Momentum Effects and Mean Reversion in Real Estate Securities

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Abstract

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This article tests for the presence of both price continuation and price reversals in international real estate securities. The results reveal evidence of performance persistence in international markets over short and medium term horizons, however the evidence on price reversals is less compelling. The empirical analysis tests for mean reversion using Variance Ratio and Augmented Dickey-Fuller tests. In neither case is there consistent evidence of mean reversion in international real estate securities. The portfolio switching tests do reveal some evidence of performance reversals. However, while under-performing markets do outperform over longer horizons, they do not do so at statistically significant levels.

Introduction

This article builds on both the work previously conducted on winner-loser and momentum effects in the general finance literature and also the large number of studies that have examined the predictability of real estate securities, and in particular real estate investment trusts (REITs). Empirical evidence from the finance literature has documented performance continuation, or momentum, in both individual stock and market indices in the short and medium term. This effect hypothesizes that those securities, or markets, that perform well in one period have a tendency to maintain that performance over the short-term into subsequent periods. Likewise, relative underperformance tends to be maintained over the short-term.[1] In addition, there is some evidence that performance reversals and mean reversion occurs over longer horizons. This effect argues that relative performance tends to revert over longer horizons, with performance persistence dissipating. Therefore, over longer time frames those securities or markets that have outperformed tend to have poorer relative long-term performance than those firms, or assets, which under-perform in the initial period. These combined effects of momentum and mean reversion have a number of implications, particularly for a portfolio manager, not least of which is concerned with the subsequent predictability in performance over both short- and long-term horizons. This study aims to examine these issues in the context of international real estate securities over the period 1977 to 2000. Three primary methodological approaches are used in this study. The first uses Variance Ratios, the second is the augmented Dickey Fuller test proposed by Balvers, Wu and Gilliland (2000) and the third is a portfolio switching strategy.

It should be noted that tests of effects such as momentum and mean reversion are effectively joint tests of both the effect under investigation and the specific model selected. In relation to the tests used in the current study, the Variance Ratio tests can be extremely sensitive to violations of the assumptions underlying the approach, and particularly the *iid* (independent and identically distributed) normality assumption concerning the return distribution. In addition, as with any empirical analysis, results can vary considerably depending on the sample period used, even if, as in the current study, the data extends over a large number of years. The contrasting findings in relation to momentum and performance reversal effects in the finance literature highlight the sensitivity of the findings to the data and the sample periods used. In addition to the overall sample period and data examined, the assessment of factors such as momentum and performance reversals is also dependent on the sample interval used.

A large literature has developed that has examined both momentum strategies and mean reversion. While the evidence in favor of momentum, both in individual stocks and in national indices, is relatively robust to different data sets, this is not true with mean reversion. Jegadeesh and Titman (1993) provide evidence that over short-term horizons of three to twelve months, a strategy involving the purchase of stocks that have performed well and the sale of stocks that have performed badly, produces profitable results. The authors also find that this profitability is not the result of the systematic risk of the stocks. These results are confirmed by studies such as the one by Chan, Jegadeesh and Lakonishok (1996), who find that medium-term return continuation can in part be explained by factors such as the underreaction to earnings information. Rouwenhorst (1998) also finds evidence of medium-term performance persistence, however, unlike previous studies that have tended to examine a single market, he examines over 2,000 stocks from twelve European markets. The author finds that even after the correction of risk, medium-term winners continue to outperform medium-term losers, with performance persistence continuing for periods of up to a year.

DeBondt and Thaler (1985, 1987) find that over horizons of three to five years, performance does reverse. Firms with poor performance over the ranking period outperform over the testing period. Fama and French (1988) and Poterba and Summers (1988) both provide evidence in favor of mean reversion in stocks in the United States using ordinary least squares and Variance Ratio approaches respectively. However, studies such as Lo and MacKinlay (1988), Kim, Nelson and Startz (1991) and Richardson (1993) provide contrary evidence. A number of studies have examined international markets. Richards (1997) examines sixteen international equity markets in an analysis of winner-loser effects in national indices. The author broadly follows the methodological approach adopted by DeBondt and Thaler (1985), with the returns for each market ranked over periods ranging from three to sixty months. The markets are then grouped into one of four portfolios based on this performance, with the value-weighted performance then assessed over the subsequent test period. Richards finds that reversals in performance are strongest over the three-year period and that it would not appear that the initial loser portfolios are riskier than the winner countries. Balvers, Wu and Gilliland (2000) examined eighteen international markets, the sixteen OECD markets plus Hong Kong and Singapore, using the panel approach that is to be adopted in the current study. The authors find evidence that a country's market relative to a reference index is a stationary process, thus implying full mean reversion. The authors' results indicate that the speed of reversion has a half-life of three to three and a half years. The results of the portfolio switching tests are also supportive of mean reversion.[2]

