

REITs impact on typical investment portfolio – further evidence of the sector split importance

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Abstract. The REIT (Real Estate Investment Trust) returns demonstrate a time-varying linear correlation with various equity indexes, therefore they are fit for multi-asset portfolio enhancement. On the one hand, each REIT sector is characterised by a unique set of return properties, and on the other, companies within those sectors remain homogenous.

The aim of this research is twofold: firstly, to verify the earlier studies on how adding REITs to mixed equities/bonds portfolios affects their risk and return characteristics, and secondly, to contribute to these studies by examining the impact of adding different REIT sectors to such portfolios over a relatively long and more up-to-date sample, i.e. the period of 1990–2019.

The results indicate that, in contrast to what some previous studies suggested, adding the REIT index exposure leads to a limited portfolio enhancement only. More significant and consistent effects can be achieved by the inclusion of individual REIT sectors in an investment portfolio. Apartment REITs offered diversification benefits across the entire spectrum in all the periods, while Industrials were useful across the curve in 1990s and 2010s. Self-storage exposure, on the other hand, improved the investment portfolio performance in each of the studied decades. In general, it was enough for investors who strived for portfolio improvement over the three decades between 1990 and 2019 to have a small portion of their Value holdings replaced with the REIT sector exposure to obtain a positive impact on both the returns and the risk.

Keywords: REIT, real estate, portfolio

JEL: G11, R33, R39

1. Introduction

Real Estate Investment Trust (REIT) legislation has been to date introduced in 39 countries with 10 more currently in the planning or legislative process (Nareit, 2020). There were over 850 REITs worldwide at the end of 2019 (European Public Real Estate Association, 2019). It has become a popular investment tool in many developed economies – approximately 80 million Americans and 14 million Australians have exposure to REITs, which constitutes 24% and 57% of these countries' respective total populations (Nareit, 2020; Property Council of Australia, 2017). REITs account for approximately 2.7% of the global listed equity market cap (and even more for some local markets, e.g. over 7.2% in Australia). Although due to their systemic meaning, REIT risk and return characteristics have been widely studied in recent years, information on their standalone performance has only limited real-life investment application. This study focuses on the REIT behaviour in multi-asset portfolios,

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namely in various portfolios consisting of bonds and equities. Given the fact that REIT returns show a time-varying correlation with equity indexes and bonds, they may be predisposed to serve as an effective tool in a diversified portfolio construction process. The 'uniqueness' of REIT characteristics is confirmed by studies of Liang and McIntosh (1998) or Chiang and Lee (2002), which point to a fact that replicating REIT returns with other asset classes is impossible.

There are numerous studies conducted by market practitioners and academics that emphasise a positive impact of including REITs in mixed-asset portfolios, vast majority of them implying that REITs are a valuable addition to multiple investment strategies, shifting efficient frontiers upward. Such conclusion may be vital for investment, pension funds and individual investors, as any investor looking for optimising their portfolio will find value in improving their investment efficiency. Individual REIT sectors expose unique price movement characteristics, and as such, they most probably could offer different benefits for portfolios at different risk levels, thus significantly expanding investors' set of tools.

The aim of this study is twofold: firstly, to verify earlier research on how adding REITs to a mixed-equities or mixed-bonds portfolio affects its risk and return characteristics. Secondly, to expand those studies by examining the impact of adding different REIT sectors to such portfolios over the period of the last 30 years. On the one hand, each REIT sector is characterised by a unique set of return properties, and on the other, companies within those sectors remain homogenous. The study is designed both to answer the question how the inclusion of REITs enhances the efficient frontier, and to help in choosing the best sectors for specific risk-tolerance strategies.

2. Literature review

The benefits from the diversification of a portfolio by including REITs have been investigated by numerous researchers. Kuhle (1987) examined monthly time series over the period of 1980–1985, concluding that adding REITs to an all-equity portfolio does not bring any benefits (although pure REIT portfolios are superior to pure equity portfolios in Markowitz's sense). Mueller et al. (1994), on the other hand, showed that the benefits depend on the time frame – REITs proved to be beneficial for the mixed-asset portfolio in the periods of 1976–1980 and 1990–1993, but not for the 1980–1990 period, which corresponds with the fact that REITs have undergone significant structural changes over the past decades.

Lee and Stevenson (2005) expanded previous studies by examining the impact of the duration of a holding period on the diversification benefits. They conclude, for example, that the attractiveness of REITs as diversification assets increases as the

holding period is becoming longer. This is in line with studies showing that the correlation between REITs and the broad market is highest for short periods and decreases with the widening of the observation window. Interestingly, the results suggest that REITs not only enhance return at the lower end of the efficient frontier, but also reduce risk at the top end. Further, Lee (2010) concludes that the overall benefits of the inclusion of REITs in a portfolio depends both on the time frame and on individual portfolio constituents (asset classes).

Bhuyan et al. (2014) measured the impact of REITs on the optimal mixed-asset portfolio creation for investors with various degrees of risk-aversion, using a mean-variance utility function framework. Their findings suggest, among other things, that risk-averse investors should invest in REITs at the expense of bonds, and that the marginal effect of REIT returns on their optimal portfolio weights increases with risk tolerance.

