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Risk and Return Characteristics of Commercial Real Estate Returns

Evidence from the U.K., the U.S., and Germany and Implications for the Asset Allocation

by

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Abstract:

Past research suggests that international real estate markets show return characteristics and interrelationships with other asset classes which probably qualify them as an interesting component in national and international asset allocation decisions. However, the special characteristics of real estate assets are quite distinct form that of financial assets like stocks and bonds. This is also the case for real estate return distributions. Therefore, proper integration of real estate markets in asset allocation decisions requires profound knowledge of the distributional characteristics of real estate returns.

Also caused by the special characteristics of real estate, representing real estate markets through reliable time-series is a complex task. Consequently reliable real estate indices with a sufficient long history for major international real estate markets are poorly available. Most of the research on real estate returns was done for the U.K. and U.S., where eligible indices exist. However, other important real estate markets like Germany are only poorly covered by research.

In this analysis the methodology of Maurer, Sebastian and Stephan (2000) for indirectly deriving an appraisal based index for the German commercial real estate market is applied. This approach is based solely on publicly available data from German open-ended real estate investment trusts. It could also provide a solution in deriving reliable real estate time-series for other countries.

We extend previous analyses for the U.K. and U.S. and provide additional fundamental insights into the return characteristics of the German commercial real estate market. Despite univariate considerations, the main focus is on interrelationships between different international real estate markets and between these markets and international stock and bond markets.

1 Introduction

International financial market crisis in recent years increased the interest in another important asset class: real estate. As past research suggests, real estate return characteristics are significantly different from that of other major asset classes.[1] There is also evidence for real estate returns to show low co-movements with alternative asset classes and with other real estate markets. A review in *Fletcher* (1995) of studies using the CREF data indicates low correlations between commercial real estate and stocks/bonds on the U.S. national level. *Stevenson* (2000) Using hedged indices found very low return-correlations considering international real estate markets. Therefore real estate could be an interesting factor in institutional investor's national and especially international asset allocation decisions.

Proper integration of real estate markets in the asset allocation process requires knowledge of the distributional characteristics of real estate returns. Considering aggregated level real estate returns, especially the U.S. and the U.K. real estate markets were subjected of several studies. Unfortunately only relatively few research covers other major international real estate markets. This is mainly due to the poor availability of adequate time-series. While particularly for the U.K. and U.S. suitable real estate time-series with a reasonable history exist, this is mostly not the case for other important international real estate markets like Germany.

This study extends previous research and provides further useful insight into the distributional characteristics and interrelationships of U.K., U.S. and also German commercial real estate markets, relative to each other and relative to other asset classes. For representing the German real estate market, an index based on the methodology of *Maurer, Sebastian* and *Stephan* (2000), which is closely related to more costly real estate indices like the IPD or NPI is applied. The index is from a quasi appraisal based type but it is founded, in contrast to other major appraisal based indices, only on publicly available information. The index methodology could also provide a solution in generating reliable real estate time-series for other countries.

This paper is organized as follows: Section 2 gives a general overview of major approaches in representing real estate market performance through real estate indices. The major appraisal based indices for the U.K. and the U.S. commercial real estate markets are discussed in detail. Finally an alternative methodology for generating an appraisal based real estate index founded only on publicly available information for Germany is provided. Section 3 contains univariate and multivariate analysis of statistical properties of commercial real estate market's return distributions in the U.K., U.S. and Germany. Finally, Section 4 contains a summery and the main conclusions.

2 Representing Real Estate Market Returns

2.1 Real Estate Market Proxies

Generally, index construction for asset markets is as follows: after specifying the relevant market and selecting a representative sample of assets from this market, that proxies the performance of the entire market, next step is to choose the appropriate index weights for the selected assets; the final step is to calculate index values or returns for the index from actual

[1] A recent extensive and systematic review of literature concerning directly or indirectly real estate return properties is provided by *Benjamin*, *Sirmans* and *Zietz* (2001), which updates older reviews by *Norman*, *Sirmans* and *Benjamin* (1995) and *Sirmans* and *Sirmans* (1995).

values of the sample assets at different equidistant points in time. In contrast to stock and bond markets several problems occur, considering index construction for real estate markets. The difficulties arise from a couple of special characteristics of properties. The uniqueness of each property and the so induced inhomogeneity of real estate markets cause problems in selecting a representative sample of the underlying market (risk of market tracking error), if this is even possible. Transactions for single properties occur mostly infrequently, transaction prices do not necessarily represent actual values and transaction data is often not publicly available. This causes problems in deriving the true values of the sample properties at the desired points in time. In any case, representing real estate markets through indices is by far less accurate then proxying stock and bond markets performance.

To avoid some of these problems several ways in deriving real estate market indices indirectly from publicly available property-depended time-series are discussed in the literature. *Burns* and *Epley* (1982), *Chan* et al. (1987), and *Fisher*, *Geltner* and *Webb* (1994) among others consider unadjusted or leverage adjusted real estate company (REIT) performance as possible proxy for direct real estate market performance. *Gilberto* (1990), *Liang* and *Webb* (1996) and *Stevenson* (2000) use hedged indices derived from real estate securities to asses the relevance of real estate markets in national and international asset allocation, relying on capital market theory. The use of publicly available data diminishes the problem of poor data availability on actual properties. However all these approaches have in common, that they proof as good proxies for real estate market performance only if strong assumptions are satisfied. Furthermore, despite other problems, they do not necessarily accurately represent the relevant real estate market under investigation. Despite the problems of these real estate market proxies, they can provide a useful mean in assessing questions related with performance of broad real estate markets, when more elaborate indices are not available.

A more direct and also more costly way to construct real estate indices is the use of transaction or appraisal based real estate data on actual properties. Transaction-based indices suffer from the problem of infrequent transactions of single properties and the poor availability of such data for many countries. In each period only the sold properties can contribute to the index performance, i.e. the index portfolio varies over time. In combination with the inhomogeneity of real estate markets, this is a serious problem. The hedonic method, which is based on a hypothetical constant quality index portfolio, avoids this problem, but the application requires additional data and assumptions. Due to the lack of available data, transaction-based indices have their main application more for small submarkets.

To cover a broad segment of a real estate market through a direct real estate index, the application of appraisal based indices proofed useful. The calculation of such indices is based, on a fixed sample of properties, i.e. a constant quality index portfolio. The sample properties are regularly appraised. Due to the strong inhomogeneity of a broad real estate market a large index portfolio, comprising a great portion of all properties is required. Additionally, the appraisal of single properties is a difficult and expensive task, so that appraisal based indices are usually calculated using properties that have to be regularly appraised due to legal requirements, e.g. the properties held by institutional investors. The restriction of sample selection to such properties itself causes the problem of market tracking error. But if the sample is relatively large in comparison to the total market under consideration this problem becomes less important. In any case a large sample size for the index-portfolio is preferable, because this increases the likelihood that the index does not represent the specific risk of some single properties but the systematic risk of the observed real estate market as a whole.[2]

[2] For the issue of specific risk depended on the sample size for real estate indices, see *Ball*, *Lizieri* and *MacGregor* (1998, p. 294f).