Few studies have explicitly analyzed performance continuation or reversal in a real estate context, however, there have been a number of studies that have examined the related issue of predictability in real estate security returns.[3] In particular, a number of studies have examined the REIT sector. One of the first studies to examine the predictability of REITs was Liu and Mei (1992) who utilized a multifactor latent variable model. This study finds that factors such as the return on Treasury Bills, dividend yields, the cap rate and the long-term yield spread, aid in the prediction of excess REIT returns. In addition, the study provides evidence that REITs are more predictable than general stocks and bonds. These findings are also confirmed by Mei and Liao (1998). Li and Wang (1995) use a multi-factor asset pricing model to examine whether the REIT market is segmented from the general equity market and whether REITs are more predictable than other stocks. The model used allows for time-varying risk premiums, as with the model used by Liu and Mei (1992), and finds evidence that REITs are integrated with the general equity market and that, in contrast to the Liu and Mei study, REIT returns are no more predictable than stocks. Liu and Mei (1998) extend their previous work in the examination of six international markets. While the focus of the study is international diversification, the study also examines the predictability of each market using five state variables.

Graff and Young (1997) more specifically analyze the persistence of monthly, quarterly and annual REIT returns. The study divides the REITs into quartiles depending on their performance in the appropriate ranking period. The authors then test for the incidence of serial persistence and specifically test the null hypothesis that the quartile ranks are serially independent. The results show that the sample interval used can lead to substantially different findings. In the case of annual sample intervals, positive momentum effects are observed, however, when monthly intervals are utilized the results provide evidence of performance reversals. In the case of quarterly intervals, no evidence was obtained of any form of persistence or reversals. The results highlight the problems highlighted previously and the inconsistency of empirical results if the analysis is undertaken on the basis of different assumptions. Mei and Gao (1995) examine the persistence of weekly returns, finding significant profits from the contrarian-based strategy of buying winners and selling losers. Cooper, Downs and Patterson (1999) use a filter-based rule on weekly data in an extension of the Mei and Gao (1995) study, finding that the presence of contrarian profits is consistent across horizons for up to fifty-two weeks. Nelling and Gyourko (1998) analyze all equity REITs listed in the period 1975–1995. The authors analyze the autocorrelation structure of the returns and also form predictive portfolios based on initial performance. While the evidence does suggest predictability in monthly returns, the profits that would be generated from such a strategy would be insufficient to offset transaction costs. Stevenson (2001) finds some indirect evidence in favor of performance reversals. The study examines the out-of-sample performance of optimal portfolios of international real estate securities on the basis of sixty-month rolling periods. The results show that the tangency portfolio-based strategy significantly under-performs both a minimum-variance and a naive equally weighted strategy.[4]

The data used in this study consists of monthly returns for eleven international real estate security markets for the period 1977 to 2000. The markets examined are Australia, Belgium, Canada, France, Hong Kong, Italy, Japan, Netherlands, Singapore, the United Kingdom and the United States. Each market is examined in their local currency, therefore, the portfolio-based tests implicitly assume perfect hedging ability on the part of an investor. While the analysis does not take into

Exhibit 1 | Summary Statistics—1977–2000

	Mean	Std. Dev.	Variance
Australia	1.553	6.967	48.535
Belgium	0.874	6.007	36.089
Canada	0.869	9.219	84.996
France	0.754	8.047	64.751
Hong Kong	1.475	12.093	146.232
Italy	1.285	8.431	71.089
Japan	0.446	8.631	74.493
Netherlands	0.584	3.615	13.065
Singapore	0.933	11.858	140.613
U.K.	1.187	6.008	36.094
U.S.	0.980	3.711	13.773

Notes: Exhibit 1 reports the summary statistic in local currency terms for each of the eleven markets examined.

account currency movements, this does mean that there is no requirement to make assumptions concerning the nationality of the investor. The remainder of the article is laid out as follows. The following three sections present the respective methodological frameworks adopted and the corresponding empirical analysis. The final section provides concluding comments.

