Disentangling bubbles in equity REITs

Daniel Huerta-Sanchez a, Mohammad Jafarinejad b, Dongshin Kim c, Kenneth W. Soye d,*

a Florida Gulf Coast University, Lusghert College of Business, Department of Economics and Finance, 10501 FGCU Blvd. S., Fort Myers, FL, 33965, United States

b University of Wisconsin – Whitewater, College of Business and Economics, Department of Finance and Business Law, Timothy J Hyland 3520, Whitewater, WI, 53190, United States

c Pepperdine University, Graziadio Business School, Department of Finance, 24255 Pacific Coast Highway, Malibu, CA, 90263, United States

d College of Charleston, School of Business, Department of Finance, 5 Liberty Street, Beatty Center, Charleston, SC, 29424, United States

A R T I C L E   I N F O

Article history:
Received 25 February 2019
Received in revised form 4 June 2019
Accepted 10 September 2019
Available online 12 September 2019

JEL classification:
C22
G12

Keywords:
Generalized supremum ADF
Equity REITs
Price bubbles
REIT property focus

A B S T R A C T

This paper examines the occurrence of price bubbles in equity real estate investment trusts (REITs) classified by property types. We employ the Generalized Supremum Augmented Dickey–Fuller (GSADF) methodology to a sample spanning January 1980–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 unique patterns in the price bubbles for all remaining six property sectors. Our results confirm that each property sector represents a distinct line of business.

© 2019 Board of Trustees of the University of Illinois. Published by Elsevier Inc. All rights reserved.

1. Introduction

Price bubbles are commonly defined as periods of unsustainable price deviation from fundamental value (Diba & Grossman, 1988). However, there is extensive debate as to whether these deviations are caused by rational expectations or by the irrational belief that prices will not correct back to their intrinsic worth. These persistent pricing errors may arise as a result of investors trading on noise or irrational expectations rather than relevant information (Phillips, Shi, & Yu, 2015). However, Brauers, Thomas, and Zietz (2014) suggest that bubbles can be driven by rational expectations if investors are compensated with higher returns for the growing risk of a potential price collapse. That is, bubbles can form under rational expectations if the collapse of the bubble is not a deterministic outcome and if investors believe that they are being compensated for the risk they bear. 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. These methods provide evidence that price bubbles do exist and can exist even within a framework of rational expectations.1

We extend the literature on price bubbles in equity REITs by testing for the existence of multiple speculative bubble periods by segmenting the industry by property type investment focus using the generalized supremum augmented Dickey–Fuller (GSADF) methodology proposed in Phillips et al. (2015). We revisit bubble formation in Equity REITs for multiple reasons. First is to address bubble formation in Equity REITs, segmenting the industry according to investment focus. An equity REIT may focus its investments 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 or using an incomplete sample of REIT property submarkets to make inferences. For example, Brauers et al. (2014) argue that REITs constitute a homogenous group within the general stock market that are prone to bubble formation thus are suitable

1 A comprehensive review of the bubble literature that describes their methodologies, sample covered, and conclusions is provided in Chen and Xie (2017).
Although Payne (2007) find that REITs have industrial property characteristics that are different from REITs in other sectors, the focus on REITs is an essential form of distinction among REITs. This distinction is important for several reasons. First, Ro and Zebrowski (2011) posit that about 90% of REITs focus their investments in one or two property classes that are closely related. Similarly, in a more recent study, Conklin, Diop, and Qiu (2018) show that REITs tend to focus their acquisitions in specific property-type sectors. Second, each asset class is affected by different economic forces. For instance, Giambona, Harding, and Sirmans (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 different 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 (2011) find statistically significant variations in the correlations between REIT price returns and net asset value returns across different property categories. Also, Gyourko and Nelling (1996) show variations in systemic risk across property types. For instance, they observe that a REIT firm that has most of its investments in retail properties tends to have a beta that is 50% larger than a firm that invests in industrial properties. Fig. 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. We contribute to the REIT literature by disentangling bubbles in equity REITs and by exploring the plausible different bubble formation periods according to REIT investment focus.