The suitability of direct applications of appraisal based indices as proxies for actual property performance has received much attention in the literature. *Blundell* and *Ward* (1987), *Ross* and *Zisler* (1991), *Geltner* (1993), *Fisher*, *Geltner* and *Webb* (1993), *Barkham* and *Geltner* (1994) and *Brown* and *Matysiak* (1998) among others suggest that appraisal based real estate indices have to be corrected for the so called "smoothing issue", to reflect actual real estate market performance. For this purpose they provide different methodologies based on several assumptions about the appraisal process, index construction process, and market (in)efficiency.[3]

The remainder of this paper focuses primarily on appraisal based indices for assessing real estate markets' financial characteristics.

2.2 Appraisal based Indices for the U.K., U.S., and Germany

U.K. Appraisal Based Property Indices

Beside some smaller indices, the major appraisal-based indices for the U.K. commercial real estate market (i.e. Industrial, Office, and Retail properties) are provide by the real estate advisors *Jones Lang LaSalle*, *Hillier Parker*, *Richard Ellis* and the independed organization *Investment Property Databank* (IPD).[4] IPD collects data from many institutional investors in the U.K. and its database is by far the largest of all providers. The main appraisal-based index from IPD is the IPD annual index, which at the end of 2001 comprised 236 complete real estate portfolios with 11,900 properties in the U.K. worth € 162.2 bn. This accounts for about 75% of all U.K. institutional investor's real estate investments. The index is a value weighted total return index of directly held unleveraged properties with a base of 100 at December 31, 1980. In December 2001, IPD switched their index methodology for the calculation of the annual total returns to chain linking time-weighted monthly returns. Before that the annual returns were calculated as year-on-year money-weighted returns, due to the poor availability of monthly data.[5]

The methodology change for the annual index now provides consistency to the IPD monthly index. The monthly index is based on a few complete portfolios of property unit trusts, pooled pension schemes and unit-linked insurance funds. It accounts for about 10% of the capital value of the annual index. The index-portfolio structure differs from that of the annual index, in that the monthly index contains a smaller portion of high value properties. Like the annual index, the IPD monthly index is an unleveraged total return index. Capital growth and income return indices as well as sectoral and geographical subindices are also provided by IPD.

U.S. Appraisal Based Property Indices

The predominate appraisal based indices for commercial real estate in the U.S. (i.e. Apartment, Industrial, Office, and Retail properties) are provided by the *National Council of Real Estate Investment Fiduciaries* (NCREIF) an organization set up in 1982 by several investment managers. NCREIF collects data on commercial properties held for institutional

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[3] For a critical view regarding correcting for appraisal smoothing see *Lai* and *Wang* (1998). However, it should also be mentioned, that *Geltner* (1999) points out that this study could be seriously misleading due to certain errors of application and interpretation.

[4] For a survey, see *Morrell* (1991).

[5] For more details, see IPD (2001).

investors by the members of NCREIF in a combination of open-end funds, closed-end funds and separate accounts. The main appraisal based index from NCREIF is the NPI (formerly the Russell/NCREIF Property Index). At the end of 2nd Quarter 2002 the NPI comprised 3880 investment grade properties appraised at $125.38 bn. The index is an unleveraged value weighted total return index on a quarterly basis set to 100 at the fourth quarter of 1977. NCREIF also calculates an income return and capital return subindex. Subindices for property type (Apartment, Industrial, Office, and Retail properties) and geographical area (West, Mid-west, East, and South) are also available.[6] As the underlying properties are in general only appraised once a year, the NPI is more an annual index partly updated quarterly.

German Appraisal Based Property Indices

In contrast to the U.K. and the U.S., for the German commercial real estate market (i.e. Apartment, Office, and Retail properties) there is no broad diversified index with a satisfying long history available. Beside some smaller providers, in 1998 the *Deutsche Immobilien Datenbank GmbH* (DID) was founded.[7] DID collects data mainly form insurance companies and open-ended real estate investment funds. The main commercial property index of DID is the Deutscher Immobilien Index (DIX), a money-weighted total return index on year-on-year basis. According to DID, at the End of 2001 the DIX comprised 2,754 properties (Apartment, Retail and Office) with an appraised value of about € 36 bn covering about 30% of the total institutional real estate market in Germany. The major drawback of the DIX is its relatively short index history, going back only to 1996 on an annual basis.

An alternative and indirect approach in deriving an appraisal based real estate index for Germany, using exclusively publicly available information from German open-ended real estate investment funds, was suggested by *Maurer* and *Stephan* (1995) and updated by *Maurer*, *Sebastian* and *Stephan* (2000). German open-ended real estate investment funds are a main group of institutional investors on the German real estate market for retail and office properties. Due to legal requirements, these funds have to invest a large fraction of the total wealth they hold in trust in real estate. However, normally they hold also considerable portions of interest bearing assets like deposits and bonds in their portfolios. The funds have to publish redemption prices for their shares and aggregated information about the composition of their wealth on a regular basis.[8]

The redemption price of shares from such a company represents the sum of the appraised value of the real estate assets and the market values of the other assets in the company's portfolio divided by the number of shares. *Maurer*, *Sebastian* and *Stephan* (2000) suggest an adjustment of the redemption-price returns on real estate investment funds for the portion of returns that are non-real estate induced to arrive at an unleveraged appraisal based real estate total return index:

Dependent on the remaining time to maturity, three classes of interest-bearing assets are defined: money market deposits (Money), interest bearing assets with at most (A1) and more than (A2) four years remaining time to maturity. Assuming that the returns on the predefined interest bearing asset classes, $r_{i,t}^{Money}$, $r_{i,t}^{A1}$, and $r_{i,t}^{A2}$, are the same as the returns on the corre-

[6] For more details see *Pagliari et. al.* (1998).

[7] One of the three owners of the DID is the U.K. Investment Property Databank (IPD).

[8] See also *Maurer* and *Sebastian* (2002) for institutional details of German open-end real estate investment funds.

sponding complete money and capital market segments with the same remaining time to maturity, the appraisal based total real estate return of company *i*, can be approximated by

$$r_{i,t}^{real\ estate} = \frac{(r_{i,t}^{funds} - r_t^{Money} \cdot x_{i,t}^{Money} - r_t^{A1} \cdot x_{i,t}^{A1} - r_t^{A2} \cdot x_{i,t}^{A2})}{x_{i,t-1}^{real\ estate}}, \qquad \textbf{(1)}$$

where $x_{i,t}^{Money}$, $x_{i,t}^{A1}$, and $x_{i,t}^{A2}$ represent the proportion of total wealth of company *i* invested in the different classes of interest-bearing assets. Through the value weighted aggregation of the calculated appraisal based returns over all companies under consideration one arrives at the total return, $r_t^{real\ estate}$ of a broad appraisal based commercial real estate index:

$$r_t^{real\ estate} = \frac{\sum_{i=1}^{N}(r_{i,t}^{real\ estate} \cdot L_{i,t-1})}{\sum_{i=1}^{N} L_{i,t-1}}, \qquad \textbf{(2)}$$

where $L_{i,t-1}$ is the fraction of the aggregated appraisal based real estate wealth of all companies under consideration, held by company *i* at time *t*-1.