Variance Ratio Tests

The initial approach adopted in the study is the variance ratio test. The approach adopted in this study is in the spirit of that proposed by Lo and MacKinlay (1988, 1989). Variance ratio tests exploit the fact that the variance of the increments of a random walk is linear in the sampling function. Therefore, if a series is a random walk, the variance of the series' kth difference will be k times the size of the variance of the first difference variable. Therefore, if the data is split into $nk + 1$ equally spaced intervals, $P_0, P_1, P_2, \ldots, P_{nk}$, then the ratio of $1/k$ of the variance of $P_t - P_{t-k}$ is expected to be equal to the variance of $P_t - P_{t-1}$, *i.e.*, unity. This can be represented as:

$$VR(k) = \frac{\sigma_k^2}{\sigma_a^2}, \qquad (1)$$

Where σ_k^2 is an unbiased estimator of one kth of the variance of $\ln P_t - \ln P_{t-k}$ and σ_a^2 is the unbiased estimator of the variance of $P_t - \ln P_{t-1}$. The estimators can be defined and derived as follows:

$$\sigma_k^2 = \frac{1}{M} \sum_{t=k}^{T} (P_t - P_{t-k} - k\hat{\mu})^2, \qquad (2)$$

$$\sigma_a^2 = \frac{1}{N-1} \sum_{t=k}^{T} (P_t - P_{t-1} - \hat{\mu})^2, \qquad (3)$$

Where:

$$N = \text{Sample Size};$$
$$P_0, P_1, P_2, \ldots, P_{nk} = \text{Log Prices};$$
$$M = k(N - k + 1)\left(1 - \frac{k}{N}\right); \text{ and}$$
$$\hat{\mu} = \frac{1}{N}(P_N - P_0).$$

$\hat{\mu}$ and σ_k^2 are the standard sample estimators of the mean and variance and the maximum likelihood estimators of μ and σ^2. Lo and MacKinlay (1989) show that the variance ratio statistic asymptotically approaches normality:

$$Z(k) = \frac{VR(k) - 1}{\sqrt{\Phi(k)}} \xrightarrow{a} N(0,1), \tag{4}$$

Where $\Phi(k)$ denotes the variance ratios asymptotic variance, which can be defined as:

$$\Phi(k) = \frac{2(2k - 1)(k - 1)}{3k} \sim N(0,1). \tag{5}$$

Lo and MacKinlay (1988) also derive a heteroskedasticity consistent variance estimator $\Phi^*(k)$, due to the potential problems that would arise with the random walk hypothesis being rejected due to stock returns being conditionally heteroskedastic with respect to time. The heteroskedasticity consistent test statistic, $Z^*(k)$, is calculated in the same manner as previously.

$$Z^*(k) = \frac{VR(k) - 1}{\sqrt{\Phi^*(k)}} \xrightarrow{a} N(0,1), \tag{6}$$

Where $\Phi^*(k)$ denotes the variance ratios asymptotic variance, which can be defined as:

$$\Phi^*(k) = \sum_{j=1}^{k-1} \left[\frac{2(k - j)}{k}\right] \delta(j), \tag{7}$$

Where:

$$\delta(j) = \frac{\sum_{t=j+1}^{T} (P_t - P_{t-1} - \hat{\mu})^2 (P_{t-j} - P_{t-j-1} - \hat{\mu})^2}{\left[\sum_{t=1}^{T} (P_t - P_{t-1} - \hat{\mu})^2\right]^2}. \tag{8}$$

The empirical findings, with the heteroskedasticity consistent test statistics, are reported in Exhibit 2. Of the eleven markets examined, only four show significant evidence of mean reversion, namely Australia, Hong Kong, Singapore and the U.K. In addition, as the heteroskedasticity consistent test statistics are used throughout, these findings are not due to altering variances. In the remaining seven cases, evidence is presented showing significant variance ratios in excess of unity for long lag lengths. As Campbell, Lo and MacKinlay, (1997) note, the following relationship can be observed for the ratio of variance ratios.

$$\frac{VR(2k)}{VR(k)} = 1 + \rho_k(1), \tag{9}$$

Where $\rho_k(1)$ is the first order autocorrelation coefficient for k-period returns. Therefore, the fact that in most of the remaining seven cases the variance ratio initially rises with the value of k, also implies positive autocorrelation in multiperiod returns.