Several authors dealt with the issue of the role of non-US REITs in the portfolio optimisation. Marzuki and Newell (2016) elaborated on the significance of the UK-REITs in a mixed-asset portfolio. Their study shows that over the 2007–2014 period, REITs delivered poor returns compared to the broad stock market (prior to the global financial crisis (GFC), after July 2009, the risk-adjusted return was strong), and generated virtually no diversification benefits for mixed-asset portfolio (both in the pre- and the post-GFC period). A study by Newell et al. (2013), on the other hand, found that French REITs (SIICs) contributed to the mixed-asset portfolio in the post-GFC era.

There are also numerous studies conducted by market practitioners, such as Wilshire (Nareit, 2016), Fidelity Investments (2016) or Morningstar (2016), which almost unanimously point to a significant contribution of REITs to the improvement of portfolio characteristics. It has to be borne in mind, however, that some of these studies was either sponsored by or written in collaboration with the REIT associations.

In a recent study, Ye and Song (2017) examined the diversification benefits of adding REITs to a portfolio, placing a special focus on the sector split (Hotel, Healthcare, Industrial, Retail, Diversified, Office, Self-storage, Manufactured Home, Apartments and Residential). Using daily, monthly and annual data from the period between 1998 and 2016, they examined the performance of the optimal mean-variance portfolios based on investors' risk aversion level and the access to different asset classes. The conclusions are threefold: Hotel and Self-Storage REITs have the highest potential for improving portfolio characteristics, Self-Storage, Manufactured and Residential REITs are becoming increasingly wealth-compensating as the risk aversion is increasing, and, finally, bonds downplay the importance of REITs for a moderate- or high-risk aversion.

This study's contribution to the literature is expanding the sector analysis. The mature US REIT market offers investors access to several REIT sectors with different risk and return characteristics, which should not be treated as one, uniform 'bag'. The sector focus became popular in the 1990s, so the time series were insufficient until recently, when studies including sector split started to appear.

Compared to the above-mentioned study by Ye and Song (2017), the author will add those REIT segments that play an important role in today's US REIT market, namely Tower, Data Centre and Timber. According to Green Street Advisors, non-traditional REIT sectors, as those mentioned above, constitute up to approximately 55% of total equity REIT market capitalisation. At the end of 2019, three out of five largest REITs in the US belonged to one of the added categories (NYSE:AMT, NYSE:CCI – Cell Tower and NASDAQ:EQIX – Data Centre). Additionally, high-tech sectors were among the best performing in the post-GFC period, so including them in the analysis can presumably yield interesting results in terms of the portfolio-performance metrics.

This study also updates and expands the sample base of earlier studies by using the data from the period between 1990 and 2019, presenting a coherent picture of the REITs' role in a mixed-asset portfolio over the last 30 years.

3. Data and methodology

This study has been based on the monthly total return data for US REITs over the period of 1990–2019. The sample consists of panel data of up to 91 REITs (depending on the availability) grouped into 14 equally-weighted sector indexes (Apartment, Data Centre, Healthcare, Hotel, Industrial, Mall, Manufactured Home, Office, Self-Storage, Single-Family Rental, Strip, Student Housing, Timber and Tower).

Given the fact that the idea behind this analysis is to introduce REITs from the perspective of an investor, the constituents were chosen using market capitalisation and liquidity criteria. Most importantly, a given stock should be investable and price dynamics should not be disturbed by low liquidity. An arbitrary threshold of market cap of USD 200 million and the average daily volume of trailing 30 days of USD 1 million at any given date were applied. FTSE NAREIT Equity REITs Index was used as a broad REIT market proxy.

The study was conducted from the standpoint of an American investor due to data availability, the elimination of currency risk exposure and, most notably, in order for the results to be comparable to other studies. For the purpose of stock market replication and in order to capture different styles, the author used four US domestic stock indexes: S&P 500 Growth and S&P500 Value for Large-Growth and Large-Value, respectively, and Russell 2000 Growth and Russell 2000 Value for Small-

Growth and Small-Value, respectively. Non-US domestic stocks were replicated by MSCI World ex-US Index (USD-denominated). The US government bonds of various maturities were used to address the fixed-income part of the portfolio. An arbitrary set of 2, 5 and 10-year maturities was chosen. All the equity data were the total returns coming from the Thomson Reuters Datastream, and the fixed income data came from the Federal Reserve Economic Data (Federal Reserve Bank of St. Louis).

There were several constraints imposed on the composition of portfolios. In order to stick to the mixed-asset framework, the share of each of the above-mentioned stock indexes should not exceed 70% of the portfolio, and the share of each bond maturity, as well as all of bonds combined, should not be larger than 50%. Due to the domestic preference, the MSCI World was capped at 30%. For the purpose of the analysis, the share of an individual REIT sector index was limited to 20% – this constraint was imposed to address the potential risk of concentrations. No short-selling strategies were applied.

The data sample was divided into three time periods: 1990–1999, 2000–2009 and 2010–2019. The ‘Modern REIT Era’ starts with the IPO boom in the 1990s. Prior to that time, the REIT market was in the development stage and was immature. Ott et al. (2005) differentiate between the old-REIT (pre-1992) and the new-REIT (post-1992) era. Their study reveals that the market grew significantly between the year 1992 and the time of their study. Moreover, capital management and the structure (including debt ratios), as well as internal business operations of REITs changed in the last three decades. What is also extremely important, in the 1990s, REITs became sector-oriented, substantially diverging from the diversified model.

