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A Re-Examination of the Inflation-Hedging Ability of Real Estate Securities: Empirical Tests Using International Orthogonalized & Hedged Data

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This study re-examines the relationship between real estate securities and inflation in a total of ten international markets. In addition to the raw data, both the orthogonalized and hedged approaches were adopted in order to strip out the general impact of the domestic equity market. The results revealed that there is minimal evidence of a positive relationship between real estate securities and inflation, which is in line with existing empirical evidence. However, the strong evidence of perverse relationship, noted in previous studies of REITs, is not robust throughout the other nine markets. The hedged and orthogonalized data also provided minimal evidence in favour of a positive relationship, both in the short and long terms.

Keywords

Inflation hedging, International real estate, real estate securities

Introduction

The relationship between inflation and real estate securities stems from evidence which supports the hypothesis that securities such as REITs act as perverse hedges against inflation, and in particular inflation's unexpected component. This evidence has been in accordance with that reported in relation to common stocks; however, it is in contrast to the evidence found in the context of the direct real estate market. Studies such as Murphy & Kleiman (1989) and Park, et al. (1990) found that REITs act as a perverse hedge against both expected and unexpected inflation, while papers such as Gyourko & Linneman (1988) and Yobaccio, et al. (1995) supported this hypothesis with regard to unexpected inflation. Dissenting pieces of evidence in relation to expected inflation include Chen & Tzang (1988), Gyourko & Linneman (1988), and Yobaccio, et al. (1995). The empirical evidence in relation to real estate securities is in contrast to that reported in the context of the direct real estate market. International evidence has been relatively consistent in terms of the unstable relationship that exists between real estate and inflation. Earlier studies, such as Fama & Schwert (1977), Hartzell, et al. (1987), Limmack & Ward (1987), and Rubens, et al. (1989) found strong supportive evidence that the asset acts as an effective hedge. However, more recent evidence has tended to be less conclusive. Papers such as Brown (1991), Tarbert (1996), and Stevenson (2000b) have all provided evidence of the instability of commercial and residential real estate's ability to act as an effective hedge against inflation. Such studies have, however, also utilised cointegration techniques, with the results being generally supportive evidence for the assets' long-term hedging ability.

This study has three primary purposes. First, while a large number of papers have examined the ability of REITs to act as effective hedges against inflation and its component parts, few studies have extended this into an international context, the main exception being Liu, et al. (1997), who compared the hedging ability of real estate securities across seven international markets. In most cases, the authors found no evidence that real estate securities provided a better hedge against inflation than stocks in general. The only piece of dissenting evidence was for France, and even in this case, the evidence was not consistent across alternative measures for expected inflation. Second, this paper extends the analysis in the aforementioned paper to examine the long-term inflation hedging ability of real estate securities in a cointegration context. Finally, the paper also re-examines the issue after attempting to strip out general stock market sentiment using both the hedged and orthogonalized approaches. These issues were analysed in the context of REITs by Chatrath & Liang (1998). The authors examined both raw and hedged REIT returns, and found that while REITs failed to provide a short-term hedge, the evidence indicated that hedged REIT returns may act as a long-term hedge against inflation.

The remainder of the paper is as follows. The following section provides details of the data analysed and the measures of expected and unexpected inflation used in this study. The following two sections present the empirical findings, first using the conventional OLS techniques and then examining the issue on a long-term basis using cointegration techniques. The final section provides concluding comments.

Data Requirements & Methodological Framework

This study tests the relationship between real estate and inflation using indirect real estate data for ten international markets. The original data set runs from 1976 to 1999. However, due to the manner in which the hedged indices were constructed, the period examined in terms of real estate's relationship with inflation was shortened by five years. The indices used are the ASX Property Trusts Index (Australia), the Brussels SE Real Estate Index, Toronto SE Real Estate Index, AGEFI Property Index (France), Milan MIB Real Estate Index, Nikkei Real Estate Index (Japan), Amsterdam Kempen Property Index, Singapore All Properties Index, FTSE Property Index (UK) and the NAREIT Indices for the United States. The hedged index approach, as proposed by Giliberto (1993) has been previously used in assessing the relationship between inflation and REITs by Chatrath & Liang (1998). The premise behind such an approach is two-fold. First, by stripping out general stock market sentiment, the estimated series provides a real estate security return series that is hedged against stock market movements. Second, the approach can also be used to provide an alternative proxy for the direct real estate market. The hedged approach provides a data series that both utilizes information available in the capital markets and overcomes potential biases that may be present in either appraisal techniques or in the methods used in index construction. This second rationale is behind its common use in portfolio studies in which the potential biases present in risk measures for the direct market can lead to substantial differences in the empirical results[1]. The technique involves the adjustment of the indirect real estate security markets for the influence of their respective equity markets through the use of the following model:

$$r_t^p = \alpha + \beta r_t^e + \varepsilon_t \qquad (1)$$

where r_t^p is the unhedged index and r_t^e is the domestic equity series. The 'hedged' real estate series can therefore be estimated in the following fashion.

$$r_t^{hp} = r_t^p - \beta r_t^e \qquad (2)$$

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[1] See for example Stevenson (2000a).

As was the case in previous studies, such as Giliberto (1993), Liang & Webb (1996), and Stevenson (2000a), the hedged indices were calculated on a 48-month rolling basis. Monthly data for the indirect markets was initially used to create the hedged series. This was then reduced to a quarterly series for the main analysis contained in the paper. The rationale behind such an approach was to allow additional comparisons with existing studies of the direct market, as most such indices are constructed on a quarterly basis. The alternative orthogonalized approach, as utilized by Brooks & Tsolacos (1999), simply uses the residuals from an overall model such as in Equation (1). Such an approach thus removes that part of the real estate returns that are linearly and contemporaneously related to general equity market movements. The primary difference between the two approaches is that while the hedged approach is an active strategy and based on rolling data, the orthogonalized return series is estimated over the entire data sample.

A number of the tests utilised in the study required inflation to be decomposed into its expected and unexpected components. Previous studies have found that the choice of proxy can lead to substantial variations in the empirical findings. Therefore, in order to avoid the results being dependent on the proxy selected, a total of six alternative methods were initially examined. The first alternative was that originally proposed by Fama (1975, 1976, 1977), and is the lagged Treasury Bill rate. This proxy can lead to biases, however, due to factors such as the possibility that the real return on short-term rates may not be constant. Fama & Gibbons (1982) therefore suggested a correction to the measure that takes this issue into account. The correction can be formulated as follows:

$$E(\Delta_t) = y_{t-1} - (1/x)\sum_{s=t-1}^{t=x}\left(y_{s-1} - \log\left(\frac{CPI_s}{CPI_{s-1}}\right)\right) \quad (3)$$

where y is the short-term rate and x represents the frequency of the data. The third alternative proxy is a simple first order autoregressive model, as used in studies such as Brown (1991). The final three proxies are alternative ARIMA models. These are of the respective form: ARIMA (1,0,3), as used by Gatzlaff (1994), ARIMA (1,1,3), as proposed by Barkham, et al. (1996), and finally ARIMA (0,1,1).

The effectiveness of each alternative proxy is assessed using the following model:

$$\Delta_t = \alpha + \beta E(\Delta_t) + \varepsilon_t \quad (4)$$

where Δ is the actual inflation rate and $E(\Delta)$ is the respective proxy for expected inflation. The effectiveness of each of the proxies is assessed on the basis of the intercept and beta coefficient estimated from Equation (4). To act as an effective proxy, the expected inflation rate should have an insignificant intercept term and a beta that is significantly different from zero, but statistically not different from unity. Throughout this study, only those results obtained with the estimated 'best' proxy for each market is reported[2]. Table 1 reports the findings from Equation (4), with the estimated best proxy represented in bold for each market. In those cases where the primary determinants of the best proxy were satisfied, namely the insignificance of the intercept and the significance of the beta coefficient, the decision on the most appropriate proxy was based on the performance of the alternative proxies in sub-samples, and whether the beta coefficient was statistically and significantly different from unity. In nine of the ten markets, one of the alternative ARIMA models was thus selected as the best proxy, the only exception being the USA, for which the Fama & Gibbons (1982) corrected measure of short-term yields was found to be the most appropriate proxy. It was noticed that in a number of the markets, some of the proxies performed extremely badly in estimating inflation, thereby highlighting the need to examine alternative measures.