Augmented Dickey Fuller Tests

The second test used to examine for the presence of mean reversion is based on the approach proposed by Balvers, Wu and Guilliland (2000). The approach is initially based on the following specification of a stochastic process for an asset displaying mean reversion:

$$P^t_{t+1} - P^i_t = a^i + \lambda^i \, (P^{*i}_{t+1} - P^i_t) + \epsilon^i_{t+1}. \tag{10}$$

P^i_{t+1} is the log index for each respective market, P^{*i}_{t+1} is the log of the fundamental value of each market index and λ^imeasures the speed of reversion. If the parameter is equal to unity, full reversion occurs in the subsequent period, if it is equal to zero the market follows an integrated process and if the parameter is between zero and unity deviations are reversed over time. It is assumed that the fundamental value for a market can be specified as follows:

$$P^{*i}_t = P^{*r}_t + z^i + \eta^i_t. \tag{11}$$

z^i is a constant, η^i_t is a zero-mean stationary process, which may be serially correlated, and P^{*r}_t is the log price of a specified reference index.

Exhibit 2 | Variance Ratio Statistics

	Australia	Belgium	Canada	France	Hong Kong	Italy	Japan	Netherlands	Singapore	U.K.	U.S.
	0.977	1.150	0.989	0.998	1.043	1.110	0.959	1.249	1.070	1.035	1.144
VR-2	(−0.298)	(0.935)	(−0.213)	(−0.029)	(0.538)	(0.808)	(−0.404)	(1.219)	(0.681)	(0.375)	(0.897)
	0.903	1.126	1.148	1.100	1.107	1.248	0.916	1.469	1.100	1.061	1.171
VR-4	(−0.901)	(1.257)	(1.351)	(1.233)	(1.159)	(1.727*)	(−0.774)	(2.369**)	(1.077)	(0.724)	(1.408*)
	0.847	1.170	1.297	1.190	1.017	1.296	0.968	1.538	1.071	1.099	1.205
VR-6	(−1.426)	(1.807**)	(2.342**)	(1.951*)	(0.534)	(2.317**)	(−0.422)	(2.895***)	(1.070)	(1.163)	(1.934**)
	0.848	1.285	1.431	1.293	0.983	1.347	1.000	1.548	1.047	1.084	1.263
VR-8	(−1.618)	(2.681***)	(3.270***)	(2.796***)	(−0.299)	(2.928***)	(−0.003)	(3.203***)	(0.902)	(1.223)	(2.562***)
	0.891	1.487	1.597	1.499	1.054	1.533	1.064	1.545	1.017	1.078	1.265
VR-12	(−1.576)	(4.313***)	(4.875***)	(4.578***)	(2.989)	(4.422***)	(1.654*)	(3.771***)	(0.444)	(1.214)	(3.249***)
	0.892	1.640	1.537	1.809	1.018	1.801	1.141	1.520	0.966	1.026	1.312
VR-18	(−1.721*)	(6.176***)	(6.290***)	(7.249***)	(0.492)	(6.626***)	(12.704***)	(4.496***)	(−2.572**)	(0.617)	(4.674***)
	1.312	1.734	1.444	1.976	1.010	1.781	1.255	1.450	0.846	0.966	1.325
VR-24	(−2.387***)	(7.805***)	(7.286***)	(9.356***)	(0.233)	(7.750***)	(8.425***)	(4.731***)	(−3.457***)	(−1.838*)	(6.235***)
	0.788	1.633	1.609	1.960	0.966	1.676	1.484	1.316	0.889	0.842	1.314
VR-36	(−3.518***)	(9.925***)	(9.390***)	(11.990***)	(−0.721)	(9.640***)	(11.815***)	(4.600***)	(−2.907***)	(−6.963***)	(8.816***)
	0.697	1.782	1.786	2.012	0.725	1.476	1.758	1.170	0.837	0.730	1.220
VR-48	(−5.128***)	(13.190***)	(12.156***)	(15.018***)	(−4.810***)	(9.732***)	(15.359***)	(3.765***)	(−3.671***)	(−9.287***)	(13.475***)
	0.663	1.333	1.405	1.791	0.576	1.226	1.548	1.146	0.631	0.777	1.234
VR-60	(−5.714***)	(5.443***)	(6.388***)	(11.848***)	(−6.556***)	(8.386***)	(11.624***)	(2.985***)	(−6.475***)	(−8.408***)	(9.564***)

Notes: Exhibit 2 presents the Variance Ratio statistics and the heteroskedasticity consistent test statistic.
* Indicates significance at the 0.1 level.
** Indicates significance at the 0.05 level.
*** Indicates significance at the 0.01 level.