The next period, 2000–2009, begins at the peak of the dot-com bubble and ends right after the start of the post-GFC rebound. The turn of the millennium was another mark in the REIT history. Sing et al. (2016) notes that the time-varying beta characteristics are fundamentally different prior to the 2000 and in the 2000s. Intriguingly, a strong downward trend in the equity REITs betas observed throughout the period of 1972–2000 seems to be substantially reversing after the year 2000.

The 2010–2019 period marks the post-GFC decade. In that period, REITs have expanded significantly both in terms of market cap and the number of entities. It was not only because the asset class experienced a meaningful market expansion, but also because REITs materially changed their capital structure (by lowering LTVs even more), and moved from the external to the internal management model.

A variance-covariance matrix is constructed for each period and an efficient (in Markowitz’ sense) mixed-asset ex-REIT portfolio frontier is estimated (the *base*). Each *base* frontier consists of 10 efficient portfolios, ranging from the least volatile MVP (minimum variance portfolio) to the one producing largest returns (portfolio no. 10).

The returns and variance are calculated as follows:

$$r_p = w'r, \quad (1)$$

where

$$r = [r_1, \dots, r_n] \text{ and } w = [w_1, \dots, w_n], \quad (2)$$

and

$$\delta_p^2 = w'\Sigma w \quad (3)$$

given

$$r \sim N(\mu, \Sigma). \quad (4)$$

The *base* portfolios were estimated solving the optimisation problem:

$$\min_w \delta_p^2 = w'\Sigma w \quad (5)$$

under the conditions

$$\mu_p = w'\mu = \mu_i, \quad (6)$$

$$w'i = 1, \quad (7)$$

where i is the identity matrix. Using Lagrangian to solve constrained optimisation problem

$$\mathcal{L} = w'\Sigma w + \lambda_1(w'\mu - \mu_i) + \lambda_2(w'i - 1) \quad (8)$$

$$\nabla \mathcal{L} = 0, \quad (9)$$

so the first order conditions being:

$$\frac{\partial \mathcal{L}}{\partial w'} = 2 \Sigma w + \lambda_1 \mu + \lambda_2 i = 0, \quad (10)$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_1} = w' \mu - \mu_i = 0, \quad (11)$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_2} = w' i - 1 = 0 \quad (12)$$

with no $\mu_p = \mu_i$ condition for MVP and μ_i for portfolios no. 2–10 growing proportionally.

Then, similarly to Lee and Stevenson (2005), two sets of new efficient frontiers were calculated for each period. The reason behind it was to evaluate (a) if REITs as a whole contribute to portfolio diversification, (b) what REIT sectors would have been included in efficient portfolios, and (c) what is the impact of including specific REIT segments on the overall efficient portfolio characteristics. The first set was computed by fixing the standard deviation of the base portfolios, and then re-estimating the portfolios by adding the REIT index and 14 different sector indexes, one at a time. Such an approach made it possible to see if there was any impact of specific sector inclusion on portfolio returns, and if so, how significant it was.

The second set was produced by fixing the returns of the first efficient frontier and following the same procedure which, analogically to the above, serves the purpose of examining the potential of REITs in terms of the portfolio volatility reduction.

Apart from the three *base* (ex-REIT) frontiers, there were 30 frontiers computed for each time period, each consisting of 10 portfolios, accumulating up to 903 portfolios in total.

4. Results

Table 1 presents the main statistics of the first efficient frontier (years 1990–1999). The high end of the curve is dominated by growth stocks (as the period ends in the eve of the dot-com bubble burst). Interestingly, the small-cap growth stocks index did not make it to any of the portfolios, while the small-cap value stocks have a place at the lower end of the frontier (together with non-US index). All the data presented throughout the study are on a monthly basis.

Table 1. Efficient frontier (*base*) for the 1990–1999 period with portfolio holding weights

Portfolio	MVP	2	3	4	5	6	7	8	9	10
	%									
μ_p	0.78	0.86	0.93	1.00	1.08	1.15	1.23	1.30	1.37	1.45
δ_p	1.87	1.89	1.96	2.07	2.29	2.58	2.86	3.19	3.56	3.94
RUSSELL 2000 Value	16.8	13.2	9.6	4.7	0.0	0.0	0.0	0.0	0.0	0.0
RUSSELL 2000 Growth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S&P 500 Value	11.0	9.5	8.0	3.0	0.0	0.0	0.0	7.5	18.6	30.0
S&P 500 Growth	9.6	19.7	29.6	42.3	53.4	60.6	67.7	70.0	70.0	70.0
MSCI WORLD ex-US	12.5	7.6	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
US 2 Y	50.0	50.0	50.0	50.0	46.6	39.4	32.3	22.5	11.4	0.0
US 5 Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
US 10 Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: author's calculations based on Thomson Reuters data.

Adding the REIT exposure to the efficient portfolios in 1990s had an impact on their overall performance. Tables 2 and 3 show the share of individual indexes in efficient portfolios (upper tables) and their impact on returns and volatility.

What is interesting is that NAREIT index found a place in efficient portfolios only at the lower end of the frontier at the expense of the Russell 2000 Value and the S&P Value indexes, and it was a risk-reduction scenario where the REITs' share was larger (e.g. 25.4% vs 11.8% for MVP). It can be stated that in the 1990s, REITs were a valuable addition to low-risk portfolios, successfully replacing value stocks.