Another reason to look at bubbles in Equity REITs is that the fact that real estate as an asset class and REITs, in particular, are prone to prolonged increases in prices that tend to decrease quickly (see, e.g., Anderson, Brooks, & Tsolacos, 2011; Brauers et al., 2014). Prior research argues two plausible explanations for this phenomenon: comparative REIT short-selling constraints and persistent REIT underpricing with respect to net asset value (NAV). Brauers et al. (2014) and LIM (2011) explain that REIT investors have less short-selling abilities in comparison to other equities which limits the overvaluation signal that short-selling activity may send to the market and that can slow an explosive increase in prices. Some of the limitations to REIT short-selling are caused by low stock liquidity and a relatively small number of REITs which translates into a comparatively low number of publicly traded options. Alternatively, the REIT NAV underpricing limits the motivation for REIT seasoned equity offerings (SEOs) which, in turn, does not allow for new stock issuances to mitigate a growing bubble (Anderson et al., 2011). Jirasakuldech, Campbell, and Knight (2006) explain that given the consistent REIT underpricing, REIT managers lack the incentive to issue new shares. Kim and Wiley (2019) support this assertion by showing that REITs mostly have the motivation to increase their investment through SEO when there is market overvaluation of their assets. Therefore, the REIT market lacks the SEO signaling effect and the supply of new stock to mitigate explosive REIT price growth and creates an environment that favors price bubble formation. Additionally, because investing in real estate is very capital-intensive, REITs are typically highly leveraged compared to other non-REIT firms (Ooi, Ong, & Li, 2010; Versmissen & Zietz, 2017), thus making them more susceptible to bubbles. As can be seen from Fig. 2, book leverage for REITs from 2000 to 2017 has stayed around 50% of assets with much volatility in the market debt ratio peaking at around 65% during the 2007–2009 financial crisis.

Given these REIT market characteristics, studying bubble formation behavior in REITs remains a relevant research avenue especially if it is recognized that REITs that focus on a property type are subject to particularities pertinent to that property specialization.

Also, by looking at bubble formation in Equity REITs, we can apply a robust methodological framework proposed in Phillips, Wu,
and Yu (2011) and further developed in Phillips et al. (2015) to help reveal behavior in REIT prices over a more extended sample period. Although the technique has been applied in the general finance literature, REITs are often excluded in these studies because of their regulated nature. To maintain their corporate tax-exempt status, among other requirements, they must pay at least 90% of their taxable income as dividends with a minimum of 75% of their assets held in real estate. Notwithstanding their exclusion from most general finance studies, REITs have witnessed very substantial growth in their market size. Ling, Ooi, and Xu (2019) note that the size of the average REIT grew from $500 million in 1993 to over $4 billion in 2013. Given this rapid expansion of the REIT sector, understanding the bubble formation behavior in the industry, especially at the subsector level, should be relevant to investors and policymakers.

The good thing about applying the GSADF methodology to examine REIT price behavior is its ability to date-stamp the beginning and end of multiple bubble periods in a time series and to provide test statistics to determine a statistically significant bubble. The advantage of this method is that it may allow for investors to build portfolio management strategies that will allow them to profit in the different stages of a price bubble since the methodology will alert the investor that a bubble period has begun and when the bubble is showing signs of collapse. In addition, the GSADF methodology allows for the detection of price bubbles without the need to observe fundamentals; this provides investors with an alternate tool to establish trading triggers for enhanced portfolio management. The REIT literature has seen multiple attempts to accurately detect the formation and collapse of price bubbles in order to develop profitable trading strategies (e.g., Escobar & Jafarinejad, 2016; Jirasakuldech et al., 2006; Nneji, Brooks, & Ward, 2013; Payne & Waters, 2007; Xie & Chen, 2015). However, results for these multiple attempts are mixed and have not provided investors with a straightforward answer as to how to detect the start of a bubble in order to ride the upward move in prices and the start of the collapse to either liquidate positions or use some short-selling strategy.

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 unique 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 unique bubble occurrences with durations between 3 to 70 months. Notably, we document bubble episodes that coincide with the period before the 2007–2009 financial crisis, which indicates that the model is accurate in detecting widely-recognized bubbles which speaks in favor of the reliability of the results. We also show REIT specific bubbles in the late 1990s fueled by growth in institutional ownership after new organizational changes and legislation attracted them to 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 episodes of speculative bubbles. In other words, it shows when prices begin to rise and when they start to fall. Additionally, the technique can detect bubbles over a long period. 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.

