Time-series characteristics of UK commercial property returns: Testing for multiple changes in persistence

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The random-walk hypothesis, *vis-à-vis* asset prices, suggests that prices traded in a market cannot be predicted based on historical information. Employing unsecuritised UK commercial property returns, we analyze this hypothesis, investigating multiple changes in persistence in the series. Our results uncover multiple changes in persistence in both the aggregate and sector-specific data. We highlight some implications for academics, practitioners and regulators.

Keywords: real-estate property returns; multiple changes in persistence; fractional integration.

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1. Introduction

The last 30 years or so have experienced a strong interest from institutional investors for commercial real estate[1]. Incorporating securitised and unsecuritised real estate as part of their investment portfolios turned into common practice and the existence of indexes such as the IPD, NCREIF and the NAREIT allowed these investors to be able to use real property information giving them a clearer idea of the investment characteristics of property and relate it to other asset classes.

The interest for commercial real estate triggered numerous studies provided by academics and practitioners investigating issues such as normality, skewness, kurtosis, error-in-variables, serial correlation, market efficiency and smoothing in commercial real estate[2].

In statistical terms, property returns are assumed to follow a linear stationarity process and as stated by Bodman (1998) whether or not economic time series possess asymmetry and non-linearities is critical for the understanding, estimation, testing and forecasting of the series under investigation. Empirical evidence provided by Bond and Hwang (2007), when analysing issues such as smoothing and nonsynchronous appraisal in real estate price indexes suggests that kurtosis, skewness, non-normality, serial correlation attached to appraised commercial real estate indexes hampered the gaussian conditions of normality and stationary.

Stationary and cointegration were also investigated, for example, Myer et al. (1996) looked at the stochastic properties of the commercial real estate for three countries (US, Canada and the UK) finding all series being non-stationary and showing evidence of cointegration.

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[1] DTZ (2013), a global real estate adviser, estimates the current stock value invested globally in commercial real estate to be around USD12.4tn.

[2] A good review of commercial real estate distribution can be found in Lizieri and Ward (2000), studies such as Serrano and Hoesli (2012), Rehring and Sebastian (2011), MacGregor and Schwann (2003), Brown (2001) Lee and Ward (2000) investigate issues related to volatility, serial correlation, fractional cointegration on both securitized and unsecuritised commercial real estate indexes, returns and prices for the UK and US markets. Smoothing issues can be found, for example, on Barkham and Geltner (1994,1995), Bond and Hwang (2003), Chao, Kawaguchi and Shilling (2003) to cite a few.

Recently, Belaire-Franch and Opong (2013), investigating the behavior of UK construction and real-estate indexes by employing standard unit-root tests, show that both series are I(*1*) processes in levels. However, when they allow for nonlinear time trends, the unit-root hypothesis is clearly rejected in the case of the real-estate index. They also find evidence of serial-correlation when analyzing the indexes' returns.

Hutchison et al. (2012) investigation of regime shifts in ex post UK commercial property risk premia using structural break tests and a Markov Switching Model suggests that industrial and retail sectors exhibit regime shifting behaviour. The findings of Hutchison did not come as a surprise as Leybourne et al. (2007) state the conventional assumption of a constant order of integration for a time series is debatable and a growing body of evidence appears to suggest that few economic and financial time-series are likely to display changes in persistence, varying between difference stationary and trend-stationary regimes what might be one of the reasons behind the regime shifts for the UK commercial property market found by Hutchison et al.

To our knowledge issues related to a constant order of integration for commercial real estate returns have not been investigated and we assert, likewise the other issues cited in this paper, that this is also an important point to be disclosed as it is likely to also have consequences for the development of portfolio models, investment strategies and performance measures.

In this study, we aim to investigate whether or not the nominal time series commercial real estate returns represented by UK IPD property index plus its sectorial counterparts (Office, Industrial and Retail sectors) do in fact show multiple changes in persistence.

To achieve our aim we will be applying recent methodology developed by Leybourne et al. (2007) for detecting multiple changes in persistence on the order of integration of a time series what will help us to define the ex post features of these indices.