The benefits of the REITs' inclusion, however, differ significantly depending on the sector exposure an investor could have had. In general, for the analysed period, REITs tend to be a valuable addition to a portfolio rather at the lower end of the spectrum – this is where the largest risk reduction and return enhancement is visible, and where individual REIT sectors replace both value indexes and bonds.

There are three notable exceptions among the classic real estate segments, namely the Office, Apartment and the Industrial segments. Each of them constituted a share of the efficient portfolio close or at the upper constraint (20%) across the whole curve. Those sectors also displayed the largest diversification benefits – although it is worth noting that in terms of the return enhancement, this was the case rather in low-risk portfolios (23–26 bps for MVP and 6–7 bps for portfolio no. 9), whereas the highest risk reduction could have been observed for high-volatility portfolios (40–52 bps for portfolio no. 9 and 28–31 bps for MVP). None of the REIT sectors improved the characteristics of the riskiest portfolio.

Healthcare and Timber REITs also had a slight, yet consistent impact on the efficient portfolio performance across the entire risk spectrum. Investors of various risk tolerance levels would have benefitted by dedicating approximately one tenth of their portfolios to those segments.

The overall effect of the Manufactured Housing was marginal and applied only to the lowest-yielding portfolios; however, a notice of short sample (only two years) has to be taken into account.

Table 2. Share of an individual index in the efficient portfolio (upper part) and the return improvement (lower part), 1990–1999

Portfolio	MVP	2	3	4	5	6	7	8	9	10
	%									
NAREIT	11.77	10.63	7.59	3.07	0.00	0.00	0.00	0.00	0.00	0.00
Apartment	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	12.71	0.00
Healthcare	12.06	11.70	7.42	7.41	8.35	9.56	10.75	16.34	18.92	0.00
Hotel	5.34	5.24	4.88	2.98	3.20	3.48	3.76	4.74	5.27	0.00
Industrial	15.00	15.19	15.72	16.60	18.31	20.00	20.00	20.00	12.10	0.00
Mall	7.03	6.39	6.59	6.91	7.53	8.32	9.11	10.25	10.72	0.00
Manufactured Home	7.37	6.75	5.00	2.11	0.00	0.00	0.00	0.00	0.00	0.00
Office	16.61	16.82	17.40	18.36	20.00	20.00	20.00	20.00	11.69	0.00
Self-Storage	11.31	11.24	7.44	5.71	6.31	7.09	7.87	12.42	13.68	0.00
Strip	7.59	6.88	6.00	6.29	6.85	7.57	8.30	10.07	10.71	0.00
Timber	8.54	7.59	6.70	6.98	7.52	8.21	8.91	12.11	12.41	0.00
NAREIT	0.16	0.10	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Apartment	0.26	0.19	0.14	0.10	0.09	0.10	0.10	0.11	0.07	0.00
Healthcare	0.18	0.12	0.07	0.03	0.01	0.01	0.02	0.03	0.03	0.00
Hotel	0.14	0.09	0.06	0.02	0.01	0.01	0.01	0.01	0.01	0.00
Industrial	0.23	0.17	0.11	0.07	0.06	0.07	0.07	0.08	0.06	0.00
Mall	0.19	0.12	0.07	0.02	0.01	0.01	0.01	0.01	0.01	0.00
Manufactured Home	0.14	0.08	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Office	0.24	0.17	0.12	0.08	0.07	0.07	0.08	0.09	0.06	0.00
Self-Storage	0.17	0.11	0.07	0.02	0.01	0.01	0.01	0.02	0.02	0.00
Strip	0.19	0.12	0.07	0.02	0.01	0.01	0.01	0.01	0.01	0.00
Timber	0.19	0.13	0.07	0.03	0.01	0.01	0.01	0.02	0.02	0.00

Source: author’s calculations based on Thomson Reuters data.

Table 3. Share of an individual index in the efficient portfolio (upper part) and the volatility improvement (lower part), 1990–1999

Portfolio	1	2	3	4	5	6	7	8	9	10
	%									
NAREIT	25.4	21.9	13.5	4.6	0.0	0.0	0.0	0.0	0.0	0.0
Apartment	18.3	19.9	20.0	19.0	20.0	20.0	20.0	20.0	20.0	0.0
Healthcare	13.7	13.4	12.6	7.0	8.2	9.3	10.5	11.7	17.9	0.0
Hotel	5.5	5.4	5.3	4.7	3.2	3.5	3.7	4.7	5.2	0.0
Industrial	16.5	17.0	17.1	14.7	16.7	18.7	20.0	20.0	20.0	0.0
Mall	18.5	17.0	11.5	6.7	7.4	8.2	9.0	10.2	10.7	0.0
Manufactured Home	16.5	11.8	7.1	2.4	0.0	0.0	0.0	0.0	0.0	0.0
Office	17.7	18.7	19.1	16.1	18.2	20.0	20.0	20.0	20.0	0.0
Self-Storage	10.3	13.1	14.8	10.3	11.0	12.4	13.8	18.1	20.0	0.0
Strip	19.0	16.4	9.7	3.4	3.7	4.0	4.3	3.1	2.8	0.0
Timber	12.0	11.5	9.2	5.9	6.5	7.1	7.6	8.2	10.3	0.0
NAREIT	-0.24	-0.19	-0.13	-0.04	0.00	0.00	0.00	0.00	0.00	0.00
Apartment	-0.28	-0.33	-0.37	-0.33	-0.31	-0.34	-0.36	-0.42	-0.52	0.00
Healthcare	-0.17	-0.16	-0.15	-0.10	-0.04	-0.05	-0.06	-0.11	-0.15	0.00
Hotel	-0.10	-0.10	-0.09	-0.07	-0.03	-0.03	-0.03	-0.04	-0.05	0.00
Industrial	-0.30	-0.32	-0.33	-0.25	-0.21	-0.23	-0.26	-0.32	-0.40	0.00
Mall	-0.32	-0.30	-0.23	-0.09	-0.03	-0.03	-0.04	-0.04	-0.04	0.00
Manufactured Home	-0.34	-0.19	-0.08	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
Office	-0.31	-0.34	-0.36	-0.27	-0.23	-0.26	-0.28	-0.35	-0.42	0.00
Self-Storage	-0.08	-0.10	-0.12	-0.09	-0.03	-0.03	-0.04	-0.08	-0.09	0.00
Strip	-0.33	-0.30	-0.23	-0.09	-0.03	-0.04	-0.04	-0.08	-0.09	0.00
Timber	-0.24	-0.26	-0.25	-0.12	-0.07	-0.07	-0.08	-0.13	-0.15	0.00