Empirical Analysis

This section of the paper contains the main OLS-based empirical tests. Initially, it was tested to see whether real estate securities and common stocks acted as effective hedges against actual inflation. This form of analysis is equivalent to assuming that expected inflation rates are always correct, and unexpected inflation rates are constantly zero. This analysis was tested using the following model:

$$R_{jt} = \alpha_t + \beta_j \Delta_t + \varepsilon_{jt} \qquad (5)$$

where R_{jt} represents the return on real estate and Δ_t is the actual rate of inflation. The results from Equation (5) are contained in Table 2, and largely confirm existing empirical evidence for the short-term inflation hedging ability of real estate securities and common stocks. In no case did any of the assets provide an effective hedge against actual inflation, with the exception of the hedged series for Australia and both the hedged and orthogonalized series for Japan. The results did highlight a number of issues, however, with

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[2] The full empirical results using the alternative proxies are available from the author on request.

the primary one being that the strong evidence of REITs acting as a perverse hedge is not confirmed in many of the other markets. For the US markets the overall NAREIT index and Equity and Mortgage sub-sectors act as perverse hedges at significant levels, results confirmed for the overall index for both the hedged and orthogonalized data and for EREITs for the orthogonalized series. However, in no other market did any of the three real estate series, or the common stock indices, provide significantly negative coefficients that would indicate a perverse hedge. These results also confirmed the findings of Liu, et al. (1997), who discovered that the US results were a great deal stronger than those in other markets. It is of interest that despite the strong evidence with regard to the direct market, the two adjusted series did not tend to support such findings.

The second part of this section extends the above analysis to decompose inflation and utilises the model proposed by Fama & Schwert (1977), which can be expressed as follows:

$$R_{jt} = \alpha_t + \beta_j E(\Delta_t | \phi_{t-1}) + \gamma_j [\Delta_t - E(\Delta_t | \phi_{t-1})] + \eta_{jt} \qquad (6)$$

where $E(\Delta_t | \phi_{t-1})$ represents expected inflation, given available information (ϕ_{t-1}), and $[\Delta_t - E(\Delta_t | \phi_{t-1})]$ is the unexpected rate. The β coefficient assesses the assets' hedging ability against expected inflation, and γ represents the hedging ability against unexpected inflation. The results from Equation (6) are contained in Table 3 and largely confirm the preceding findings. The raw REIT series' for the United States provided significant perverse hedges against both expected and unexpected inflation, with only the exception being Mortgage REITs and expected inflation. In addition, the hedged series for the overall NAREIT index and for MREITs also are perverse hedges with respect to unexpected inflation. As with the analysis for actual inflation, the results for the other markets were in stark contrast to the US results. For the raw real estate returns, only the results for Singapore in relation to expected inflation indicated any significant evidence of the securities acting as perverse hedges, while even in this case Singaporean real estate securities acted as an effective hedge against unexpected inflation. For the orthogonalized and hedged series, significantly positive coefficients were found in relation to expected inflation for Japan (orthogonalized data) and France (both series), while for unexpected inflation positive results were found for Australia (both series) and Singapore (orthogonalized data). The only evidence outside of the USA of these series acting as perverse hedges was in the French hedged data. Even in the case of common stocks the only evidence of perverse hedges were for Singapore (expected) and Japan (unexpected).