Through the application of this methodology *Maurer*, *Sebastian* and *Stephan* (2000) generated an (unleveraged) appraisal based real estate total return index for Germany on monthly basis, the IMMEX. The IMMEX covers a time period from January 1980 till today. As the NPI, the IMMEX represents an annual index partly updated monthly. Table 1 provides an overview of annual appraisal based returns on commercial real estate markets in different countries.

Table 1: Appraisal Based Annual Real Estate Returns

Country	Index	1998	1999	2000	2001
Ireland	(IPD/SCS)	38.2	31.1	27.9	8.3
Sweden	(SFI/IPD)	14.4	17.6	22.1	4.8
U.K.	(IPD)	11.8	14.5	10.4	6.7
South Africa	(SAPIX/IPD)	5.2	12.0	11.3	10.5
Netherlands	(ROX/IPD)	13.4	15.8	16.6	11.4
France	(IPD France)	4.7	13.6	14.3	9.6
Denmark	(DEI/IPD)	-	-	9.9	11.6
U.S.	(NPI)	16.2	11.4	12.2	7.3
Germany	(DIX)	4.9	5.0	5.7	5.9
Germany	(IMMEX)	3.6	4.3	5.9	5.1

Source: IPD Index Reports, NCREIF, IMMEX.

It is obvious that the annual real estate returns for the considered countries are very different in their magnitude and trend. While the yearly real estate returns for most countries are on average of high magnitude and exhibit high volatility, the German real estate returns are of persistent low magnitude and low volatility. Additionally there are no big differences between magnitude and trend of the IMMEX and the more comprehensive DIX. The slight differences between the DIX and the IMMEX can be probably traced back to the different real estate portfolios that the indices cover.

The major drawback of the IMMEX is that no distinction between the different investment sectors (Apartment, Office, and Retail properties) or local markets is possible. As the German real estate investment funds essentially hold commercial properties, the index can be regarded as a representation of and investment in German commercial properties.[9] But despite these imperfections, up till today the IMMEX is the only broad commercial real estate index with a sufficient long history available for Germany.

3 Empirical Analyses

3.1 Data

For the analyses in the remainder of this paper, the following time-series, covering the time period January 1987 till March 2002, were used. As representative for the respective stock and bond markets the MSCI Monthly Gross Indices and the Salmon Brothers Government Bond Indices, respectively, were used. As proxy for the U.K., U.S., and German real estate market the IPD monthly index, NPI, and IMMEX, as described in the previous section, were employed. The main focus is on discrete quarterly and yearly returns, which were calculated from the respective index time-series. For purposes of analyzing real returns, inflation rates were discretely calculated from the respective national consumer price indices.

3.2 Univariate Considerations

3.2.1 Analysis of Nominal Returns

Exhibit 1 shows the quarterly nominal return time-series for the U.K., U.S., and German stock, bond, and real estate market proxies. As expected, the stock markets exhibit higher return fluctuations then the bond and real estate markets. The real estate market return fluctuations are about in the same range than those of the bond markets, but the former are much smoother. Comparing the three real estate markets, it is obvious that the German market shows the lowest return fluctuations.

Exhibit 2 shows the respective real estate series on their individual scales. Most striking is that there appears to be a somewhat similar run of the return curves for the U.K. and U.S. real estate markets while the German real estate series tends to show an antidromic run regarding the other real estate markets, indicating negative return interdependencies.

Some fundamental descriptive statistics of the considered markets on quarterly and yearly basis are set out in Table 2. Considering quarterly returns (Panel A) it is obvious that, in the time period under consideration, for each country, the mean returns and standard-deviations from the stock markets were always by far higher than those from the corresponding bond and real estate markets. The mean returns from the real estate markets were, for all countries, about or a bit lower then that from the corresponding bond markets. However the standard-deviations from these real estate time-series were by far smaller than those found for the bond markets.

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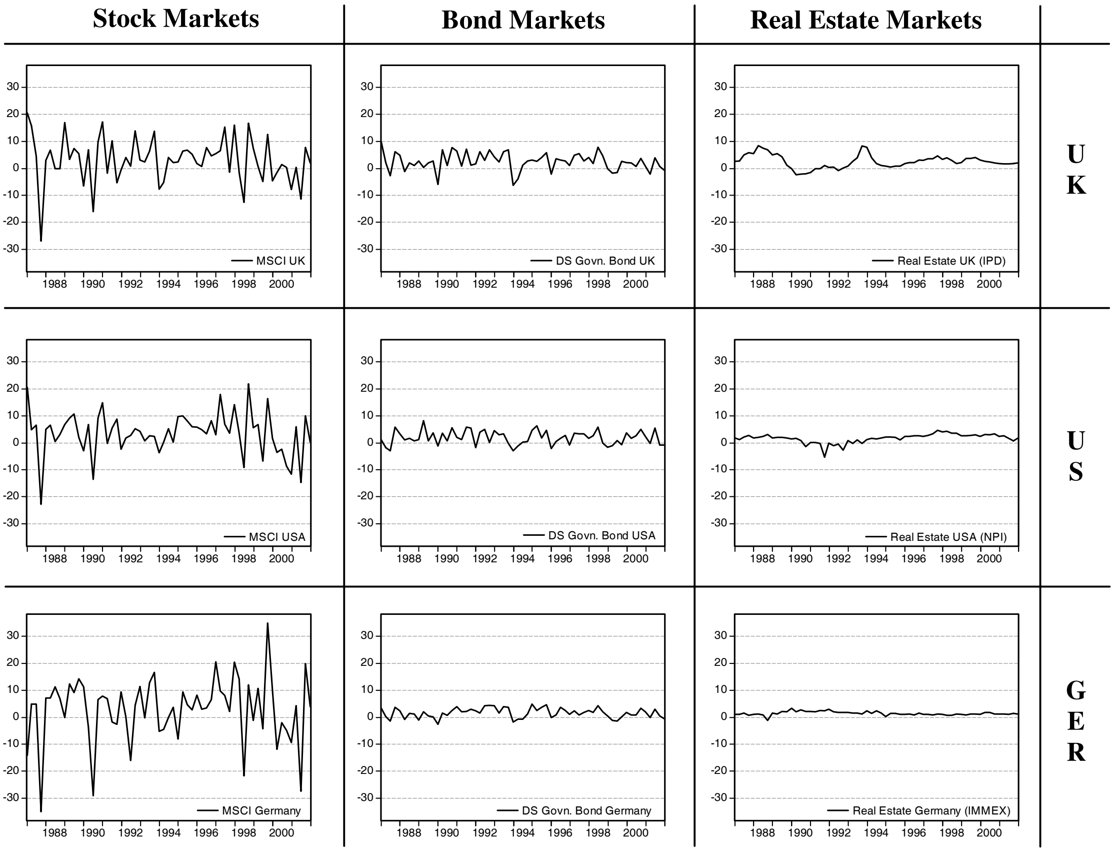
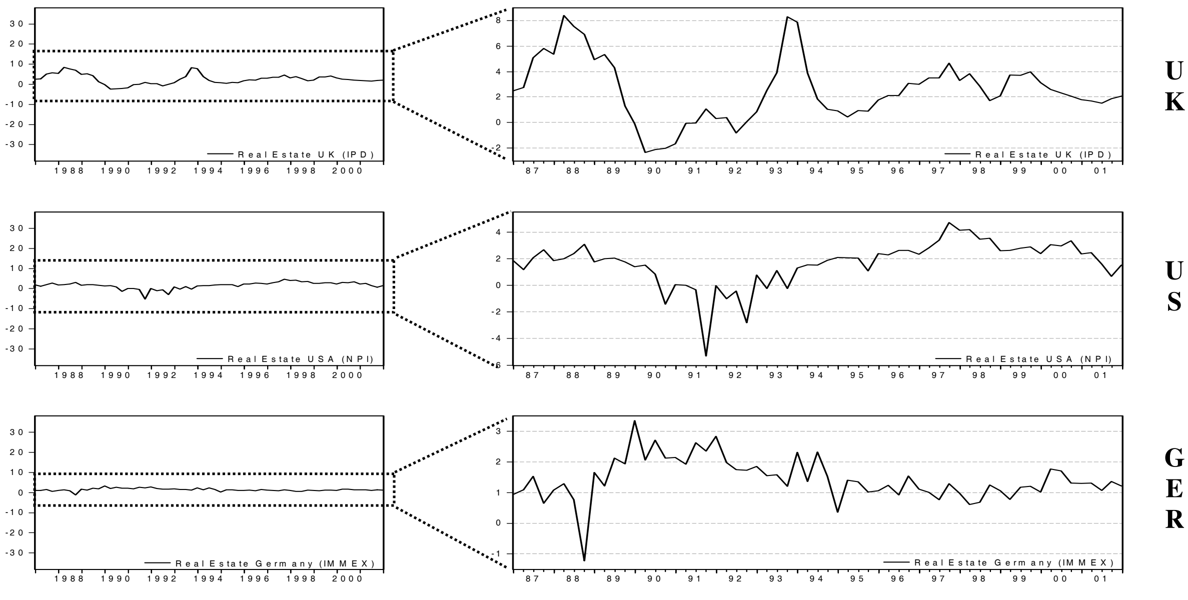
[9] One further approximation of the IMMEX should be mentioned. The portion of non-domestic real estate asset holdings of German open ended real estate investment funds is continuously increasing in the last years. So for the more recent years the IMMEX returns are slightly diluted by foreign real estate returns. Currently the authors are working on a revision of the IMMEX to account for the problem of foreign real estate asset holdings in the portfolios of German open ended real estate investment funds, to provide a revised IMMEX, covering purely German real estate.