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

2. Related literature

There is a growing literature on REIT price bubbles that employs various econometric techniques but provides inconclusive evidence. Clayton and Mackinnon (2003) suggest that the significant link between financial assets, REITs, 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 Bohl (2003) and argue that since REITs are integrated with other stocks and share similar risk characteristics, bubbles should also be expected in REITs. 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, Hassan, and Huff (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 the possibility of bubbles in equity REITs classified by property sectors. We argue that equity REITs must not be considered a 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 investigate further the formation of price bubbles in the REIT industry by dissecting REITs into several other property categories. Our paper builds on Brauers et al. (2014) by employing a model that is arguably more precise in date-stamping bubbles. We employ the generalized supremum augmented Dickey–Fuller (GSADF) methodology. This method produces robust estimates by allowing a more flexible estimation window with various starting and ending dates to capture periods of explosive behavior in the sample and testing the statistical significance of these periods based on critical values that are obtained based on 2000 Monte Carlo simulations.

Escobar and Jafarinejad (2016) test for the existence of inflation-adjusted REIT price bubbles utilizing SADF and GSADF 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 Equity 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 for the Equity REIT index and seven property type indices: Diversified, Healthcare, Industrial/Office, Lodging/Resorts, Residential, Retail, and Self-Storage. The indices are constructed from all REITs that have traded on the three major exchanges since 1980 (i.e., NYSE, NYSE MKT and NASDAQ). The process for calculating the indices involved calculating returns for individual securities as well as the returns for the indices. The series at the security level include returns, prices, shares outstanding and adjustment factors. Included in the adjustment data are dividends, period and cumulative adjustment factors. The index levels reveal the cumulative value of the portfolio relative to a fixed starting date. Even though the indices are constructed from 1980, the base year is December 30, 1994. All the indices are set to 100 in the base year. To control for the effect of inflation on prices at different stages of the business cycle, we divide REIT prices by the Consumer Price Index (CPI): the CPI is obtained from the Federal Reserve Bank of St. Louis. 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.

Table 1 reports the descriptive statistics. The real (inflation-adjusted) equity REIT index is on average 294.80 over the sample period with a minimum of 17.40 and a maximum of 1101.28. Among the 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 the standard deviation. Lodging/Resorts has the lowest mean (224.13) and volatility (96.14) in our sample. Jain, Robinson, Singh, and Sunderman (2017) note that Lodging/Hotel REITs witnessed lower volatility during the 2007–2008 crisis and post-crisis, which aligns with what we observe in our data.

4. Methodology

We follow the methodological framework of 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 estimates the following augmented Dickey–Fuller (ADF) regression equation using a rolling window:

\[
\Delta y_t = \alpha_{r_1, r_2} + \beta_{r_1, r_2} y_{t-1} + \sum_{i=1}^{n} \hat{\beta}_{r_1, r_2}^{(i)} \Delta y_{t-i} + \varepsilon_t
\]

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 value, \( \tilde{\beta}_{r_1, r_2} \): Phillips et al. (2011) propose supremum ADF (SADF) statistic as a recursive procedure on the estimation of \( ADF^{(i)}_{r_1, r_2} \) using different subsamples,

\[
SADF(r_0) = \sup_{r_2 \in [r_0, 1]} ADF^{(i)}_{r_0, r_2}
\]

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

---

3 Our results are in contrast with Payne and Waters (2007); we discuss this in the results section.

4 \( ADF^{(i)}_{r_0, r_2} \) is the standard ADF test statistic.
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>
</tr>
</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>
</tr>
<tr>
<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>
</tr>
<tr>
<td>Healthcare REIT Index</td>
<td>456</td>
<td>389.27</td>
<td>175.87</td>
<td>411.63</td>
<td>15.85</td>
<td>1443.37</td>
</tr>
<tr>
<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>
</tr>
<tr>
<td>Lodging/Resorts REIT Index</td>
<td>456</td>
<td>224.13</td>
<td>238.10</td>
<td>96.14</td>
<td>45.45</td>
<td>414.98</td>
</tr>
<tr>
<td>Residential REIT Index</td>
<td>456</td>
<td>374.32</td>
<td>185.34</td>
<td>423.32</td>
<td>10.52</td>
<td>1675.51</td>
</tr>
<tr>
<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>
</tr>
<tr>
<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>
</tr>
</tbody>
</table>

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).