Combining Equations (10) and (11) allows the following specification:[5]

$$R^i_{t+1} - R^r_{t+1} = a^i - \lambda(P^i_t - P^r_t) + \overline{\omega}^i_{t+1}. \quad (12)$$

As previously, a positive parameter would indicate mean reversion. If the error term does not display any evidence of autocorrelation, Equation (12) can be run using conventional OLS. However, if autocorrelation is found to be present, the following estimation may be used and mean reversion can be tested using the augmented Dickey-Fuller (ADF) unit root test.

$$R^i_{t+1} - R^r_{t+1} = a^i - \lambda(P^i_t - P^r_t) + \sum_{j=1}^{k} \phi^i_j \, (R^i_{t+1-j} - R^r_{t+1-j}) + \overline{\omega}^i_{t+1}. \quad (13)$$

Due to the lack of an acceptable index, a simple equally weighted portfolio of the markets is used as the reference index. In addition, the tests are re-run with an equally weighted index excluding the market in question. Balvers, Wu and Guilliland (2000) use the MSCI World index and the US market as alternative reference indices, while Cutler, Poterba and Summers (1991) estimate a similar model using the logarithm of the dividend price ratio as the measure of fundamental price. The ADF tests are reported in Exhibit 3. It can be seen that in no case are the ADF statistics significant at conventional significance levels. Thus indicating that the null hypothesis of no mean reversion cannot be rejected. Previous studies have also found minimal evidence of mean reversion on individual market data. Balvers, Wu and Guilliland (2000) examined eighteen national stock indices, only finding evidence of mean reversion in three cases.

Balvers, Wu and Guilliland (2000) note the low power of unit root tests in small samples and therefore use a panel approach to estimate the common speed of reversion. The approach adopted makes two key assumptions. First, in order to overcome problems of small samples and so that pooled data can be utilized, it is assumed that the speed of reversion is equal across all eleven markets. Second, that international differences in the fundamental values are stationary. A similar approach is adopted here. Equation (13) is estimated using the Seemingly Unrelated Regression (SUR) approach. The null hypothesis of no mean reversion is tested with the following statistics: $z_\lambda = T\hat{\lambda}$ and $t_\lambda = \hat{\lambda}/s(\hat{\lambda})$, where $\hat{\lambda}$ is the SUR estimate of λ, $s(\hat{\lambda})$ is the standard error of $\hat{\lambda}$ and T is the sample size. As the two test statistics don't have limiting normal distributions the critical values are estimated using Monte-Carlo simulation.[6] The median-unbiased estimate of λ is also based on Monte Carlo simulation.

Exhibit 3 | ADF Tests

Country	World Reference I	World Reference II
Australia	0.820	0.829
Belgium	−2.211	−2.248
Canada	−0.954	−0.945
France	−0.493	−0.443
Hong Kong	−1.591	−1.565
Italy	−0.918	−0.927
Japan	0.272	0.381
Netherlands	−0.126	−0.070
Singapore	−2.313	−2.309
U.K.	0.289	0.300
U.S.	−2.047	−2.045

Notes: Exhibit 3 reports the augmented Dickey-Fuller statistics based on Equation (13).
*Indicates significance at the 0.1 level.
**Indicates significance at the 0.05 level.
***Indicates significance at the 0.01 level.

The results of the panel tests are reported in Exhibit 4 and as with the previous results provide no evidence of mean reversion in real estate security markets. Neither test statistic is significant at conventional levels, while the implied half-life of thirty-nine years again provides evidence against mean reversion. These findings are in contrast to previous results of general national equity markets. Balvers, Wu and Guilliland (2000) estimated median-unbiased estimates for λ of 0.182 and 0.202 for the two alternative reference indices used, thus implying half-lives of 3.5 and 3.1 years, respectively. In addition, Cutler, Poterba and Summers (1991), find an average speed of reversion of 0.16 when the speed is constrained to be equal across the thirteen markets they examine. The results found in the current study are perhaps due to the variation in the results between markets, as evident in both the individual market ADFtests and in the previously reported variance ratio findings.