Exhibit 1: Quarterly Nominal Returns on U.K., U.S., and German Stock, Bond, and Real Estate Markets (I/1987 - I/2002).



Notes: For purposes of comparability all graphs have the same scaling (percent per three months).

Exhibit 2: Quarterly Nominal Returns on U.K., U.S., and German Real Estate Markets on Individual Scales (I/1987 - I/2002).



Notes: The scaling for the graphs on the left is the scale of the German stock market. The graphs on the right are on the individual scales of the respective real estate markets (percent per three months).

Interestingly, there are also considerable differences regarding mean returns and standard deviations from the different real estate markets. Like in the case of bonds the U.K. real estate market exhibits a substantial higher mean return and standard deviation than the U.S. and German markets. While the German and U.S. real estate markets show about the same mean returns, German real estate has by far the lowest standard deviation.

Table 2: Selected Descriptive Statistics on U.K., U.S., and Germany Stock, Bond, and Real Estate Market (Nominal) Returns.

	Stock Markets			Bond Markets			Real Estate Markets		
	U.K.	**U.S.**	**GER**	**U.K.**	**U.S.**	**GER**	**U.K.**	**U.S.**	**GER**
Panel A: Quarterly Nominal Returns (I/1987 - I/2002)									
Mean	3.10	3.55	2.86	2.47	1.89	1.61	2.53	1.67	1.43
Stdev.	8.58	8.04	12.12	3.28	2.59	1.79	2.44	1.67	0.69
CV	2.76	2.26	4.24	1.33	1.37	1.12	0.97	1.00	0.48
Width	47.44	44.70	69.78	16.04	11.17	7.32	10.72	10.04	4.57
Panel B: Yearly Nominal Returns (1987 - 2001)									
Mean	12.37	14.98	11.76	10.51	7.99	6.81	10.78	6.97	5.88
Stdev.	14.56	16.85	27.01	7.95	6.30	5.60	9.28	6.20	2.40
CV	1.18	1.12	2.30	0.76	0.79	0.82	0.86	0.89	0.41
Width	48.38	50.72	84.62	27.67	21.83	18.36	37.75	21.83	8.74
Panel C: Standard Deviation Ratio									
SDR	1.70	2.10	2.23	2.42	2.43	3.13	3.80	3.71	3.48

Notes: Mean, Stdev., CV, and Width are the arithmetic mean (in %), the empirical standard deviation (in %), the empirical absolute difference between maximum and minimum return (in % points), and the empirical coefficient of variation for the respective nominal return time-series. SDR is the ratio between the yearly and quarterly return standard deviations.

Shifting to yearly returns (Panel B) the relationships between the stock, bond, and real estate markets' mean returns are hardly altered. Again the stock markets show by far higher mean returns than the corresponding bond and real estate markets. While the means from the real estate markets are about or a bit lower than that from the corresponding bond markets. However, while the standard deviations from the stock markets are still considerably higher than those from the corresponding bond markets, the standard deviation from the yearly U.K. and U.S. real estate series are higher or about those from the corresponding bond markets. The exception is the German real estate series, which still shows considerably lower volatility than the German bond market.

To have a closer look at this phenomenon Panel C shows the standard deviation ratios (SDR, yearly standard deviation divided by quarterly standard deviation) for the respective series. Considering iid observations, the empirical SDR between yearly and quarterly observation should be about the approximate theoretical value 2.[10] This is true for all stock markets, and the U.K. and U.S. Bond Market. On the other hand all real estate series and the German bond market show SDRs which are considerably higher than 2, indicating violations

[10] To see the relationship between quarterly and yearly standard deviation for discrete iid-returns, let R_4 be the random discrete quarterly return of some period. Then the yearly return $R_1 = (1+R_4)^4 - 1$ which is equivalent to $R_1 = 4 \cdot R_4 + 6 \cdot R_4^2 + 4 \cdot R_4^3 + R_4^4$. So R_1 is approximately equal to $4 \cdot R_4$ and, if quarterly returns are iid, $\sigma(R_1) \approx \sqrt{4} \cdot \sigma(R_4)$. Equivalently $\sigma(R_1)/\sigma(R_4) \approx 2$. For log-returns $\sigma(R_1)/\sigma(R_4) = 2$ holds exactly.

of the iid assumption. Assuming non-time-varying variances this findings indicate positive autocorrelation for these series.[11]

In Table 3 further distributional statistics and test for the quarterly time-series are tabulated. Considering skewness and excess-kurtosis of the different quarterly series there are tendencies for all observed stock markets to be significantly leftward skewed and leptokurtic. The skewness and excess-kurtosis for the considered bond markets are not significantly different from zero at the 5%-level. The picture for the real estate markets is mixed. Whereas the U.S. real estate market is significantly leftward skewed and considerably leptokurtic, the German real estate market does not show much skewness but it is significantly leptokurtic. U.K. real estate shows neither significant excess-kurtosis nor significant skewness.