Testing and identification of the order of integration for time-series has become commonplace in economic time-series analyses. In part, this is because the series' trending properties determine the models and inference procedures to be employed in later stages of analyses.

Significantly though, the idea of a constant order of integration for a time-series is not uncommon, albeit controversial. Some new lines of research enquiry suggest that certain economic and financial time-series display changes in persistence, varying between difference-stationary, I(*1*), and trend-stationary, I(*0*) regimes (see Busetti and Taylor, 2004; Taylor, 2005; Harvey *et al*., 2006; Leybourne *et al*., 2007). Further, some recent studies provide empirical evidence of such behavioral shifts.[3]

Arguably, for academic, practice, and regulatory reasons such rigorous scrutiny of the time-series properties of returns on investments should be of considerable interest i.e., understanding the behaviour of asset prices over time, identification of any observed exploitable patterns, and the informational efficiency of the market respectively. Although the international importance of UK investment markets is well-documented and despite the high institutional and financial interest in commercial property, surprisingly little is known about the possibility of changes in persistence in commercial property returns.[4] With huge monies involved, an investigation of whether or not these returns present regime shifts on their level of stability is important. Not

[3] See among others, Pesaran *et al*., 2006 (US Treasury bills); Sollis, 2006 and Navarro, 2009 (the S&P composite dividend yield); and Noriega and Ramos, 2009 (US inflation rates), Leone and Ribeiro (2012).
[4] The Investment Property Databank Ltd. (IPD) Property Index estimated the sector to be worth an estimated £31.409billion in the UK (May-2013); and an estimated invested stock value of £541bn, (DTZ, 2013).

least, because it is likely to play a key role in assisting institutional investors (e.g., pension funds and insurance companies) make investment decisions regarding the level of commercial real-estate in their portfolios. Specifically, the results will help in investment decision-making to achieve a desired target in terms of returns and portfolio diversification.

In this paper, our aim is two-fold: First, identifying the likelihood of changes in persistence over time in nominal monthly returns of the Investment Property Databank Ltd (IPD) index for the UK (*All properties* and, by sector – *Office*, *Industrial* and *Retail*), and second, uncovering differences in the order of (fractional) integration across same. From this analysis we expect to be able to foresee based on the time series characteristics of these indices their potential as likely benchmarks to help investors on defining the benefits of having or not different property types on their real estate portfolios. We also discuss some implications of the multiple changes in persistence and degree of (fractional) integration. We suggest that such analyses may be harnessed for financial maneuverings, which underscores their importance. The results are not entirely surprising considering the myriad political and economic factors likely to influence the process of property valuation and, consequently, return.

The contributions of this study are threefold first it brings to the real estate economics field the multiple changes in persistence problem already reported to other economic and financial time series data, second it provides another likely feature attached to real estate indexes to the already well know issues such a non-normality, serial correlation and smoothing to cite a few, and third it adds to the literature related to the time series characteristics of commercial real estate.

The remainder of this paper is organized as follows. Section 2 summarizes the data, econometric techniques and main results. Section 3 concludes.

2. Data, econometric methods and results

2.1 Data

Our dataset, based on the IPD index i.e., *All*, *Retail*, *Office*, and *Industrial*, consists of total monthly returns, in aggregate form and by sector, for the UK commercial property market and is obtained from the IPD Bank Monthly Digest, over 1987m01-2013m05[5]. Table 1 displays preliminary information about the statistical properties of the returns.

Table1: Summary Statistics , Serial Correlation, Normality and Stationary
Sample: 1987M01 2013M05

	ALL PROPERTIES	INDUSTRIAL	OFFICE	RETAIL
Mean	0.702777	0.830629	0.647217	0.66956
Median	0.762972	0.825303	0.726543	0.727576
Maximum	3.637458	4.820795	3.810496	4.227891
Minimum	-5.267447	-4.845752	-5.305574	-5.775159
Std. Dev.	1.109469	1.094484	1.212294	1.137401
Skewness	-1.638752	-0.908383	-1.288365	-1.668848
Kurtosis	9.659496	8.098557	7.633832	10.53836
Jarque-Bera (JB)	727.659(0.000)	386.954 (0.000)	371.319(0.000)	897.731(0.000)
Q-Statisitc (36 lags)	1280 (0.000)	1142.3 (0.000)	1529.6 (0.000)	1131.4 (0.000)
KPSS Test	0.0572***	0.055628***	0.058753***	0.068851***
Sum	222.7804	263.3094	205.1679	212.2506
Sum Sq. Dev.	388.971	378.5348	464.4118	408.8034
Observations	317	317	317	317