Source: author's calculations based on Thomson Reuters data.

As shown in Table 4, effective portfolios in the 2000s were dominated by a combination of Small Value stocks and bonds. It should be noted that the US stocks outperformed the ex-US ones, and Large Growth stocks found a place in low-risk portfolios. Unlike in the previous decade, the addition of NAREIT index played some role in the return enhancement only in the highest end of the curve. Interestingly, the aggregate REIT index again substituted Value stocks. It is worth noting, though, that the overall portfolio characteristics improvement was limited (0.05% of additional return and 0.29% reduction of standard deviation).

Table 4. Efficient frontier (*base*) for the 2000–2009 period with portfolio holding weights

Portfolio	MVP	2	3	4	5	6	7	8	9	10
	%									
μ_p	0.24	0.28	0.32	0.36	0.40	0.45	0.49	0.53	0.57	0.61
δ_p	2.20	2.21	2.23	2.27	2.32	2.39	2.47	2.56	2.68	3.88
RUSSELL 2000 Value	9.7	15.0	20.2	25.0	29.2	33.4	37.4	41.4	49.1	70.0
RUSSELL 2000 Growth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S&P 500 Value	9.8	7.3	4.6	1.7	0.0	0.0	0.0	0.0	0.0	0.0
S&P 500 Growth	30.5	27.7	24.5	20.9	16.3	11.3	6.0	0.7	0.0	0.0
MSCI WORLD ex-US ..	0.0	0.0	0.7	2.4	4.5	5.3	6.6	7.9	0.9	0.0
US 2 Y	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
US 5 Y	49.1	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	0.0
US 10 Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0

Source: author’s calculations based on Thomson Reuters data.

An interesting picture arises from the analysis of the inclusion of REIT sectors in an investment portfolio. On the one hand, the share of individual REIT segments grow in efficient portfolios as we move upwards the risk spectrum, but on the other, their impact moves right the opposite way. The REIT characteristics were, once again, most valuable at the lower end of the frontier.

The 2000–2009 decade was another one when Office REITs contributed the largest benefits to the portfolio. Student Housing, Strip Centres and Apartments were also among the most effective segments across the entire frontier.

Unlike the REIT Index, several sectors would only have worked for more risk-averse investors. The Hotel, Industrial, Timber and Tower sectors found a place only at the lower end of the curve of the efficient portfolios, and the impact of the two latter segments was rather limited straight from the MVP. Those were predominantly a replacement for Large Growth stocks.

It is worth noting that in the analysed period, REITs played a larger role in the overall portfolio risk reduction than in 1990s, i.e. an average of 0.46% compared to 0.16% a decade earlier. REITs generally decreased the overall risk at the lower end of the spectrum, predominantly replacing riskier Growth stocks and, to some minor extent, 5Y Bonds. Additionally, compared to the previous decade, numerous REIT segments were present in portfolio no. 10, where they replaced Value stocks.

An impact of Data Centre and Tower REITs is muted. The burst of dot-com bubble and limited trust for any high-tech names afterwards contributed to their relatively poor performance.

Table 5. Share of an individual index in the efficient portfolio (upper part) and the return improvement (lower part), 2000–2009