Table 1: Comparison of Alternative Proxies for Expected Inflation

	α	β	R^2	α	β	R^2	α	β	R^2	α	β	R^2
		Australia			Belgium			Canada			France	
Short Term Yield	-0.3856*	0.6282***	0.4610	-0.3706	0.5627***	0.3965	0.5623**	0.3912***	0.1283	-0.6589***	0.7207***	0.5733
Fama & Gibbons Correction	-0.2311	0.7584***	0.4119	-0.3449*	0.7370***	0.3915	0.6212**	0.4870***	0.1151	-0.6286***	0.9478***	0.5681
ARIMA (1,0,3)	**-0.0310**	**0.9550*****	**0.5344**	**-0.0237**	**0.9369*****	**0.4538**	-0.0641	1.0279***	0.4946	0.02118	0.8463***	0.6696
ARIMA (1,1,3)	0.1370	0.8972***	0.5281	0.1284	0.8150***	0.4528	**0.0642**	**0.9308*****	**0.5269**	**0.1009**	**0.8326*****	**0.7208**
ARIMA (0,1,1)	0.1507	0.8856***	0.5174	0.1216	0.8171***	0.3920	0.0888	0.9143***	0.4905	0.1207	0.8097***	0.6662
First Order Autoregressive	0.3844***	1.3918***	0.4417	0.4269***	0.8779***	0.1730	0.5206***	0.9676***	0.3697	0.2638**	0.8283***	0.4826
		Italy			Japan			Netherlands			Singapore	
Short Term Yield	0.0745	0.9501***	0.3012	-0.0069	0.3192**	0.0415	0.0223	0.3356**	0.0482	0.3088	0.0804	0.0035
Fama & Gibbons Correction	0.1136	1.2380***	0.2862	-0.0198	0.4447**	0.0482	0.0356	0.4379**	0.0483	0.3712*	0.0357	0.0004
ARIMA (1,0,3)	**0.0266**	**0.9117*****	**0.7763**	-0.1733**	1.0069***	0.6183	-0.1223	0.9930***	0.6414	**0.1034**	**0.5359****	**0.0558**
ARIMA (1,1,3)	0.1980*	0.8648***	0.8055	**0.0260**	**0.9073*****	**0.5818**	**0.0502**	**0.8877*****	**0.6766**	0.2609**	0.2919	0.0173
ARIMA (0,1,1)	0.1845*	0.8828***	0.7797	0.1971	0.3319	0.0060	0.3333*	0.3720	0.0126	0.2788**	0.2533	0.0129
First Order Autoregressive	0.2074*	0.9814***	0.7174	0.5438***	2.3650***	0.3417	0.7986***	1.4923***	0.1978	0.3438***	0.4166	0.0083
		UK			USA							
Short Term Yield	-0.4956	0.6941***	0.2344	0.2702*	0.3483***	0.1535						
Fama & Gibbons Correction	-0.5125	0.9372***	0.2578	**0.2396**	**0.4926*****	**0.1719**						
ARIMA (1,0,3)	0.2635	0.6314***	0.1011	0.4135**	0.4529***	0.0795						
ARIMA (1,1,3)	**0.1651**	**0.8354*****	**0.3977**	0.5009***	0.3862***	0.0779						
ARIMA (0,1,1)	0.6242**	0.4230**	0.0495	0.5311***	0.3407**	0.0610						
First Order Autoregressive	1.2359***	-0.3840	0.0028	0.7324***	0.1798	0.0013						

Notes: (1) * indicates coefficient statistically significantly different from zero at 10% level, ** at a 5% level, and *** at a 1% level.
(2) Those proxies indicated in bold are those reported throughout the remainder of the paper.

Table 2: OLS Results Against Actual Inflation

	Real Estate Securities		Real Estate Orthogonalized Data		Real Estate Hedged Data		Common Stocks	
	α	β	α	β	α	β	α	β
Australia	1.1673	1.9980	-1.7183	1.4177	-0.2592	1.7907 *	1.6755	0.5372
Belgium	3.3963 **	0.2599	0.4724	-0.6227	1.4254	0.3448	2.6195	1.2690
Canada	-2.8873	2.3522	-2.6995	1.9270	-2.5821	0.9288	1.0175	0.3525
France	0.2406	2.8421	-1.6532	1.8853	-2.1840	2.3110	2.8370	1.0959
Italy	3.6450	-1.1003	0.0679	-0.0452	0.9364	-0.5232	-1.2408	4.6953
Japan	1.7030	-1.30083	-0.7030	2.1113 *	-0.5210	2.1134 *	2.3038	-2.5812
Netherlands	1.6492 *	-0.5268	0.3436	-0.6361	0.2977	-0.4395	3.4180 **	0.2912
Singapore	-0.5757	4.6999	-0.9786	2.4350	-1.3767	2.3207	0.3539	1.6811
UK	4.3222 **	-1.5982	1.1552	-1.0596	0.7323	-0.9469	3.7618 **	-0.6008
USA	6.2574 ***	-4.41 ***	2.1965 *	-2.6412 **	2.7922 **	-2.2765 *	6.1999 ***	-3.5058 **
EREITs	6.3723 ***	-3.898 ***	1.7575	-2.1134 *	3.1726 ***	-1.9488	-	-
MREITs	5.5786 ***	-4.4181 **	2.2264	-2.6772	1.0992	-1.6483	-	-

Note: * indicates coefficient statistically significantly different from zero at 10% level, ** at a 5% level, and *** at a 1% level.