Portfolio Strategies

In order to test for both short- and long-term performance, performance of the markets is examined over varying time periods. Over each ranking period, the markets are divided into equally weighted 'winner' and 'loser' portfolios. The winner portfolio consists of those four markets that outperform during the ranking

Exhibit 4 | Pooled ADF Tests

	World Reference I	World Reference II
Point Estimate of λ	−0.026	−0.026
z_λ	−0.549	−0.549
t_λ	−0.982	−0.982
Median Unbiased Estimate of λ	−0.018	−0.018
Implied Half-Life	−39.473	−39.473

Notes: Exhibit 4 presents the results of the panel based test for mean reversion. The point estimate of λ is estimated using Seemingly Unrelated Regression (SUR) techniques. The test statistics can be defined as: $z_\lambda = T\hat{\lambda}$ and $t_\lambda = \hat{\lambda}.s(\hat{\lambda})$, where λ is the SUR estimate of λ, $s(\hat{\lambda})$ is the standard error of $\hat{\lambda}$ and T is the sample size. The critical values and the median unbiased estimate of λ are estimated using Monte Carlo simulation. The implied half-life is calculated as $\ln(1/2)\ln(1 - \lambda)$, where λ is the median unbiased estimate.

period, while the loser portfolio contains the four worst performing markets. The classification of performance is undertaken first using raw returns and second on a risk-adjusted basis. In addition, the performance of a contrarian portfolio is also assessed. This portfolio consists of a long position in the loser portfolio and a short position in the winner portfolio. The performance of these portfolios is then examined in subsequent periods. The portfolios are re-balanced on a quarterly basis in the testing period. Previous empirical evidence would hypothesize that over short-run horizons, winner markets continue to out-perform, while loser markets continue to under-perform. However, over longer horizons, a reversal in performance should occur.

In order to assess the comparative performance of the three portfolios in both the ranking and testing periods, the Jobson and Korkie (1981) pairwise test for the equality of Sharpe Ratios is used. The test statistic can be displayed as:

$$t = \frac{s_j\bar{r}_i - s_i\bar{r}_j}{\left[2/T(s_i^2 s_j^2 - s_i s_j s_{ij})\right]^{1/2}}. \tag{14}$$

s_j is the standard deviation of portfolio j, $\bar{r}_j$ is the mean return of j and s_{ij} is the covariance between portfolios i and j. Exhibits 5 and 6 present the findings of the portfolio switching results and provide broadly similar findings. As would be expected, the Jobson and Korkie (1981) test statistics, reported in Exhibits 7 and 8,

Exhibit 5 | Portfolio Switching Strategies

	Ranking Period			Testing Period		
	Winner Portfolio	Loser Portfolio	Contrarian	Winner Portfolio	Loser Portfolio	Contrarian
Panel A: Three-Month Rolling Portfolios						
Return	1.762	−1.008	−2.770	0.451	0.218	−0.233
Std. Dev.	1.960	2.026	2.164	2.163	1.877	2.283
Return/Risk	0.899	−0.498	−1.280	0.209	0.116	−0.102
Panel B: Six-Month Rolling Portfolios						
Return	1.376	−0.648	−2.028	0.466	0.227	−0.240
Std. Dev.	1.839	2.120	2.883	2.298	1.962	2.530
Return/Risk	0.748	−0.306	−0.704	0.203	0.116	−0.095
Panel C: Twelve-Month Rolling Portfolios						
Return	1.129	−0.399	−1.528	0.505	0.138	−0.367
Std. Dev.	1.985	1.854	2.112	2.228	1.902	2.367
Return/Risk	0.569	−0.215	−0.723	0.227	0.072	−0.155
Panel D: Twenty-Four Month Rolling Portfolios						
Return	0.919	−0.209	−1.128	0.385	0.261	−0.124
Std. Dev.	2.153	1.851	2.255	2.233	1.925	2.429
Return/Risk	0.427	−0.113	−0.500	0.172	0.136	−0.051
Panel E: Thirty-Six-Month Rolling Portfolios						
Return	0.810	−0.107	−0.917	0.329	0.313	−0.016
Std. Dev.	2.109	1.904	2.215	2.084	1.946	2.333
Return/Risk	0.384	−0.056	−0.414	0.158	0.161	−0.007
Panel F: Forty-Eight-Month Rolling Portfolios						
Return	0.742	0.005	−0.803	0.236	0.250	0.014
Std. Dev.	2.103	1.867	2.227	2.092	1.963	2.287
Return/Risk	0.353	0.002	−0.361	0.113	0.127	0.006
Panel G: Sixty- Month Rolling Portfolios						
Return	0.675	0.013	−0.662	0.194	0.325	0.131
Std. Dev.	2.123	1.822	2.203	2.149	1.900	2.271
Return/Risk	0.318	0.007	−0.301	0.090	0.171	0.058

Notes: Exhibit 5 reports the performance of the winner, loser and contrarian portfolio strategies both in the ranking and testing periods. The winner portfolio consists of an equally weighted portfolio containing the top four performing markets. The loser portfolio contains the worst four performing markets. The contrarian strategy involves a long position in the loser portfolio and a short position in the winner portfolio. For the testing period, each portfolio is re-balanced each quarter.