Portfolio	MVP	2	3	4	5	6	7	8	9	10
	%									
NAREIT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0
Apartment	14.6	14.7	15.0	15.4	15.8	16.4	17.1	20.0	20.0	20.0
Data Centre	0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC	9.0	9.6	11.1	13.0	15.0	17.1	19.2	20.0	20.0	20.0
Hotel	7.4	7.4	7.4	7.4	7.4	7.4	7.4	3.4	0.3	0.0
Industrial	12.5	12.5	12.6	12.7	11.1	7.6	4.9	2.6	0.3	0.0
Mall	9.9	10.0	10.2	10.6	11.0	11.6	14.8	17.9	20.0	20.0
Manufactured Home	14.7	14.9	15.2	15.7	16.4	17.2	20.0	20.0	20.0	20.0
Office	16.2	16.3	16.5	17.8	20.0	20.0	20.0	20.0	20.0	20.0
Self-Storage	6.2	6.4	7.0	7.6	8.3	9.1	10.0	10.8	12.4	20.0
Strip	17.2	17.3	17.6	19.1	20.0	20.0	20.0	20.0	20.0	20.0
Student Housing	17.9	17.9	18.2	18.5	18.9	19.4	20.0	20.0	20.0	20.0
Timber	11.0	11.0	11.1	11.0	11.0	11.0	6.5	3.2	0.3	0.0
Tower	1.9	1.9	2.0	2.1	2.2	2.4	2.5	2.6	0.4	0.0
NAREIT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Apartment	0.23	0.19	0.16	0.14	0.13	0.12	0.11	0.10	0.06	0.06
Data Centre	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	0.15	0.13	0.12	0.13	0.13	0.14	0.15	0.16	0.17	0.17
Hotel	0.18	0.15	0.12	0.10	0.08	0.07	0.06	0.04	0.00	0.00
Industrial	0.26	0.22	0.19	0.17	0.14	0.11	0.08	0.04	0.00	0.00
Mall	0.27	0.23	0.20	0.18	0.17	0.16	0.09	0.11	0.08	0.08
Manufactured Home	0.20	0.16	0.14	0.12	0.11	0.10	0.09	0.08	0.04	0.04
Office	0.34	0.30	0.27	0.25	0.21	0.17	0.14	0.10	0.06	0.06
Self-Storage	0.09	0.06	0.04	0.04	0.04	0.03	0.03	0.03	0.04	0.07
Strip	0.37	0.33	0.30	0.28	0.24	0.20	0.17	0.13	0.09	0.09
Student Housing	0.33	0.29	0.24	0.20	0.17	0.13	0.09	0.05	0.01	0.01
Timber	0.23	0.20	0.16	0.14	0.12	0.10	0.07	0.04	0.00	0.00
Tower	0.07	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.00	0.00

Source: author's calculations based on Thomson Reuters data

Table 6. Share of an individual index in the efficient portfolio (upper part) and the volatility reduction (lower part), 2000–2009

Portfolio	MVP	2	3	4	5	6	7	8	9	10
NAREIT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.1
Apartment	14.4	12.7	14.3	14.1	13.5	15.4	16.2	17.0	17.7	18.0
Data Centre	0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC	8.9	8.7	9.4	12.6	13.9	16.2	18.9	16.4	18.9	16.3
Hotel	7.3	6.4	6.1	7.2	6.7	6.6	6.2	3.2	0.3	0.0
Industrial	11.4	11.3	10.8	12.2	9.1	6.4	4.4	2.4	0.2	0.0
Mall	9.7	9.3	9.3	9.1	9.0	10.0	14.6	15.1	18.9	18.8
Manufactured Home	12.7	13.3	13.3	15.0	15.6	17.0	16.3	17.6	19.9	18.8
Office	13.1	14.0	13.4	17.2	17.6	18.2	18.5	19.0	17.8	17.2
Self-Storage	5.5	6.1	6.1	7.3	7.2	7.4	9.1	9.9	10.4	18.2
Strip	15.6	14.7	15.4	16.8	19.4	18.5	18.1	19.1	19.9	16.0
Student Housing	17.8	16.7	17.6	15.3	15.2	16.4	16.6	17.9	16.4	19.7
Timber	10.5	10.0	11.0	9.7	10.3	10.5	5.3	3.0	0.3	0.0
Tower	1.6	1.6	1.8	1.8	1.9	2.1	2.2	2.2	0.4	0.0
NAREIT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.29
Apartment	-1.07	-0.89	-0.75	-0.64	-0.56	-0.50	-0.46	-0.40	-0.25	-0.34
Data Centre	-0.22	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HC	-0.85	-0.68	-0.61	-0.59	-0.58	-0.58	-0.59	-0.61	-0.61	-0.83
Hotel	-0.96	-0.76	-0.60	-0.48	-0.39	-0.31	-0.26	-0.16	-0.02	0.00
Industrial	-1.14	-0.97	-0.83	-0.71	-0.61	-0.47	-0.33	-0.18	-0.02	0.00
Mall	-1.16	-0.99	-0.86	-0.76	-0.68	-0.63	-0.34	-0.45	-0.33	-0.46
Manufactured Home	-1.00	-0.81	-0.67	-0.57	-0.49	-0.44	-0.40	-0.34	-0.19	-0.25
Office	-1.29	-1.15	-1.02	-0.92	-0.80	-0.67	-0.54	-0.40	-0.26	-0.34
Self-Storage	-0.58	-0.37	-0.27	-0.22	-0.19	-0.17	-0.16	-0.16	-0.16	-0.40
Strip	-1.34	-1.20	-1.08	-0.99	-0.87	-0.75	-0.63	-0.50	-0.37	-0.49
Student Housing	-1.27	-1.11	-0.96	-0.82	-0.67	-0.53	-0.38	-0.22	-0.06	-0.05
Timber	-1.09	-0.91	-0.75	-0.63	-0.52	-0.44	-0.33	-0.18	-0.02	0.00
Tower	-0.50	-0.28	-0.18	-0.13	-0.10	-0.09	-0.08	-0.07	-0.02	0.00

Source: author's calculations based on Thomson Reuters data.

The efficient frontier in the last analysed period (depicted in Table 7) was dominated by the Large Value which was a part of the portfolios across the entire curve. Interestingly, global stocks were not present in any of the portfolios. Maximal return was achieved as a combination of the Large and Small Value, which is counterintuitive given the performance of tech-oriented growth stocks in recent years.