Table 3: OLS Results Against Expected & Unexpected Inflation

	Real Estate Securities			Real Estate Orthogonalized			Real Estate Hedged Data			Common Stocks		
	α	β	γ	α	β	γ	α	β	γ	α	β	γ
Australia	3.4535	0.7442	3.6366	-0.4581	0.5307	2.5767 *	1.3222	0.6762	3.2472 **	2.1574	0.1976	0.9810 *
Belgium	2.0056	2.3834	-1.8016	-1.3916	1.4275	-2.6130	-0.8184	2.8127	-2.0511	2.5237	1.3745	1.1667
Canada	-2.6935	2.2215	2.5277	-2.3865	1.7160	2.2104	-2.4855	0.8638	1.0163	0.9187	0.4191	0.2631
France	-1.4016	4.1032 *	-5.6318	-3.4473	3.2631 *	-7.3723	-4.0136 *	3.7160 *	-7.1298 *	3.0109	0.9623	1.9935
Italy	2.6175	-0.5575	-3.6305	-0.5720	0.2325	-1.6813	0.2437	-0.2227	-2.2942	4.1933	-1.0230	-2.5241
Japan	0.7578	1.4073	-6.3000	-1.1380	3.3611 **	-0.1858	-1.2318	4.1557 ***	-1.6405	1.9187	-1.4748	-4.6150 *
Netherlands	1.6741	-0.5690	-0.3878	0.2253	-0.4357	-1.2969	0.1240	-0.1455	-1.4089	3.8001 ***	-0.3556	2.4242
Singapore	10.408 **	-14.235 *	7.5041 *	1.3895	-1.6473	3.0396 *	0.5575	-1.0136	2.8146	6.7487 **	-9.3431 *	3.3138
UK	4.2541 *	-1.5376	-1.6556	1.6148	-1.4686	-0.6726	1.1385	-1.3083	-0.6048	3.1732 *	-0.0769	-1.0964
USA	5.8911 **	-4.1519 **	-4.5625 ***	1.2290	-1.9607	-3.0454 **	2.0238	-1.7359	-2.5975	7.3919 ***	-4.3442 *	-3.0079
EREITs	6.2790 ***	-3.8327 **	-3.9372 **	1.0574	-1.6209	-2.4058	1.6426	-1.5760	-2.1702	-	-	-
MREITs	4.3342	-3.5429	-4.9379**	0.3902	-1.3856	-3.4442 *	-0.7706	-0.3331	-2.4293	-	-	-

Note: * indicates coefficient statistically significantly different from zero at 10% level, ** at a 5% level, and *** at a 1% level.

Table 4: Fisherian Causality Results

	Real Estate Securities			Real Estate Orthogonalized Data			Real Estate Hedged Data			Common Stocks		
	α	β	γ	α	β	γ	α	β	γ	α	β	γ
Australia	2.9326	0.8162	-4.7079	-1.3017	0.8551	-8.7910 **	0.4570	0.9718	-8.8201 **	2.4545	-0.0359	3.7790
Belgium	2.3722	2.3031	7.8958	-1.0192	1.4071	7.5426	-0.4916	2.7762	6.7577	2.5169	1.2884	0.5079
Canada	-3.1437	2.4272	-2.1035	-2.8404	1.9430	-2.0461	-2.5206	0.8574	-0.3443	0.9218	0.4098	-0.0476
France	-1.9818	5.0477 **	-0.2232	-4.2786 *	4.5101 **	-1.6364	-4.8836 **	4.9318 ***	-2.8183	3.2986 *	0.6158	1.6186
Italy	3.0001	-0.3804	5.6123	0.1592	0.1488	9.0878 **	0.9959	-0.2634	9.5245 **	3.7418	-0.6853	-4.5006
Japan	-0.1188	3.9701	-1.2410	-1.5433	4.4905	-0.6974	-1.9804	6.2683 *	-1.2294	1.5630	-0.3928	-0.4103
Netherlands	1.4871	-0.2366	-0.2194	0.0641	-0.1245	-0.1258	-0.0231	0.1444	-0.1001	3.7314 **	-0.2992	-0.2497
Singapore	11.3380 **	-17.8450 **	3.3469	1.7292	-3.0792	0.5525	0.8125	-2.2905	-0.7763	7.1872 **	-10.9600 **	2.0471
UK	4.7831 *	-1.9632	0.7949	2.0972	-1.8743	0.5879	1.6215	-1.7159	0.5775	3.2252	-0.0992	0.2308
USA	4.7694 **	-2.1581	-14.635 ***	0.4788	-0.6469	-10.546 ***	1.3859	-0.5926	-7.9534 **	6.6554 ***	-2.9959	-8.1056
EREITs	5.3128 **	-2.0921	-11.7210 **	0.4662	-0.5669	-7.5939 *	2.1114	-0.6022	-5.8029	-	-	-
MREITs	3.1174	-1.4178	-17.334 ***	-0.4610	0.0699	-13.3090 **	-1.3736	0.6625	-10.8010 *	-	-	-