Table 3: Distributional Statistics and Tests for Quarterly Nominal U.K., U.S., and German Real Estate, Bond, and Stock Markets Returns (I/1987 - I/2002).

		Stock Markets			Bond Markets			Real Estate Markets		
		U.K.	**U.S.**	**GER**	**U.K.**	**U.S.**	**GER**	**U.K.**	**U.S.**	**GER**
Skewness		**-0.639**	**-0.616**	**-0.846**	-0.409	0.156	-0.215	0.413	**-1.596**	-0.285
Kurtosis		**1.700**	**1.709**	**1.984**	0.421	-0.695	-0.655	0.284	**4.621**	**3.343**
Normality		*	*	*	-	-	-	-	*	*
AC	**1**	-0.09	-0.09	-0.07	0.00	0.01	0.27	**0.86**	**0.69**	**0.46**
Lag	**2**	-0.14	0.08	-0.08	-0.09	-0.04	0.02	**0.64**	**0.71**	**0.49**
	3	-0.01	0.06	0.04	0.12	-0.02	0.17	**0.40**	**0.60**	**0.36**
	4	-0.07	0.01	0.01	-0.07	-0.11	-0.12	0.17	**0.71**	**0.37**
Q(4)		2.057	1.177	0.838	1.817	0.936	7.853	86.04	120.6	46.82
p		(0.73)	(0.88)	(0.93)	(0.77)	(0.92)	(0.10)	(0.00)	(0.00)	(0.00)

Stationarity Tests for the Respective Real Estate Market Returns

	U.K.		U.S.		GER	
ADF / (p)	-2.878	(0.18)	-1.773	(0.71)	-2.834	(0.19)
KPSS / (5%)	0.09	(0.15)	0.14	(0.15)	0.13	(0.15)

Notes: Kurtosis denotes the empirical excess kurtosis. For testing the normality assumption for the respective series, a *Jarque/Bera*, *Anderson/Darling*, and *Shapiro/Wilk* test was applied. A "*" indicates that at least one of the 3 test was able to reject the null of normality at least at the 5%-level. AC 1-4 is the empirical auto correlation coefficients for lag 1, 2, 3, and 4. Q(4) denotes the *Box/Lijung* Q-test-statistic up to lag 4, ADF the test statistic from the (augmented) *Dickey/Fuller* test for the null of non-(trend)stationarity of the underlying time-series. p is the respective marginal significance level. KPSS is the test statistic from the *Kwiatkowski/Phillips/Schmidt/Shin* test with the null of (trend)stationarity, and 5% is the critical value of the KPSS test for a significance level of 5% (a value of the test statistic greater than this critical value indicates a rejection of the null at the 5% level). Statistics, different from zero at least at the 5%-level are printed in bold types.

Central for the application of modern capital market theory is the assumption of normally distributed returns. Three normality tests were applied: the *Jarque/Bera*-test, the *Anderson/Darling*-test, and the *Shapiro/Wilk*-test. In Table 3 the series, where at least one of these tests was able to reject the null of normality at least at the 5%-level are signed with a "*". While none of the stock markets and the U.S. and German real estate market showed normality, the null of normality could not be rejected for all bond and the U.K. real estate market.

[11] Estimating yearly variance through multiply quarterly variance by 2 fails in the presence of autocorrelation and so for the real estate series. *Newell* and *MacFarlane* (1995) and *Newell* and *Webb* (1996) show an approach to obtain an approximately correct estimate for yearly variance from quarterly variance estimates in the presence of autocorrelation.

However due to apparent autocorrelation the inferences about skewness, excess kurtosis, and normality for the real estate series should be interpreted cautiously. Consistent to the weak form market efficiency the various bond and stock markets do not exhibit significant autocorrelation. However there is significant and persistent positive autocorrelation observable for all considered real estate markets. This is also confirmed by the applied *Box/Lijung* Q-test through which the rejection of the null of no autocorrelation up to lag 4 could be rejected for all real estate series a minimum significance level. A rejection of this hypothesis for the bond and stock markets was not possible at reasonable levels of significance.

For further analysis, two unit root tests for testing whether the series are (trend) stationary were applied. An (augmented) *Dickey/Fuller* (ADF)-test, with the null that the series under consideration has a unit root (is not trend stationary), and a *Kwiatkowski/Phillips/Schmidt/Shin* (KPSS)-test, with the null that the series under consideration has no unit root (is trend stationary). The applied unit root tests were neither able to reject the null of nonstationarity nor to reject the null of stationarity at reasonable significance levels.

Considering again yearly returns, it is obvious from Table 4 that none of the series shows significant skewness or excess-kurtosis anymore. For all series these moments are much nearer at zero then it was the case for the corresponding quarterly series.

Table 4: Distributional Statistics and Tests for Yearly Nominal U.K., U.S., and German Real Estate, Bond, and Stock Markets Returns (1987 - 2001).

		Stock Markets			Bond Markets			Real Estate Markets		
		U.K.	**U.S.**	**GER**	**U.K.**	**U.S.**	**GER**	**U.K.**	**U.S.**	**GER**
Skewness		-0.310	-0.281	-0.231	-0.661	-0.338	0.033	0.120	-0.776	0.507
Kurtosis		-0.860	-1.214	-1.096	-0.112	-0.412	-0.749	0.766	0.181	-0.338
Normality		-	-	-	-	-	-	-	-	-
AC Lag	**1**	-0.18	0.12	-0.15	-0.26	**-0.53**	-0.21	0.35	**0.78**	**0.53**
	2	0.03	0.02	-0.19	0.03	0.24	0.05	-0.33	0.41	0.11
	3	-0.23	-0.26	-0.08	-0.23	-0.11	-0.03	-0.40	0.03	-0.13
	4	0.19	-0.16	0.07	-0.23	-0.20	-0.22	-0.21	-0.21	-0.21
Q(2)		0.582	0.255	1.113	1.226	6.264	0.804	4.305	14.361	5.422
p		(0.75)	(0.88)	(0.57)	(0.54)	(0.04)	(0.67)	(0.12)	(0.00)	(0.07)

Stationarity Tests for the Respective Real Estate Market Returns

	U.K.		U.S.		GER	
ADF / (p)	-2.878	(0.18)	-2.076	(0.52)	-1.991	(0.56)
KPSS / (5%)	0.088	(0.15)	0.101	(0.15)	0.110	(0.15)

Notes: see Table 3.

Also the inferences about normality are altered. For yearly returns the null of normality could not be rejected for all bond, stock, and real estate markets at the 10% level. It is also evident, that for yearly returns there is still significant autocorrelation for German and U.S. real estate returns observable, but only for lag 1. The U.K. real estate market does not show significant autocorrelation anymore. Additionally, while the U.S. bond market did not exhibit significant autocorrelation for monthly returns, it does so for yearly returns.

Myer/Webb (1994) suggest that the serial correlation in the appraisal based real estate time-series could be a consequence of systematic changing return expectations due to changes in inflation. Also, through inflation-indexed lease contracts, inflation could have a contemporaneous or lagged influence on rents. Because inflation rates are auto-correlated, this could introduce serial correlation into the real estate series. To investigate this item, the next section considers real returns.