Table 7. Efficient frontier (base) for the 2010–2019 period with portfolio holding weights

Portfolio	MVP	2	3	4	5	6	7	8	9	10
μ_p	0.69	0.74	0.78	0.83	0.88	0.92	0.97	1.02	1.06	1.11
δ_p	1.55	1.60	1.76	1.95	2.17	2.41	2.71	3.02	3.36	3.92
RUSSELL 2000 Value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0
RUSSELL 2000 Growth	34.2	9.9	0.0	0.0	0.0	1.7	9.6	17.5	25.3	0.0
S&P 500 Value	15.8	40.1	53.5	59.5	65.4	70.0	70.0	70.0	70.0	70.0
S&P 500 Growth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSCI WORLD ex-US	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
US 2 Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
US 5 Y	50.0	50.0	46.5	40.6	34.6	28.3	20.4	12.5	4.7	0.0
US 10 Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: author's calculations based on Thomson Reuters data.

As shown in Table 8 and Table 9, the addition of the aggregate REIT Index in the analysed period contributed the largest benefits to the upper parts of the frontier, apart from the highest-return portfolio. It is worth noting, however, that although the index becomes a part of the portfolios, the impact on return characteristics is marginal. Once again, individual REIT segments are a more valuable portfolio addition than the aggregate REIT index. In fact, for investors across the entire risk spectrum, any REIT sector had a stronger impact on overall performance than the REIT aggregate index.

It is worth noting that in the period of 2010–2019, for the third decade in a row, REITs replaced Value stocks in efficient portfolios (and to some extent they also replaced bonds at the lower end of the frontier). The REIT sectors gave the best results in the higher risk portfolios and their share averaged low-to-mid teens, depending on the segment. In other words, for the analysed period, a risk-tolerant investor should have replaced a portion of their Value stocks with individual REIT sector exposure.

The highest benefits for the portfolios were offered by high-tech REIT segments, such as Data Centres and Cell Towers, which were effective across the entire curve both in terms of the volatility reduction and the return improvement (yet with the exception of Towers not included in the riskiest portfolio in terms of the value enhancement, Self-Storage and Industrials).

A systematic shift in shopping conditions set a challenging environment for the Mall REITs performance, making them rather a redundant tool in the portfolio diversification. This stays in vivid contrast to the previous decades, when Malls offered stable benefits across the entire curve. Despite a good standalone performance, the addition of the Single Family segment would not result in any substantial portfolio improvement (or, if any, then possibly in MVPs).

The Office segment, which was a valuable addition in 1990s and 2000s, became not such a good choice in 2010s. The Apartment segment, on the other hand, was the only

one that turned out to have a positive, consistent and meaningful impact on the portfolio characteristics throughout the entire sample, except for the return improvement in the most aggressive strategies.

Table 8. Share of an individual index in the efficient portfolio (upper part) and the return improvement (lower part), 2010–2019

Portfolio	1	2	3	4	5	6	7	8	9	10
NAREIT	0.0	0.0	0.0	0.0	0.0	1.9	8.9	13.9	19.0	0.0
Apartment	14.7	15.6	18.9	20.0	20.0	20.0	20.0	20.0	13.9	0.0
Data Centre	10.3	11.5	14.4	17.7	20.0	20.0	20.0	20.0	20.0	20.0
Healthcare	4.5	3.2	4.0	5.4	6.7	8.1	14.2	17.2	8.8	0.0
Hotel	5.2	5.4	6.0	6.7	7.4	8.2	11.8	13.5	14.1	0.0
Industrial	13.7	14.5	17.0	19.8	20.0	20.0	20.0	20.0	20.0	0.0
Mall	2.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufactured Home	11.7	13.5	16.9	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Office	5.6	5.7	6.0	6.5	6.9	7.3	11.0	12.4	6.1	0.0
Self-Storage	14.3	15.4	18.9	20.0	20.0	20.0	20.0	20.0	20.0	0.0
Single-Family	4.3	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strip	7.4	7.8	8.9	10.2	11.6	12.9	18.6	20.0	8.9	0.0
Student Housing	4.8	3.0	3.6	4.9	6.2	7.5	15.0	18.3	7.8	0.0
Timber	4.8	4.7	4.4	4.1	3.7	4.3	6.5	6.7	6.9	0.0
Tower	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	15.0	0.0
NAREIT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
Apartment	0.10	0.07	0.08	0.09	0.10	0.10	0.12	0.12	0.08	0.00
Data Centre	0.09	0.06	0.07	0.08	0.10	0.11	0.13	0.14	0.13	0.03
Healthcare	0.04	0.01	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.00
Hotel	0.06	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.00
Industrial	0.13	0.10	0.11	0.12	0.13	0.14	0.16	0.16	0.12	0.00
Mall	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufactured Home	0.08	0.05	0.07	0.09	0.11	0.12	0.14	0.15	0.15	0.04
Office	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Self-Storage	0.12	0.09	0.11	0.13	0.14	0.15	0.17	0.17	0.12	0.00
Single-Family	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Strip	0.05	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.02	0.00
Student Housing	0.04	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.00
Timber	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tower	0.14	0.12	0.12	0.12	0.12	0.13	0.14	0.14	0.10	0.00

Source: author’s calculations based on Thomson Reuters data.