subsamples than the SADF where both initial point \( r_1 \) and ending point \( r_2 \) are allowed to change,

\[
GSADF(r_0) = \sup_{r_2 \in [r_1,1]} BSADF_{r_2}(r_0)
\]

where Backward SADF (BSADF) statistic is obtained by,

\[
BSADF_{r_2}(r_0) = \sup_{r_1 \in [r_2,r_0]} \{ ADF_{r_1}(r_0) \}
\]

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

\[
\hat{r}_e = \inf_{r_2 \in [r_1,1]} \{ r_2 : BSADF_{r_2}(r_0) > scv_{r_2} \}
\]

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

\[
\hat{r}_f = \inf_{r_2 \in [\hat{r}_e + 3/T,1]} \{ r_2 : BSADF_{r_2}(r_0) < scv_{r_2} \}
\]

where \( scv_{r_2} \) denotes the 100(1 – α) % critical value of the SADF based on \( r_2 T \) observations and at the α level of significance. Given the non-standard distributions of \( GSADF(r_0) \) and \( BSADF_{r_2}(r_0) \) statistics in Eqs. (3) and (4), we obtain the critical values using Monte Carlo simulations with 2000 replications. When \( GSADF(r_0) \) exceeds the right critical value, we reject the null hypothesis, suggesting the existence of explosive behavior.

5. Results

We follow Eq. (3) to compute SADF and 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.6 The interpretation of these test statistics allows us to infer whether there are significant periods of explosive behavior in a price series; that is, whether a data series presents multiple significant bubble periods. 7 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 > 6.627), Retail at the 1% level (GSADF: 7.197 > 6.627), and Self-Storage at the 1% level (GSADF: 7.651 > 6.370). Overall, these results provide strong evidence for the presence of multiple bubbles in Diversified, Healthcare, Industrial/OFFICE, Residential, Retail, and Self-Storage REIT indices.

Figs. 3–10 plot the recursive GSADF statistics for GSADF against their corresponding 95% critical values. We mark the beginning and the end of each bubble when the recursive GSADF statistics cross above and below their corresponding 95% critical values. Following Escobar and Jafarinejad (2016), we only identify bubbles that last at least three months. All figures suggest multiple bubble periods in the inflation-adjusted Equity REIT index and the aforementioned six property type indices.

The GSADF graph in Fig. 3 shows seven bubble periods. The longest bubble period from 08/2003 to 11/2007 coincides with the housing boom that consequently ended with the beginning of the great recession. Although the Federal Reserve reports that house prices started to rapidly increase in 1998Q1, the bubble behavior in REIT prices began in 2003Q3, reaching a peak in mid-2006 and finally collapsing in late 2007. Our findings coincide with anecdotal evidence that dates the great recession from December 2007 to June 2009.8

The second longest bubble reported in Fig. 3 dates from 08/1996 to 06/1998. This period coincides with a significant increase in REIT institutional ownership. Chan, Leung, & Wang (1998) explain that REIT stocks after 1994, on average, attracted more institutional investors than non-REIT stocks. After 1994, institutional ownership and the concentration of ownership restrictions in REIT stocks were relaxed, which resulted in a significant influx of institutional investors.

5 We use 3/T to identify bubbles that last at least three months (Escobar & Jafarinejad, 2016).

6 We report the GSADF results, which are more conservative for brevity; GSADF produces higher critical values compared to SADF, requiring larger test statistics for significance level at the 99%, 95% and even 90% levels. We obtain critical values for both tests using Monte Carlo simulations with 2000 replications with 2% of the sample (i.e., eight or nine observations) as the smallest window.

7 Econometric tests like SADF and GSADF mostly identify periods of explosive behavior (or exuberant growth) which is a necessary condition for a bubble (see, e.g., Shi & Kabir, 2018; Hu & Oxley, 2018). In our work, we have shown how the periods of exuberance episodes in our results coincide with financial bubbles like the one before the subprime mortgage crisis and other specific REIT bubbles.

Table 2
SADF and GSADF test statistics.