3.2.2 Analysis of Real Returns

In Table 5 the contemporaneous and cross correlations between U.K., U.S., and German real and nominal real estate returns and the corresponding inflation rates are tabulated. For the U.K. and U.S. real estate markets there could no significant contemporaneous or cross correlation be found between nominal returns and inflation. Conversely, there are clear positive contemporaneous and cross correlations between real estate returns and inflation in Germany. As mentioned earlier this could be an effect of inflation-indexed lease contracts. The use of such contracts for commercial properties is common practice in Germany.

Table 5: Contemporaneous and Cross-Correlations between Quarterly Real Estate Returns and the CPI (I/1987 - I/2002)

		CPI				
		Lag 0	**Lag 1**	**Lag 2**	**Lag 3**	**Lag 4**
Nominal Returns	**U.K.**	-0.18	-0.23	-0.21	-0.25	-0.23
	U.S.	-0.06	-0.14	-0.13	-0.20	-0.20
	GER	**0.35**	**0.41**	**0.36**	**0.28**	**0.36**
Real Returns	**U.K.**	**-0.45**	**-0.27**	-0.20	**-0.28**	**-0.43**
	U.S.	**-0.34**	-0.12	-0.19	**-0.32**	**-0.32**
	GER	**-0.34**	**0.29**	**0.47**	0.09	-0.06

Notes: Correlation coefficients that proofed to be different from zero, at least at the 5% level, are printed in bold types.

On the other hand, after deflating, there appears a significant negative contemporaneous relationship between the deflated real estate returns and inflation for all countries. It seams that there is no, at least no linear, effect of inflation on nominal U.K. and U.S. real estate returns. This also explains the significant (negative) correlation for these two real estate markets after deflating, which is also apparent for some of the cross correlation coefficients.[12] Nonetheless, it should be emphasized again that there appears a significant interrelationship between inflation and German (nominal) real estate returns.

These findings are also confirmed through the distributional statistics as presented in Table 6. While there are mostly only marginal differences between skewness, excess kurtosis, autocorrelation structure and stationarity inferences for real returns (Table 6) and nominal returns (see again Table 3), there appear considerable changes in these figures only for the German real estate market.

As shown in Table 3, nominal German real estate returns showed highly positive and persistent autocorrelation at least for four lags. From Table 6 it is clear that after deflating the German real estate series exhibits no significant autocorrelation anymore, what is also confirmed by the *Box/Lijung* Q-test. Also contrasting the findings for nominal returns, after deflating the ADF-test was able to reject the null of a unit root approximately at the 0%-level of significance for the German real estate market.

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[12] To see this, suppose that the discrete nominal real estate return R and the discrete inflation rate I in some month are independent random variables. Through deflating R with I one obtains the real return r = ((1+R)/(1+I))-1, which is also a random variable. Because r is a function of I, independence between the deflated return r and the inflation rate I is unlikely.

Table 6: Distributional Statistics and Tests for Quarterly Real U.K., U.S., and German Real Estate, Bond, and Stock Markets Returns (I/1987 - I/2002).

		Stock Markets			Bond Markets			Real Estate Markets		
		U.K.	U.S.	GER	U.K.	U.S.	GER	U.K.	U.S.	GER
Skewness		**-0.614**	-0.566	**-0.801**	-0.428	0.054	-0.219	-0.186	**-0.928**	**-0.831**
Kurtosis		**1.668**	**1.568**	**1.911**	0.303	-0.776	-0.435	1.111	**2.529**	**3.232**
Normality		*	*	*	-	-	-	-	*	*
AC Lag	**1**	-0.08	-0.11	-0.07	0.01	0.00	0.20	**0.82**	**0.68**	0.14
	2	-0.14	0.10	-0.07	-0.18	-0.05	-0.10	**0.59**	**0.69**	0.00
	3	-0.02	0.06	0.04	0.13	-0.06	0.18	**0.39**	**0.62**	0.03
	4	-0.06	0.02	0.02	0.00	-0.06	-0.08	0.22	**0.72**	0.24
Q(4)		2.057	1.552	0.783	3.210	0.631	5.837	78.843	120.41	5.138
p		(0.73)	(0.82)	(0.94)	(0.52)	(0.96)	(0.21)	(0.00)	(0.00)	(0.27)

Stationarity Tests for the Respective Real Estate Market Returns

	U.K.		U.S.		GER	
ADF / (p)	-2.922	(0.16)	-1.926	(0.63)	-6.709	(0.00)
KPSS / (5%)	0.084	(0.15)	0.136	(0.15)	0.103	(0.15)

Notes: see Table 3.

Table 7: Distributional Statistics and Tests for Yearly Real U.K., U.S., and German Real Estate, Bond, and Stock Markets Returns (1987 - 2001).

		Stock Markets			Bond Markets			Real Estate Markets		
		U.K.	U.S.	GER	U.K.	U.S.	GER	U.K.	U.S.	GER
Skewness		-0.420	-0.212	-0.226	-0.300	-0.216	0.025	-0.572	-0.429	0.414
Kurtosis		-0.966	-1.295	-1.180	-0.717	-0.683	-0.520	0.827	-0.189	2.573
Normality		-	-	-	-	-	-	-	-	-
AC Lag	**1**	-0.20	0.11	-0.13	-0.27	**-0.58**	-0.27	0.37	**0.81**	0.16
	2	0.03	0.04	-0.18	-0.01	0.23	0.01	-0.30	0.47	-0.13
	3	-0.24	-0.24	-0.08	-0.27	-0.06	0.06	-0.41	0.15	-0.24
	4	0.21	-0.14	0.06	-0.19	-0.17	-0.26	-0.21	-0.11	0.01
Q(4)		0.710	0.248	0.946	1.309	7.185	1.339	4.268	16.399	0.789
p		(0.70)	(0.88)	(0.62)	(0.52)	(0.03)	(0.51)	(0.12)	(0.00)	(0.67)

Stationarity Tests for the Respective Real Estate Market Returns

	U.K.		U.S.		GER	
ADF (p)	1.078	(1.00)	-2.363	(0.38)	-3.278	(0.11)
KPSS (5%)	0.084	(0.15)	0.098	(0.15)	0.088	(0.15)

Notes: see Table 3.

Table 7 includes the already considered statistics on yearly basis. Like in the case of deflated monthly returns, the results are hardly altered relative to yearly nominal returns for all series. Again the only exception is the German real estate market which exhibits a fundamental change in its autocorrelation structure through deflating. After deflating German real estate returns, do no longer appear to be correlated in time.

For purposes of completeness Table 8 includes mean returns and standard deviations for the deflated quarterly and yearly return series. Comparing these statistics with the corresponding statistics on basis of nominal returns (Table 2) again there are only slight differences. Surely with the exception of the mean returns, that are considerably smaller for all series through deflating. It is noteworthy that while in nominal terms German real estate showed clearly the lowest mean of all series, the deflated German real estate mean returns are approximately equal to the mean of the deflated U.S. real estate market, for quarterly and yearly observations.

Table 8: Selected Descriptive Statistics on U.K., U.S., and German Stock, Bond, and Real Estate Market Real Returns.