Table 9. Share of an individual index in the efficient portfolio (upper part) and the volatility reduction (lower part), 2010–2019

Portfolio	1	2	3	4	5	6	7	8	9	10
NAREIT	0.0	0.0	0.0	0.0	0.0	1.8	8.6	13.3	18.0	0.0
Apartment	13.5	12.6	14.4	17.0	20.0	20.0	20.0	20.0	20.0	20.0
Data Centre	8.1	8.4	10.7	13.3	15.8	18.3	20.0	20.0	20.0	20.0
Healthcare	5.9	4.0	3.9	5.2	6.5	7.8	12.4	15.8	18.5	0.0
Hotel	6.3	5.6	5.8	6.5	7.2	7.9	9.9	12.5	14.1	0.0
Industrial	10.4	10.7	12.4	14.2	16.4	18.6	20.0	20.0	20.0	20.0
Mall	3.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufactured Home	10.2	10.2	12.9	15.7	18.4	20.0	20.0	20.0	20.0	20.0
Office	8.1	5.6	6.0	6.0	6.8	7.2	10.7	12.1	8.6	0.0
Self-Storage	12.3	12.4	13.0	15.4	18.1	20.0	20.0	20.0	20.0	20.0
Single-Family	9.1	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strip	9.0	7.2	8.4	9.7	11.0	12.3	13.5	19.3	17.5	0.0
Student Housing	7.0	4.2	3.5	4.8	6.1	7.3	14.1	17.1	14.1	0.0
Timber	8.6	4.8	4.5	4.1	3.7	3.4	6.4	6.7	6.9	0.0
Tower	15.1	15.5	17.2	19.9	20.0	20.0	20.0	20.0	20.0	20.0
NAREIT	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.04	-0.06	0.00
Apartment	-0.18	-0.18	-0.22	-0.29	-0.36	-0.44	-0.55	-0.66	-0.78	-1.08
Data Centre	-0.07	-0.10	-0.19	-0.26	-0.33	-0.42	-0.55	-0.69	-0.82	-1.17
Healthcare	-0.05	-0.02	-0.01	-0.02	-0.03	-0.05	-0.11	-0.15	-0.18	0.00
Hotel	-0.10	-0.07	-0.06	-0.07	-0.08	-0.10	-0.16	-0.19	-0.22	0.00
Industrial	-0.17	-0.21	-0.30	-0.38	-0.46	-0.54	-0.68	-0.82	-0.95	-1.30
Mall	-0.06	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufactured Home	-0.06	-0.09	-0.17	-0.25	-0.34	-0.44	-0.58	-0.72	-0.85	-1.20
Office	-0.13	-0.05	-0.03	-0.03	-0.03	-0.04	-0.06	-0.07	-0.07	0.00
Self-Storage	-0.14	-0.17	-0.26	-0.35	-0.45	-0.56	-0.70	-0.84	-0.98	-1.33
Single-Family	-0.13	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Strip	-0.14	-0.08	-0.07	-0.08	-0.09	-0.12	-0.19	-0.24	-0.27	0.00
Student Housing	-0.06	-0.02	-0.01	-0.01	-0.02	-0.03	-0.09	-0.12	-0.13	0.00
Timber	-0.11	-0.04	-0.02	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	0.00
Tower	-0.19	-0.23	-0.33	-0.42	-0.49	-0.57	-0.67	-0.78	-0.89	-1.22

Source: author's calculations based on Thomson Reuters data.

5. Conclusions

There are several interesting conclusions to be drawn. First of all, in contrast to some previous studies (Lee, 2010; Lee & Stevenson, 2005), the author's analysis demonstrated that the extent to which portfolio's properties were enhanced by a broad REIT index exposure was limited. In the 1990s, the aggregate REIT exposure provided benefits for low-risk portfolios. Between the year 2000 and 2019, the impact of the REIT index inclusion was marginal and visible only in the upper parts of the spectrum. This is a meaningful conclusion for the contemporary market practitioners – the REIT market exposure *per se* did not improve efficient portfolios in the last 20 years.

A larger, more meaningful and more consistent effects can be achieved by the inclusion of the individual REIT sectors in an investment portfolio. Apartment REITs offered diversification benefits across the entire spectrum and throughout all the

periods. Industrials were useful across the curve in the 1990s and the 2010s, but in the 2000s worked well only in lower risk portfolios. Self-Storage exposure improved the performance in each decade, although its impact was slightly smaller in the 2000s than in the other analysed decades. The benefits of the inclusion of the Office segment were not visible in last decade to such an extent as the in the earlier periods. The last analysed period was skewed towards the high-tech REITs, namely the Data Centres and the Cell Towers. The Mall REITs offered no significant benefits. Also, in contrast to the observations by Ye and Song (2017), the Hotel REITs provided only moderate (yet consistent over all the three time periods) improvement of the portfolio characteristics.

The optimal share of REITs in a portfolio is still a matter of discussion. It hit the upper boundaries (20) numerous times throughout the study, but a high share of REITs did not always result in increased benefits for a portfolio. What is interesting is that REITs were a replacement for Value stocks in most of the cases. In general, if investors strived for a portfolio improvement over the past three decades, they should have replaced a small portion of their Value holdings with the REIT sector exposure, as it had a positive impact on both the returns and the risk. Further studies on the REIT portfolio inclusion, especially in the COVID-19–impacted environment (post-2020), are recommended.

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