<table>
<thead>
<tr>
<th>Equity REIT</th>
<th>Diversified REIT</th>
<th>Healthcare REIT</th>
<th>Industrial/Office REIT</th>
<th>Lodging/Resorts REIT</th>
<th>Residential REIT</th>
<th>Retail REIT</th>
<th>Self-Storage REIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SADF</td>
<td>5.308***</td>
<td>3.993***</td>
<td>3.883***</td>
<td>3.254***</td>
<td>0.681</td>
<td>5.942***</td>
<td>7.197***</td>
</tr>
<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>
</tr>
</tbody>
</table>

Finite Sample Critical Values for SADF/GSADF

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>99%</td>
<td>2.315/5.627</td>
<td>2.315/5.627</td>
<td>2.262/6.297</td>
<td>2.315/5.627</td>
<td>2.315/5.627</td>
<td>2.315/5.627</td>
<td>2.273/6.370</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 SADF is the Supremum Augmented Dickey-Fuller methodology and GSADF is the Generalized SADF methodology proposed by Phillips et al. (2011) and Phillips et al. (2015), respectively. Critical values are obtained from Monte Carlo simulations with 2000 replications. The smallest window in the recursive procedures has nine observations (or 2% of the sample). *, **, *** denote significance at the 10%, 5%, and 1% level, respectively, based on the finite sample critical values.

![Fig. 3](image1.png)

**Fig. 3.** Price bubble periods in equity REITs.

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 generalised SADF methodology proposed in Phillips et al. (2015). 95% critical values are calculated using Monte Carlo simulations with 2000 replications (the smallest window has nine 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.

![Fig. 4](image2.png)

**Fig. 4.** Price bubble periods in Diversified REITs.

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 generalised SADF methodology proposed in Phillips et al. (2015). 95% critical values are calculated using Monte Carlo simulations with 2000 replications (the smallest window has nine 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 eight 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.

Another period of explosive price behavior is dated from 12/1984 to 03/1985. This bubble period is observed just before the Tax Reform Act of 1986 when rules to prevent partnerships from sheltering earnings were introduced. It appears that REIT market participants anticipated a change in legislation that placed limits on how investors could save on taxes through REITs.

For the Diversified REIT index, we observe eight significant bubbles. The GSADF graph in Fig. 4 indicates multiple bubble periods in the early 1990s that were likely driven by the acquisition of real assets at low cost due to the overbuilding by private real estate developers in the 1980s. The figure also reveals the boom of 1996 to 1998 attributed to the rapid influx of institutional investors to the REIT market along with the higher demand in REITs. In addi-
Fig. 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 nine 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.

Fig. 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 nine 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.

In the case of the Healthcare REIT index, Fig. 5 shows that the Modern REIT Era starting in the early 1990s had a significant impact on Healthcare REIT stock prices with a bubble dated from 02/1991 to 01/1992 followed by another bubble period from 02/1993 to 11/1993. The GSADF graph also provides a bubble episode from 11/1995 to 08/1998, aligning with the peak of the REIT industry’s boom. Beginning in 08/2003, the graph also captures four consecutive bubbles that are only separated by intervals of no more than three months. Despite the gaps in explosive behavior, we interpret the period 08/2003 to 09/2008 as one bubble that manifests alongside the housing bubble and the overall Equity REIT bubble recorded in Fig. 3. Interestingly, results in Fig. 5 suggest that the explosive behavior in Healthcare REIT prices began at the same time as the overall Equity REIT index but crashed ten months later than the overall Equity REIT bubble (the Equity REIT index bubble ended on 11/2007 and 09/2008 for the Healthcare REIT index). Finally, we capture two additional bubble periods in healthcare REITs that are not observed in the Equity REIT index from 05/2012 to 07/2013 and 10/2014 to 03/2015. In all, the Healthcare REIT series displays the largest number of explosive behavior occurrences compared to other specialized REITs.

In Fig. 6, the bubbles in Industrial/Office REITs are mainly observed for the periods 07/1996 to 04/1998 and 07/2004 to 10/2007. The later bubble period ends almost contemporaneously
with the bubble recorded in the Equity REIT index that is attributed to the housing crisis. Surprisingly, the dot-com bubble, which led to rising office rents in early the 2000s 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. Similar to the phenomenon observed in the Equity REIT index (Fig. 3), the period 08/1990 to 12/1990 shows explosive price behavior associated with a decrease in the index that is followed by a rapid recovery.