	Stock Markets			Bond Markets			Real Estate Markets		
	U.K.	U.S.	GER	U.K.	U.S.	GER	U.K.	U.S.	GER
Panel A: Quarterly Returns (I/1987 - I/2002)									
Mean	2.18	2.73	2.29	1.54	1.08	1.06	1.61	0.86	0.88
Stdev.	8.56	8.06	12.05	3.36	2.69	1.89	2.66	1.76	0.68
CV	3.93	2.95	5.25	2.18	2.49	1.79	1.65	2.05	0.77
Width	47.11	44.74	69.22	16.09	10.87	7.90	14.77	10.46	4.21
Panel B: Yearly Returns (1987 - 2001)									
Mean	8.35	11.47	9.40	6.55	4.66	4.56	6.87	3.68	3.65
Stdev.	14.05	16.72	26.41	7.75	6.24	5.45	9.56	6.46	1.68
CV	1.68	1.46	2.81	1.18	1.34	1.19	1.39	1.76	0.46
Width	44.07	50.17	82.11	26.70	21.42	19.04	39.02	22.79	7.67
Panel C: Standard Deviation Ratio									
SDR	1.64	2.07	2.19	2.31	2.32	2.88	3.60	3.66	2.47

Notes: Mean, Stdev., CV, and Width are the arithmetic mean (in %), the empirical standard deviation (in %), the empirical absolute difference between maximum and minimum return (in % points), and the empirical coefficient of variation for the respective nominal return time-series. SDR is the ratio between the yearly and quarterly return standard deviations.

All in all one saw that there is only little influence of inflation on stock and bond market returns. This also holds for U.K. and U.S. real estate returns. The exception is the German real estate market, which showed clear interrelationships with the German inflation rate. Especially, contrasting U.K. and U.S. real estate, it seams that there is a strong effect of inflation on real estate returns in Germany.

To address the question of causality of the relation between German real estate returns and German inflation rates, Table 9 provides some *Granger* causality tests for the two time-series. While on quarterly basis the null “German real estate returns (IMMEX) does not *Granger* cause German CPI” could not be rejected, the converse null could be rejected at the 2%-significance level. Therefore it appears that *Granger* causality runs one-way from German inflation rates to (nominal) German real estate returns. However a rejection of both hypothesizes for yearly data was not possible, maybe due to decreasing power of the test for fewer observations.

Table 9: Granger Causality Test for the Relationship between German Real Estate and Inflation.

Null hypothesis (H0)	F-Statistic	p
Panel A: Quarterly Returns (I/1987 - I/2002)		
"CPI does not Granger cause IMMEX"	5.34	0.02
"IMMEX does not Granger cause CPI"	1.43	0.24
Panel B: Yearly Returns (1987 - 2001)		
"CPI does not Granger cause IMMEX"	3.06	0.11
"IMMEX does not Granger cause CPI"	1.42	0.26

Notes: For the calculation of the *Granger*-test in both cases, quarterly and yearly, only one lag was included in the test regressions. p denotes the marginal significance level of the test.

The apparent autocorrelation in nominal real estate returns is often attributed to smoothing effects in appraisal based indices through the appraisal behavior and temporal aggregation effects in index construction. To address this issue the next section analysis unsmoothed real estate returns.

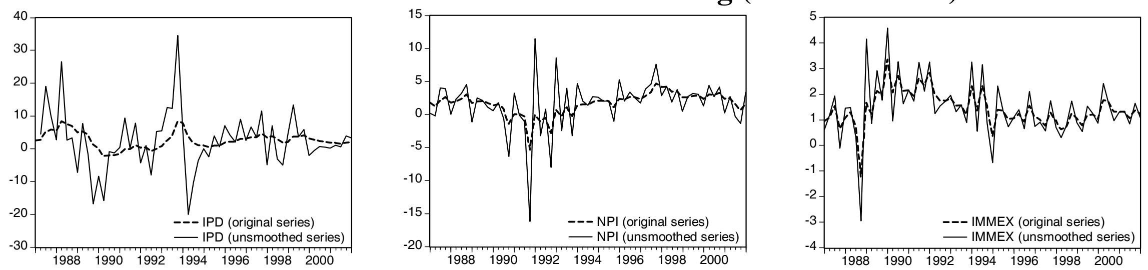
3.2.3 Analysis of Unsmoothed Returns

There is a wide consensus in literature that returns calculated from appraisal based real estate indices do not correctly reflect (unobservable) actual returns of the underlying real estate markets. The use of previous valuations in generating actual valuations and temporal aggregation of valuations, which occur mostly once per year and for different properties in different months, induce autocorrelation and smoothing in the respective appraisal based series. An often mentioned effect of appraisal smoothing is the underestimation of the true volatility through the use of an appraisal based series.

Different procedures, relying on different assumptions, to correct appraisal based real estate series for smoothing effects and to generate the true series exist. The choice of an appropriate unsmoothing procedure is always somehow arbitrarily. In this section the *Blundell/Ward* (1987) unsmoothing methodology was applied to address the issue of analyzing unsmoothed real estate returns. This methodology assumes that the real estate markets are at least weakly information efficient, i.e. that the respective real estate return time-series should be not serial correlated. In technical terms: this approach tries to correct the original series for serial correlation to arrive at an unsmoothed (not serial correlated) series. Therefore an AR(1)-process is assumed for the original series. The Hypothesis of weak form market efficiency for real estate markets is questioned by more actual research. On the other hand, as already motioned, the choice of the appropriate unsmoothing methodology is always arbitrary to some degree and second the *Blundell/Ward* (1987) procedure is an easy to use approach, which should be able to neutralize a large portion of smoothing effects in the considered real estate series.

Exhibit 3 shows the original and unsmoothed quarterly nominal real estate return series for the U.K., U.S., and Germany. As expected, the unsmoothed series exhibit much more volatility than the original series, the highs and lows are of considerably more magnitude.

Exhibit 3: Quarterly Nominal Returns on U.K., U.S., and German Real Estate Markets Before and After Unsmoothing (I/1987 - I/2002).



Notes: The dotted lines represent the original nominal real estate return series, the solid lines are the unsmoothed nominal real estate return series. For unsmoothing the original series the methodology of *Blundell/Ward* (1987) was used.

Comparing the unsmoothed real estate returns from Table 10 with the original series in Table 2 it is obvious that the unsmoothed returns are much more volatile than the original ones. The standard deviation for unsmoothed quarterly U.K., U.S., and German real estate returns is about 264%, 132%, and 65% higher than for the original series. After unsmoothing the quarterly standard deviation of the IPD is somewhat higher then those of the corresponding stock market series and the NPI series is between the corresponding bond and stock market series. Also for the German series the quarterly standard deviation increases for about 65% but it remains still much lower than the standard deviation from the German bond and stock market series. For yearly returns, through unsmoothing, there is a growth of standard deviation about 47%, 196%, and 90% for the U.K., U.S., and Germany relative to the original series observable.

Table 10: Selected Descriptive Statistics on U.K., U.S., and German Unsmoothed (Nominal) Real Estate Returns.