JB test rejects the normality hypothesis at 1% level, no serial correlation also rejected at 1% level by Ljung-Box test. The critical values for the KPSS for stationarity are 1% 0.216***, 5% 0.146**, and 10% 0.119*.

Following previous studies such as Brown and Matsysiak (2000), Lizieri and Ward (2001) the aggregate and sectorial monthly returns are non-normal, serial correlated and stationary over the whole sample. Serial correlation is quite persistent and still strong after 36 lags. Over the sample period there is some significant similarity in some

[5] The IPD Monthly Index measures returns to direct investment in commercial property. It is compiled from valuation and management records for individual buildings in complete portfolios, collected direct from investors by IPD. All valuations used in the Monthly Index are conducted by qualified valuers, independent of the property owners or managers, working to RICS guidelines. The Monthly Index shows total return on capital employed in market standing investments. Standing investments are properties held from one monthly valuation to the next. The market results exclude any properties bought, sold, under development, or subject to major refurbishment in the course of the month. The monthly results are chain-linked into a continuous, time-weighted, index series (IPD, 2013).

of the statistical measures reported across the four groupings which, from the policy point of view, is interesting, and suggests co-movement. Notably, all sectors are characterized by a long left tail (*negative skewness*)[6], and leptokurtosis (*fat tails*).[7] It should be noted that a number of studies have suggested that real estate return distributions are often skewed and with relatively fat tails (Myer and Webb, 1993, 1994a; Young and Graff, 1995; Graff, Harrington, and Young, 1997; Lu and Mei, 1999; Liow and Sim, 2005; Young, Lee, and Devaney, 2006; and Young, 2008).

Table 2 shows the correlation coefficients for all indices and suggests that some benefits can be achieved by diversifying a real estate portfolio using different sectors with all correlations significant at 1% level[8].

Table 2: Correlation Matrix

Correlation t-Statistic Probability	IPD ALL	IPD INDUSTRIAL	IPD OFFICE	IPD RETAIL
IPD ALL	1.000000 ----- -----			
IPD INDUSTRIAL	0.951747 53.17642 (0.0000)	1.000000 ----- -----		
IPD OFFICE	0.962069 60.46762 (0.0000)	0.920789 40.47633 (0.0000)	1.000000 ----- -----	
IPD RETAIL	0.968703 66.91544 (0.0000)	0.886893 32.91747 (0.0000)	0.872068 30.55444 (0.0000)	1.000000 ----- -----

[6] Bond and Patel (2003) also found that a large portion of the UK property company returns does exhibit skweness

[7] The shape of the distribution of returns can vary with market conditions, e.g. when the markets suffered a major adjustment after the market crash in October 1987, this caused returns to be negatively skewed. This might also be captured by the real estate returns data on analyses especially during the recent 2007-2009 financial crisis. Positive kurtosis suggests that probabilities of obtaining extreme values are higher than implied by the normal distribution. This could be a reflection of reality of the marketplace when large market surprises may tend to induce large movements in the markets and in property values.

[8] For example the IPD monthly databank contains 3,350 properties in total embraced by 63 portfolios split between retails (1,430 properties); offices (811 properties); industrial (843 properties); other (266 properties).