Exhibit 6 | Risk Adjusted Portfolio Switching Strategies

	Ranking Period			Testing Period		
	Winner Portfolio	Loser Portfolio	Contrarian	Winner Portfolio	Loser Portfolio	Contrarian
Panel A: Three-Month Rolling Portfolios						
Return	1.450	−0.842	−2.292	0.383	0.235	−0.148
Std. Dev.	1.523	1.717	1.761	1.980	1.755	2.103
Return/Risk	0.952	−0.491	−1.302	0.193	0.134	−0.070
Panel B: Six-Month Rolling Portfolios						
Return	1.210	−0.545	−1.755	0.450	0.174	−0.276
Std. Dev.	1.643	1.859	1.928	2.117	1.859	2.366
Return/Risk	0.737	−0.293	−0.910	0.212	0.094	−0.117
Panel C: Twelve-Month Rolling Portfolios						
Return	1.009	−0.347	−1.356	0.511	0.144	−0.368
Std. Dev.	1.726	1.978	2.065	1.943	1.964	2.183
Return/Risk	0.585	−0.175	−0.657	0.263	0.073	−0.168
Panel D: Twenty-Four-Month Rolling Portfolios						
Return	0.820	−0.157	−0.977	0.355	0.282	−0.073
Std. Dev.	1.684	2.042	2.076	1.942	2.040	2.289
Return/Risk	0.487	−0.077	−0.471	0.183	0.138	−0.032
Panel E: Thirty-Six-Month Rolling Portfolios						
Return	0.706	−0.043	−0.749	0.317	0.335	0.018
Std. Dev.	1.640	2.167	2.124	1.890	2.083	2.183
Return/Risk	0.430	−0.020	−0.353	0.168	0.161	0.008
Panel F: Forty-Eight-Month Rolling Portfolios						
Return	0.615	0.080	−0.576	0.286	0.290	0.004
Std. Dev.	1.581	2.156	2.077	1.843	2.093	2.127
Return/Risk	0.389	0.037	−0.277	0.155	0.139	0.002
Panel G: Sixty-Month Rolling Portfolios						
Return	0.552	0.080	−0.472	0.205	0.338	0.133
Std. Dev.	1.550	2.163	2.056	1.638	2.225	2.073
Return/Risk	0.356	0.037	−0.230	0.125	0.152	0.064

Notes: Exhibit 6 reports the performance of the winner, loser and contrarian portfolio strategies both in the ranking and testing periods on a risk-adjusted basis. The winner portfolio consists of an equally weighted portfolio containing the top four performing markets. The loser portfolio contains the worst four performing markets. The contrarian strategy involves a long position in the loser portfolio and a short position in the winner portfolio. For the testing period each portfolio is re-balanced each quarter.

Exhibit 7 | Comparison of Portfolio Performance

	Ranking Period		Testing Period	
	Winner Portfolio	Loser Portfolio	Winner Portfolio	Loser Portfolio
Panel A: Three-Month Rolling Portfolios				
Loser Portfolio	21.811***		1.388*	
Contrarian	21.214***	14.188***	2.895***	3.585***
Panel B: Six-Month Rolling Portfolios				
Loser Portfolio	17.346***		1.242	
Contrarian	18.907***	13.849***	2.733***	3.525***
Panel C: Twelve-Month Rolling Portfolios				
Loser Portfolio	23.692***		2.245**	
Contrarian	24.058***	16.962***	3.482***	3.673***
Panel D: Twenty-Four-Month Rolling Portfolios				
Loser Portfolio	22.288***		0.514	
Contrarian	23.605***	17.289***	1.991**	3.007***
Panel E: Thirty-Six-Month Rolling Portfolios				
Loser Portfolio	22.129***		−0.038	
Contrarian	24.584***	19.486***	1.457*	2.765***
Panel F: Forty-Eight-Month Rolling Portfolios				
Loser Portfolio	20.851***		−0.196	
Contrarian	24.309***	20.251***	0.927	1.920**
Panel G: Sixty-Month Rolling Portfolios				
Loser Portfolio	18.935***		−1.092	
Contrarian	23.086***	20.019***	0.270	1.673**

Notes: Exhibit 7 reports the Jobson and Korkie (1981) test for the equality of the Sharpe ratios on the three portfolios during both the ranking and testing periods.
*Indicates significance at the 0.1 level.
**Indicates significance at the 0.05 level.
***Indicates significance at the 0.01 level.