For the Lodging/Resorts REIT index, Fig. 7 and the test statistics in Table 2 suggest the episodes cannot be considered statistically significant bubbles. Unlike the other figures, if you observe the inflation-adjusted index (i.e., the green line), you will realize that it is declining instead of increasing as seen in the other figures. Hu and Oxley (2016) describe this declining nature of the index as collapse episodes, although the backward SADF crosses the 95% critical value line. 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 which may explain why our method does not recognize significant explosive behavior in the Lodging/Resort
REIT index. 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 (MTAR) and the Residuals-Augmented Dickey–Fuller (RADF) techniques. The authors, however, fail to show the presence of bubbles in the other sectors. According to Phillips et al. (2015), GSADF is a more suitable methodology for long time series datasets, in which multiple episodes of explosive behavior or mildly explosive behavior are expected. Therefore, we can reveal multiple episodes of explosive behavior in our indices that were not captured by previous work but align with widely-recognized anecdotal evidence of bubbles specific to the REIT industry.9 In addition, the GSADF methodology that we employ in this paper is viewed as successful in recognizing bubble behavior in other applications. For example, Shi and Kabir (2018) use the approach to show animal spirits in residential real estate data in Auckland, New Zealand. Using the same model, Fabozzi and Xiao (2017) document explosive rents in five cities that are related to market-specific housing bubbles. Moreover, Fabozzi and Xiao (2019) 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. Recently, Hu and Oxley (2018) employ this methodology on the South Sea Company and several 18th-century financial organizations to present evidence of bubbles in the stock prices of these companies for the first time.

The Residential REIT results in Fig. 8 show the longest bubble before the subprime crisis from 11/1995 to 11/2007. Although the Federal Reserve shows that the rapid increases in house prices began in 1998Q1, our method captures explosive behavior in the Residential REIT index over two years prior to that with a sudden crash in 2008Q4.10 The results for the Residential REIT index are not surprising since the housing market mainly drove the boom that eventually collapsed during the Great Recession. Interestingly, our results suggest a re-emergence of bubble behavior beginning in 11/2014 that has yet to collapse. This is consistent with the work of Fabozzi and Xiao (2019) who find the re-emergence 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 Fig. 9 suggests two long bubbles from 10/1982 to 08/1987 and 02/2002 to 12/2007. The bubble from 1982 to 1987 is attributed to favorable tax rules that motivated investments in retail real estate during this era. 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, when the stock market crashed in Hong Kong and spread to the U.S. and other countries. In Fig. 9 we also observe that although the bubble period that aligns with the housing bubble and crash is not as extensive as for the Residential REIT index, it is considerably longer than for the other property-specific indices and the Equity REIT index. Our results indicate that the explosive behavior in Retail REIT prices began more than one and a half years before it appeared in the general Equity REIT index. This may suggest a stronger connection between the residential and the retail markets when compared to other property types.

Finally, the Self-Storage GSADF graph in Fig. 10 provides evidence of lengthy bubble periods around the REIT boom of 1996–1998 and the subprime mortgage boom. In all, Fig. 10 suggests five bubble periods. Notably, results suggest that Self-Storage REIT prices began a period of explosive behavior on 02/2011 that had not collapsed by the end of our sample period (12/2017). Grant (2018) argues that the self-storage sector saw the overvaluation of its stock during this time frame due to the unreasonably higher rent increases caused by scant development. The results we present here could serve as an over-valuation signal for Self-Storage REIT stakeholders that warrants further scrutiny.

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 and by adopting the generalized supremum augmented Dickey–Fuller (GSADF) methodology proposed in Phillips et al. (2015).

We document statistically significant bubble periods in the equity REIT index and its subsectors 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 unique patterns in the price bubbles for the other six property sectors with varying durations. This indicates that each REIT category represents a distinct line of business.

The key advantage of the GSADF methodology is the ability to date stamp multiple bubbles (see, e.g., Fabozzi & Xiao, 2018). Our results are relevant because investors and portfolio managers can utilize this form of analysis on real-time data 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 this to monitor explosive behavior as it occurs and possibly formulate policies to avert bubble formation at earlier stages. According to Cecchetti et al. (2000), central banks occasionally need to act to prevent bubbles from getting out of control. Interestingly, our results clearly show bubble patterns in the various REIT property types during the REIT boom periods of 1996 to 1998 and the subprime mortgage boom. This can be considered evidence favoring the importance of capturing bubbles as they form to provide the possibility of early action to correct prices in order to avoid significant market crashes. Additionally, we observe explosive episodes unique to Residential and Self-Storage REITs toward the end of our sample period. This could warrant further scrutiny by investors and regulators.

References