Econometric methods

We adopt a three-stage approach. First, we apply standard individual and panel unit-root tests to the data. These include Levin *et al*. (2002) [LLC], Im *et al*. (2003), Maddala and Wu (1999) [MW]. LLC assume a null hypothesis of a common unit-root against the alternative of stationarity of all units; whereas the other tests allow for individual unit-roots under the alternative hypothesis (supposing a less restrictive framework since the former may be too strong). Table 2 summarizes the results of the aforementioned panel unit-root tests.[9]

Table 2: Panel unit-root tests (1987*m*01 – 2011*m*08)

Method	Statistic	Probability#
Levin, Lin and Chu	0.225	0.5892
Im, Pesaran and Shin	-4.605	0.0000
ADF - Fisher Chi-square	38.548	0.0000
PP - Fisher Chi-square	50.221	0.0000

Notes: Lag order has been determined using the Modified Akaike information criterion.
#Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Our results, based on the individual and panel unit-root tests for the whole sample suggest that the data is I(*0*). Based on only such a result, the deduction will be that the market returns are, indeed, efficient, at least on its weak form.

Second, we test for the likelihood, and order, of fractional integration (FI) in the full sample. Specifically, we compute Phillips' (1999a, 1999b) *Modified Log Periodogram Regression* estimator, which addresses a major criticism of the widely used Geweke and Porter-Hudak (1983) [GPH] estimate of the long-memory parameter, *d*.[10] Phillips proposes a modified form of the long-memory parameter, in which the dependent

[9] The standard individual unit-root tests (ADF and KPSS tests) both point to data being I(*0*). For brevity, these results are not reported here, but are available upon request.
[10] The GPH estimator is inconsistent against $d>1$ alternatives. Hence, practically, under those circumstances, distinguishing unit-root behaviour from fractional integration may be problematic.

variable is modified to reflect the distribution of d under the null hypothesis that d=1. Phillips' estimator gives rise to a test statistic for d=1, which is a standard normal variate under the null.[11] Table 3 summarizes the implications of the estimated d.

Table 3: Summary of fractional integration parameter values

d	Variance	Shock duration	Stationarity
$d=0$	Finite	Short-lived	Stationary
$0<d<0.5$	Finite	Long-lived	Stationary
$0.5\leq d<1$	Infinite	Long-lived	Nonstationary
$d=1$	Infinite	Infinite	Nonstationary
$d>1$	Infinite	Infinite	Nonstationary

Source: Tkacz (2001)

Applying the less restrictive FI approach, our results provide evidence that, in each case, the null hypothesis of d=0 and d=1 can be rejected, and that the I(d) classification is more appropriate.[12] On the one hand, such a result proves interesting for the academic; and implies some predictability in returns, and hence some scope for exploitable profits for the investor/practitioner. On the other hand, this may pose problems for regulators concerned with informational efficiency within the markets.

Third, we apply a test proposed by Leybourne *et al*. (2007) [LKT] which determines changes in the order of integration of a time series and allows for the consistent estimation of the change dates. Being robust to the presence of (multiple) level breaks, the procedure has advantages over similar tests proposed by Harvey *et al*. (2006) and Leybourne *et al*. (2006), which are inconsistent against processes which display multiple changes in persistence. The data generation process (DGP) consists of the following time-varying AR(p):

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[11] Phillips suggests removal of the deterministic trends from the series before application of the estimator. The test is performed using the STATA 'modlpr' command. See Phillips (1999a, 1999b) for a more detailed description.

[12] Reported in column 3, Table 4.

$$y_t = d_t + u_t \quad (1)$$

Where y_t is the returns, $d_t = z'_t \beta$ being the deterministic component. In Equation 2, u_t is taken to be a time-varying AR(p) process, which can be rewritten as $u_t = \rho_i u_{t-1} + \sum_{j=1}^{k_i} \vartheta_{ij} \Delta u_{t-j} + \varepsilon_t, \quad t = 1,2,\dots,T$, where $k_i = p_i - 1$, $i = 1,\dots,m+1$, and m is the number of changes in persistence. LKT allow for two alternatives (i) $z_t = 1$ and $\beta = \beta_0$, the (possibly non-constant) level of returns, and (ii) $z_t = [1, t]$ and $\beta = [\beta_0, \beta_1]'$, and ε_t is a martingale difference sequence. There are two hypotheses: the null, H_0: $y_t \sim I(1)$ throughout, that is, $\rho_i = 1 \forall t$, versus the alternative, H_1: y_t undergoes one or more regime shifts between I(1) and I(0) behavior. The test statistic proposed by LKT is based on doubly-recursive sequences of DF type unit root statistics:

$$M = \inf_{\lambda \in (0,1)} \inf_{\tau \in (\lambda,1)} DF_G(\lambda, \tau) \quad (2)$$