Note: * indicates coefficient statistically significantly different from zero at 10% level, ** at a 5% level, and *** at a 1% level.

The final OLS-based model is the Fisherian Direct Causality model, which has been previously used in a real estate context in studies such as Liu, et al. (1997) and Stevenson (2000b). This model uses real returns and regresses them with expected inflation and changes in expected inflation. The model is based on the premise that only real factors influence real returns and therefore, real returns should be independent of expected inflation rates. The model can be formulated as follows:

$$r_{jt} = \alpha_t + \beta_j E(\Delta_t | \phi_{t-1}) + \gamma_j [E(\Delta_{t+1} | \phi_t) - E(\Delta_t | \phi_{t-1})] + \eta_{jt} \quad (7)$$

where r_{jt} represents the real return on the asset and $[E(\Delta_{t+1} | \phi_t) - E(\Delta_t | \phi_{t-1})]$ the revisions in expected inflation. The null hypothesis is that both coefficients are zero. The results, reported in Table 4, show that in a majority of the cases, the two coefficients were significantly different from zero, thus supporting the hypothesis that only real factors influence real returns. As with the previous results, there were marked differences between the results for REITs and those for the other nine markets examined. In the case of REITs, significantly negative coefficients were reported across all three series with the exception of the Hedged EREIT series. In contrast, only three other real estate series provided similar results, these being the Australian orthogonalized and hedged series for changes in expectations, and Singapore for expected inflation. In addition, all three French series provided significant positive figures for expected inflation, with similar findings for Japan and the γ coefficient in relation to Italy.

The results showed that in the majority of cases, real estate securities displayed no significant economic relationship with inflation, its expected and unexpected components, or changes in expectations. The primary exception to this was the United States, for which a number of significant findings were reported, usually in a perverse direction in line with previous studies. The findings also confirmed Liu, et al's. (1997) results in that while relatively few markets showed significant findings, the number is beyond that found with common stocks. The use of the hedged and orthogonalized approaches did not substantially alter the results. It is probable that although such methods do strip out the direct equity component of real estate securities the fact is that some degree of expectations will still be incorporated into the returns. Therefore, there may be a conflicting basis of valuation between the adjusted series and the direct markets themselves. While capital markets are forward-looking and incorporate expectations into prices, the need for comparable evidence in direct market appraisals will lead to some degree of backward-looking pricing in valuations. Furthermore, factors that should also be considered when considering the hedged and orthogonalized results are that most studies to have examined the direct market have based their analysis on indices, and thus induced further smoothing into returns due to temporal aggregation. Secondly, more recent studies of the direct market have been far less conclusive in terms of real estate's ability to act as an effective inflation hedge.

Long-Term Hedging Ability

The second part of the empirical analysis concentrates on the long-term hedging ability of the assets examined, and extends that analysis to examine whether any causal relationships exists between both real estate and common stocks with inflation. Throughout this section, only actual inflation is analysed on the basis that as the analysis is based over a long-horizon, it is legitimate to assume that expected and actual inflation are equal. Two alternative means of testing for cointegration are used in this study, namely the two-step Engle & Granger (1987) method and the Johansen (1988) procedure. The Engle-Granger method tests the residuals in the cointegration regression model for a unit root. If the residuals are found to be stationary, then the series are cointegrated and therefore have a common long-term equilibrium. The Johansen procedure provides estimates of all the cointegrating vectors. Under the null hypothesis of no cointegration the Johansen method is based on the maximum likelihood estimation of the following error correction representation:

$$\Delta x_t = \mu + \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + ... + \Gamma_{p-1} \Delta x_{t-p+1} + \Pi x_{t-p} + B z_t + u_t \quad (8)$$