Exhibit 8 | Comparison of Risk-Adjusted Portfolio Performance

	Ranking Period		Testing Period	
	Winner Portfolio	Loser Portfolio	Winner Portfolio	Loser Portfolio
Panel A: Three-Month Rolling Portfolios				
Loser Portfolio	22.592***		0.892	
Contrarian	22.388***	15.677***	2.465***	3.394***
Panel B: Six-Month Rolling Portfolios				
Loser Portfolio	22.293***		1.683**	
Contrarian	22.838***	16.882***	3.033***	3.592***
Panel C: Twelve-Month Rolling Portfolios				
Loser Portfolio	22.755***		2.822***	
Contrarian	24.080***	18.737***	4.071***	4.293***
Panel D: Twenty-Four-Month Rolling Portfolios				
Loser Portfolio	23.624***		0.631	
Contrarian	26.207***	22.239***	1.988**	3.095***
Panel E: Thirty-Six Month Rolling Portfolios				
Loser Portfolio	22.819***		0.103	
Contrarian	26.265***	24.067***	1.473*	2.730***
Panel F: Forty-Eight-Month Rolling Portfolios				
Loser Portfolio	21.870***		0.239	
Contrarian	25.834***	24.763***	1.395*	2.416***
Panel G: Sixty-Month Rolling Portfolios				
Loser Portfolio	20.300***		−0.390	
Contrarian	24.712***	24.785***	0.569	1.733**

Notes: Exhibit 8 reports the Jobson and Korkie (1981) test for the equality of the Sharpe ratios on the three risk-adjusted portfolios during both the ranking and testing periods.

*Indicates significance at the 0.1 level.

**Indicates significance at the 0.05 level.

***Indicates significance at the 0.01 level.

are all significant at the 0.01 level during the ranking period. The winner portfolios continue to outperform the loser portfolio up to horizons of twenty-four and forty-eight months on the raw and risk-adjusted bases respectively. The out-performance is also statistically significant for the first three periods in both cases. The winner portfolio also outperforms the contrarian strategy over all horizons, with the findings significant up to the thirty-six-month horizon for the original data and to 48 months on a risk-adjusted basis. These findings are consistent with the existing literature that indicates performance persistence at shorter-term horizons. However, the performance does start to converge and at the longer horizons the loser portfolio does outperform the winner portfolio. The original portfolio switching tests indicate performance reversal at horizons of thirty-six months and above, while on a risk-adjusted basis the loser portfolio outperforms at the sixty-month horizon. However, in none of the cases is the out-performance statistically significant at conventional levels.

Conclusion

This study has aimed to examine the predictability of real estate securities over both short- and long-term horizons. The specific tests for mean reversion in real estate securities provide little evidence in favor of such price behavior. In the case of the Variance Ratio tests, only four of the eleven markets examined display signs of mean reverting behavior. The Augmented Dickey-Fuller tests provide no significant findings whether on an individual market basis or on a panel basis. The portfolio switching tests do reveal price continuation on a short-term basis with the winner portfolio significantly outperforming both the loser and contrarian portfolios.

The results highlight the potential problems that may arise in the testing of performance persistence and reversals. As stated in the introduction, many of the models used to test for these effects effectively result in joint tests, both of the effects and the model used. In addition, factors such as the data analyzed, the sample period and the intervals selected for comparing relative performance, will also impact on the results obtained. The results also add to the inconsistent findings previously obtained both in the REIT literature in relation to predictability and in the broader financial economics literature.

Endnotes

[1] There is also a large literature documenting similar performance persistence in mutual funds, see for example Grinblatt and Titman (1992) and Brown and Goetzmann (1995).

[2] See also Kasa (1992) and Richards (1995).

[3] Two studies to have examined such issues in the context of the direct real estate market include Young and Graff (1996) and Graff, Harrington and Young (1999).

[4] See also studies such as Kuhle and Alvayay (2000) who examine the efficiency of 108 Equity REITs using runs tests and autocorrelation coefficients, finding evidence of inefficiencies in the market.

[5] In addition, $\alpha^i = \alpha^i - \alpha^r + \lambda z^i$ and $\overline{\omega}_t^i = \varepsilon_t^i - \varepsilon_t^r + \lambda\eta_t^i$. Also the error term maintains the properties of the terms in Equations (10) and (11) and thus can be serially correlated.

[6] The test statistics are estimated on the basis of 5,000 simulations.

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