The corresponding estimators are $(\hat{\lambda}, \hat{\tau}) \equiv \arg \inf_{\lambda \in (0,1)} \inf_{\tau \in (\lambda,1)} DF_G(\lambda, \tau)$ give the start and end points, i.e. the interval $[\hat{\lambda}, \hat{\tau}]$, of the first $I(0)$ regime over the whole sample. Any further $I(0)$ regimes are then detected sequentially by applying the M statistic to each of the resulting subintervals $[0, \hat{\lambda}]$ and $[\hat{\tau}, 1]$. We continue in this fashion for all temporal dimensions exceeding 20 observations, which is the minimum for which LKT (p.13) report finite sample critical values until, for each period considered, the 'most prominent' $I(0)$ regime, together with their start and end points, have been identified.[13]

Identifying these multiple breaks in trending behavior further underscores the importance of employing appropriate and less restrictive methods when testing and

[13] We note that the period between the end point of one $I(0)$ regime and the start point of the next $I(0)$ regime must represent an $I(1)$ regime. See Table 4.

identifying the order of integration of time-series in empirical work.[14] Figure 1 presents the results graphically, where a horizontal line indicates the I(*0*) period as identified by the *M*-test. Despite significant similarities across sectors, some heterogeneity in dynamics is observed which the standard unit-roots tests are incapable of uncovering, but is informative for academics, practitioners and regulators alike.

Table 4: Results of the LKT test [no trend]

Series	Sample	d^a	Sample size	k (lags)	M	I(*0*) start	I(*0*) end
All	*1987m01-2011m08*	$0.5168^{*,+}$ (0.1511)	296	4	-5.033	*1993m08*	*2003m05*
	1987m01-1993m07		79	0	-2.538	*1989m12*	*1992m09*
	2003m06-2011m08		99	4	-7.523	*2009m08*	*2011m08*
	2003m06-2009m07		74	0	-5.079	*2004m03*	*2006m07*
Retail	*1987m01-2011m08*	$0.4998^{*,+}$ (0.1413)	296	4	-6.043	*1993m08*	*2003m08*
	1987m01-1993m07		79	0	-3.383	*1987m07*	*1988m12*
	2003m09-2011m08		96	4	-6.872	*2009m08*	*2011m04*
	2003m09-2009m09		71	0	-5.530	*2003m09*	*2006m07*
Office	*1987m01-2011m08*	$0.5250^{*,+}$ (0.1519)	296	3	-4.632	*1993m06*	*2008m03*
	1987m01-1993m05		77	3	-4.289	*1991m08*	*1993m01*
	1987m01-1999m06		55	0	-3.695	*1987m07*	*1989m07*
Industrial	*1987m01-2011m08*	$0.5544^{*,+}$ (0.1556)	296	3	-4.096	*1989m11*	*2011m08*

Notes: ^{a} d estimated and reported for full sample, and for power = 0.6, i.e., for sample size of 296, ordinates = 30. * and $^+$ imply rejection of the null of d=0 and d=1 respectively. Values in parenthesis are the standard errors for estimated d.

3. Summary and Conclusions

Aiming to contribute to the literature analyzing multiple changes in order of integration relating to assets management, we analyze monthly returns for UK three commercial property sectors, and a composite group. Our evidence suggests that assumption of a knife-edge I(*0*)/I(*1*) process may be sub-optimal and there is no clear aggregation effect.

Three main conclusions emerge: From the academic perspective, the standard methods that assume a constant order of integration over time, *a priori*, may be

[14] We also perform the LKT tests, with a linear. The results are similar to the estimations without a linear trend. For parsimony and due to the similarities to dates reported, these estimates are not reported here, but are available upon request.

inappropriate. For practice, the astute investor can decipher exploitable patterns based on which policies apply and, lastly, for regulatory reasons, informational efficiency of the real-estate market can be deemed highly questionable.