where x_t is a mx1 vector of $I(1)$ variables, $\Gamma_1 .... \Gamma_{p-1}$ are mxm matrices of unknown parameters, z_t is a sx1 vector of $I(0)$ variables, B is a mxs matrix, and $u_t \sim N(0.\sum \ )$. The parameter matrix *P* indicates whether or not the mx1 vector has a long run relationship, while the rank of *P* indicates the number of cointegrating vectors. The findings for the cointegration analysis are contained in Tables 5 and 6, and show consistently across all of the series analysed that there is no evidence of cointegration, with the exception of the Japanese orthogonalized series with the Engle-Granger method. These findings indicated no evidence of a long-term common trend between inflation and the alternative series used in the study. These results are in contrast to those reported in Chatrath & Liang (1998), who examined raw and hedged REIT returns, and in a number of papers on the direct market. Matysiak, et al. (1996) and Barkham, et al. (1996) both provided evidence to support the hypothesis of a cointegrating relationship between UK commercial real estate and inflation, although less conclusive findings were reported by Tarbert (1996).

Table 5: Engle-Granger Cointegration Tests

	Real Estate Securities	Real Estate Orthogonalized Data	Real Estate Hedged Data	Common Stocks
Australia	-2.4533	-2.4939	-2.3691	-2.3514
Belgium	-2.8319	-1.5382	-1.2814	-1.5337
Canada	-1.4130	-1.9913	-2.1775	-2.6921
France	-2.5904	-2.7868	-2.9921	-1.0061
Italy	-2.3376	-1.9066	-1.8340	-2.2024
Japan	-1.6360	-3.7199 *	-2.7969	-1.8774
Netherlands	-2.0624	-2.8988	-3.1540	-0.6648
Singapore	-2.4499	-3.3401	-3.3608	-2.9159
UK	-3.0260	-3.1452	-1.9489	-1.7009
USA	-1.7733	-1.8268	-1.7662	-0.3842
EREITs	-1.9351	-1.4247	-2.0196	-
MREITs	-1.7626	-2.5665	-2.5479	-

Note: * indicates coefficient statistically significantly different from zero at 10% level.

Table 6: Johansen Cointegration Tests

		Real Estate Securities		Real Estate Orthogonalized Data		Real Estate Hedged Data		Common Stocks	
		Trace	Max	Trace	Max	Trace	Max	Trace	Max
Australia	r=0	4.775	3.902	12.022	7.755	11.875	7.865	4.847	4.425
	r=1	0.873	0.873	4.267	4.267	4.010	4.010	0.421	0.421
Belgium	r=0	10.637	8.542	12.273	8.501	10.576	7.812	4.959	4.702
	r=1	2.096	2.096	3.772	3.772	2.764	2.764	0.257	0.257
Canada	r=0	14.139	11.415	13.371	10.517	15.877	12.805	12.002	9.774
	r=1	2.724	2.724	2.855	2.855	3.072	3.072	2.228	2.228
France	r=0	12.117	8.623	9.587	7.426	10.228	8.063	10.875	9.671
	r=1	3.494	3.494	2.161	2.161	2.165	2.165	1.204	1.204
Italy	r=0	11.150	8.067	9.733	7.140	10.800	8.387	10.166	5.906
	r=1	3.083	3.083	2.593	2.593	2.413	2.413	4.260	4.260
Japan	r=0	14.268	8.860	18.730	15.679	12.399	9.675	16.315	10.862
	r=1	5.408	5.408	3.051	3.051	2.724	2.724	5.543	5.543
Netherlands	r=0	15.184	13.914	17.165	15.960	15.202	14.577	7.043	7.029
	r=1	1.270	1.270	1.206	1.206	0.625	0.625	0.014	0.014
Singapore	r=0	13.915	13.883	8.984	8.726	5.022	4.601	22.138	21.998
	r=1	0.032	0.032	0.258	0.258	0.421	0.421	0.140	0.140
UK	r=0	5.846	5.754	24.865	23.894	24.639	23.430	3.416	3.186
	r=1	0.092	0.092	0.971	0.971	1.209	1.209	0.230	0.230
USA	r=0	7.169	7.092	11.330	11.322	11.903	11.901	16.631	16.065
	r=1	0.078	0.078	0.007	0.007	0.002	0.002	0.566	0.566
EREITs	r=0	8.246	8.129	8.518	8.357	12.634	12.632	-	-
	r=1	0.118	0.118	0.161	0.161	0.002	0.002	-	-
MREITs	r=0	6.794	6.781	9.299	9.284	9.936	9.913	-	-
	r=1	0.014	0.014	0.015	0.015	0.023	0.023	-	-

As in the previous tests, the sensitivity of the results to both the time period examined and the models adopted is a key factor. The fact that the results with regard to REITs differed from those reported by Chatrath & Liang (1998) highlights the problems over the use of different time periods, while the adjusted findings are dependent on the exact model and approach adopted.

