 2000 replications (the smallest window has 9 observations or 2% of the sample). The shaded areas mark the price bubble periods. Price bubbles in the equity REIT index are significant at the 5% level per the GSADF test statistic.
This graph shows results for the inflation-adjusted Diversified REIT index. The sample spans from January 1980 to December 2017 with 456 monthly observations. GSADF is the generalized SADF methodology proposed in Phillips et al. (2015). 95% critical values are calculated using Monte Carlo simulations with 2000 replications (the smallest window has 9 observations or 2% of the sample). The shaded areas mark the price bubble periods. Price bubbles in the Diversified REIT index are significant at the 5% level per the GSADF test statistic.
This graph shows results for the inflation-adjusted Healthcare REIT index. The sample spans from March 1984 to December 2017 with 406 monthly observations. GSADF is the generalized SADF methodology proposed in Phillips et al. (2015). 95% critical values are calculated using Monte Carlo simulations with 2000 replications (the smallest window has 8 observations or 2% of the sample). The shaded areas mark the price bubble periods. Price bubbles in the Healthcare REIT index are significant at the 10% level per the GSADF test statistic.
This graph shows results for the inflation-adjusted Industrial/Office REIT index. The sample spans from January 1980 to December 2017 with 456 monthly observations. GSADF is the generalized SADF methodology proposed in Phillips et al. (2015). 95% critical values are calculated using Monte Carlo simulations with 2000 replications (the smallest window has 9 observations or 2% of the sample). The shaded areas mark the price bubble periods. Price bubbles in the Industrial/Office REIT index are significant at the 5% level per the GSADF test statistic.
Figure 7. Price bubble periods in Lodging/Resorts REITs

This graph shows results for the inflation-adjusted Lodging/Resorts REIT index. The sample spans from January 1980 to December 2017 with 456 monthly observations. GSADF is the generalized SADF methodology proposed in Phillips et al. (2015). 95% critical values are calculated using Monte Carlo simulations with 2000 replications (the smallest window has 9 observations or 2% of the sample). The shaded areas mark the price bubble periods although, for the Lodging/Resort REIT index, these bubble periods are not statistically significant per the GSADF test statistic.
Figure 8. Price bubble periods in Residential REITs

This graph shows results for the inflation-adjusted Residential REIT index. The sample spans from January 1980 to December 2017 with 456 monthly observations. GSADF is the generalized SADF methodology proposed in Phillips et al. (2015). 95% critical values are calculated using Monte Carlo simulations with 2000 replications (the smallest window has 9 observations or 2% of the sample). The shaded areas mark the price bubble periods. Price bubbles in the Residential REIT index are significant at the 1% level per the GSADF test statistic.
Figure 9. Price bubble periods in Retail REITs

This graph shows results for the inflation-adjusted Retail REIT index. The sample spans from January 1980 to December 2017 with 456 monthly observations. GSADF is the generalized SADF methodology proposed in Phillips et al. (2015). 95% critical values are calculated using Monte Carlo simulations with 2000 replications (the smallest window has 9 observations or 2% of the sample). The shaded areas mark the price bubble periods. Price bubbles in the Retail REIT index are significant at the 1% level per the GSADF test statistic.
This graph shows results for the inflation-adjusted Self-Storage REIT index. The sample spans from November 1982 to December 2017 with 422 monthly observations. GSADF is the generalized SADF methodology proposed in Phillips et al. (2015). 95% critical values are calculated using Monte Carlo simulations with 2000 replications (the smallest window has 8 observations or 2% of the sample). The shaded areas mark the price bubble periods. Price bubbles in the Self-Storage REIT index are significant at the 1% level per the GSADF test statistic.