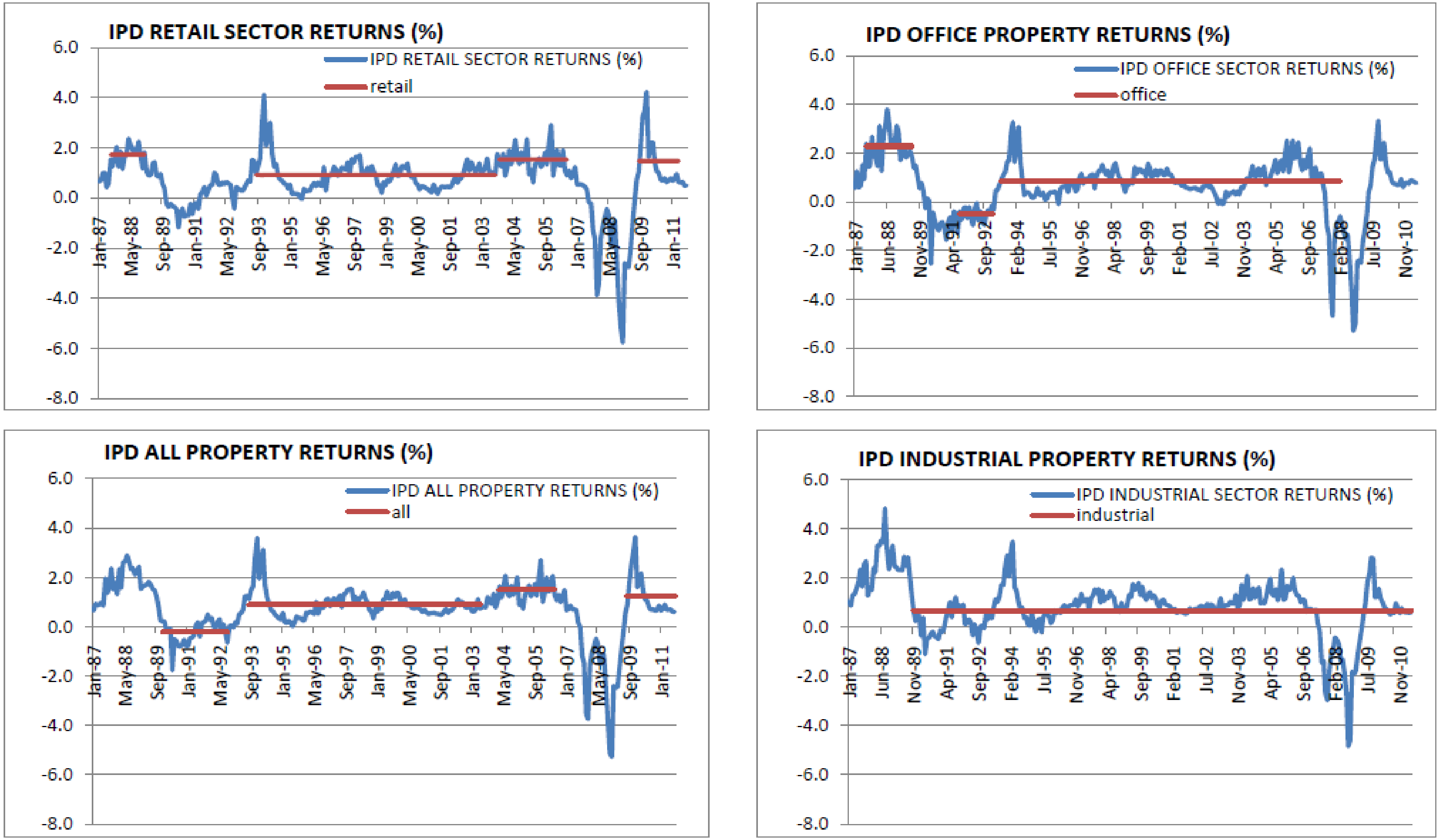

Figure 1: Results of LKT test across IPD UK commercial properties sectors, 1987m1-2011m8.

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