The final section of the empirical tests extends the above analysis to examine causality. Granger-causality tests are used to examine whether inflation Granger-causes the financial assets, or vice-versa, using restricted and unrestricted lagged regressions[3]. To test for a causal relationship, the models are estimated in both restricted and unrestricted forms, with the restricted version including only the lagged variables of the respective dependent variable. The following *F* statistic is then used to test for causality:

$$F^{*} = \frac{(SSE_r - SSE_u)/m}{SSE_u/(T - 2m - 1)} \sim \chi^2_m \qquad (9)$$

where SSE_r is the residual sum of squares of the restricted model, SSE_u is the residual sum of squares for the unconstrained model, T represents the total number of observations, and m is the number of lags. Rather than use an arbitrary number of lags, autoregressive equations are estimated for each of alternative series', with the number of lags varied. The optimum number of lags is determined by the minimum value of Akaike's final prediction error. It can be seen from the results reported in Table 7 that in no case is there evidence of causal relationships from the real estate assets or common stocks to inflation, or vice-versa, thereby broadly confirming the OLS tests previously reported.

Conclusion

The results reported in this study are in many respects in marked contrast to those found in relation to the direct real estate market. While the failure of REITs and other such securities to act as effective inflation hedges is well documented, studies of the direct market have tended to find some evidence of a relationship with inflation, although this relationship may not be consistent. No evidence was found of a positive relationship between any of the series in the conventional least squares tests, while previous evidence of a perverse relationship was only confirmed consistently for REITs. The use of

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[3] In the case of where there is evidence of cointegration it is also necessary to incorporate an error correction term into the models. As no such evidence was found in the current study error correction terms are not included.

the hedged and orthogonalized data was aimed at providing an alternative proxy for the direct market, as with the use in the context of asset allocation studies. The results highlighted, however, the potential limitations such adjustments may have in wider contexts. Despite the fact that data is stripped of the direct influence of general stock market sentiment, the fact remains that expectations will be incorporated into these return series', unlike with the direct market. This issue may help in explaining why the alternative series provide results so different from those reported in relation to the direct market.

Table 7: Causality Results

	Real Estate Securities	Real Estate Orthogonalized Data	Real Estate Hedged Data	Common Stocks
Panel A: Inflation ⇒ Real Estate				
Australia	0.6623	2.0520	1.5663	0.9025
Belgium	1.0828	0.7138	0.8251	0.7415
Canada	2.1061	2.7519	1.8619	1.2545
France	2.5092	5.5343	5.6732	0.7204
Italy	0.9157	1.1252	1.1185	1.8850
Japan	0.6740	1.3977	2.1455	1.0549
Netherlands	0.9966	0.5441	0.9393	2.8636
Singapore	2.6851	1.4669	1.0774	2.0626
UK	0.9894	1.6070	1.6206	0.4717
USA	3.1194	2.6309	2.0173	1.5449
EREITs	3.2921	3.1029	2.1958	-
MREITs	1.4654	1.2900	1.0981	-
Panel B: Real Estate ⇒ Inflation				
Australia	1.6198	1.8850	1.9982	1.9240
Belgium	1.4786	1.1785	1.2199	0.4090
Canada	1.6786	0.7582	0.7540	1.0189
France	1.6083	2.7846	2.6358	0.5945
Italy	1.4419	0.7746	0.8768	1.5416
Japan	1.8103	1.8812	0.9801	1.1621
Netherlands	0.5102	0.9004	1.3916	0.4981
Singapore	3.0841	1.6338	1.1413	2.8886
UK	2.4364	1.8422	1.4552	1.6409
USA	3.6048	3.2615	2.5988	0.8849
EREITs	2.6032	2.0305	1.7509	-
MREITs	3.2412	2.7994	2.2861	-

Note: The F-statistic used to test for significance is displayed in Equation (9).

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