	Real Estate Markets		
	U.K.	**U.S.**	**GER**
Panel A: Quarterly Returns (I/1987 - I/2002)			
Mean	2.49	1.65	1.44
Stdev.	8.88	3.88	1.14
Panel B: Yearly Returns (1987 - 2001)			
Mean	9.94	6.71	6.07
Stdev.	13.66	18.38	4.56

Notes: Mean and Stdev. are the arithmetic mean (in %) and the empirical standard deviation (in %) of the respective nominal return time-series.

The inferences about standard deviation are hardly altered for U.K., and German real estate relative to the case of quarterly returns. However the standard deviation from yearly U.S. real estate returns is now relatively higher than for quarterly returns, even if it is still considerably lower the yearly U.S. stock market's standard deviation.

Considering the auto-correlation coefficients for the unsmoothed quarterly and yearly real estate series as given in Table 11 it is clear that unsmoothing eliminated a great proportion of the serial correlation of the original series. For annually returns no autocorrelation can be observed anymore.

Table 11: Distributional Statistics and Tests for Unsmoothed Nominal U.K., U.S., and German Real Estate Returns.

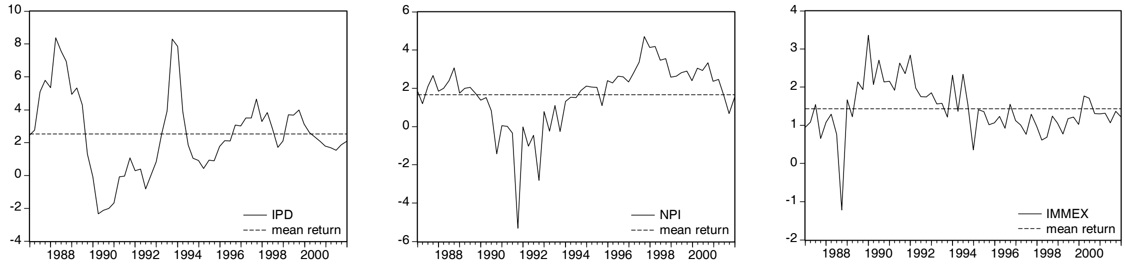
		Quarterly Returns (I/1987 - I/2002)			Yearly Returns (1987 - 2001)		
		U.K.	**U.S.**	**GER**	**U.K.**	**U.S.**	**GER**
Skewness		**0.613**	**-1.692**	**-0.46**	0.037	-0.798	0.416
Kurtosis		**2.821**	**6.920**	**4.513**	0.674	-0.351	-0.409
Normality		*	*	*	-	-	-
AC	**1**	**0.30**	**-0.30**	-0.06	0.06	0.41	0.10
Lag	**2**	0.14	**0.29**	0.13	-0.42	0.05	-0.09
	3	-0.05	-0.17	-0.01	-0.20	-0.25	-0.13
	4	-0.08	**0.62**	0.16	-0.14	-0.12	-0.04
Q(4)		7.540	38.705	3.040	3.296	3.066	0.356
p		(0.11)	(0.00)	(0.55)	(0.19)	(0.22)	(0.84)
ADF		-5.538	-1.730	-8.115	-3.922	-2.065	-3.150
p		(0.00)	(0.41)	(0.00)	(0.01)	(0.26)	(0.05)
KPSS		0.054	0.450	0.192	0.319	0.161	0.159
5%		(0.46)	(0.46)	(0.46)	(0.46)	(0.46)	(0.46)

Notes: see Table 3.

3.2.4 Temporal Structure of Real Estate Returns – Real Estate Cycles

Autocorrelation in real estate returns can also be a consequence of real estate cycles. Exhibit 4 shows the quarterly nominal real estate return time-series from the U.K., U.S., and Germany together with their respective means. In contrast to stock and bond markets, the real estate return series do not stagger regularly about their means. There are periods, which comprise several quarters or even years, where real estate returns are persistently higher/lower than their (long term) mean. This is observable for all real estate markets under investigation, indicating cyclical behavior of real estate returns.

Exhibit 4: Quarterly Nominal Returns on U.K., U.S., and German Real Estate Markets (I/1987 - I/2002).



Notes: The solid lines represent the original nominal real estate return series, the dotted lines are the mean returns.

"Property cycles are recurrent but irregular fluctuations in the rate of all-property total return, which are also apparent in many other indicators of property activity, but with varying leads and lags against the all-property cycle." (*Royal Institution of Chartered Surveyors* Report 1994, p. 127). The consideration of cyclical behavior of real estate returns in strategic investment decisions is of great importance, especially due to the fact that real estate is a long-term investment.

Harmonic analysis provides a formal mean to analyze cyclical behavior without the need to specify an economic model that explains the cycle.[13] Technically, a cyclical variable resembles a sine/cosine-curve.[14] With simultaneous consideration of a linear trend, seasonality and cyclical behavior, the model given in equation (3) can be fitted to the respective real estate time-series via ols-regression:[15]

$$r_t = a_o + a_1(2\pi t) + a_2(Sin\left(\frac{2\pi t}{SL}\right)) + a_3(Cos\left(\frac{2\pi t}{SL}\right)) + a_4(Sin\left(\frac{2\pi t}{CL}\right)) + a_5(Cos\left(\frac{2\pi t}{CL}\right)) + \varepsilon_t \qquad \textbf{(3)}$$

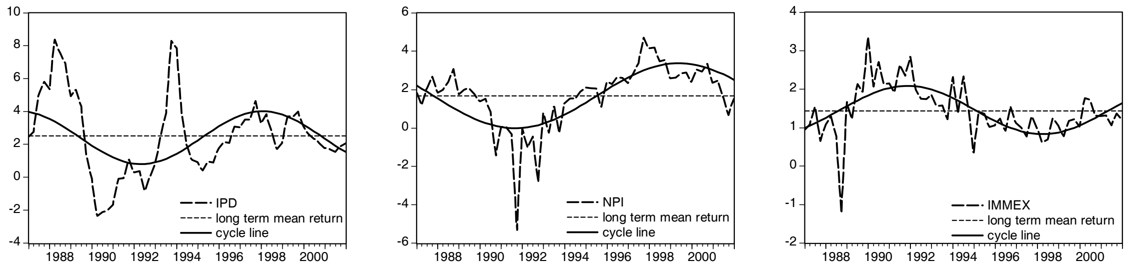
The *a*'s are regression coefficients and *t* is the time index, i.e. $t = 1, 2, 3, ...$ for the first, second, third, ... observation. *SL* is the season period parameter, and *CL* the cycle period ("cycle length") parameter, i.e. the cycle length is *CL*/4 years for quarterly data.

To estimate cycle length, the regression model in equation (3) should be evaluated for different combinations of *SL* and *CL*, whereby the best fit provides the estimates for *SL* and *CL*.

Using different settings of the model in equation (3), with and without the trend component and with and without the seasonal component, the pure sine/cosine-representation without trend and without seasonality proofed most adequate for the considered real estate time-series. Also, different fitting criteria were applied and evaluated. The MAPE (mean percentage squared error) was most adequate and indicated mostly nearly the same results like e.g. the R²-criterion.

In Exhibit 5 the sine/cosine-curve representations of the respective real estate market time-series together with the original series and their mean returns are given.

Exhibit 5: U.K., U.S., and German Real Estate Market Cycles (I/1987 - I/2002).



Notes: The intersected lines represent the original quarterly nominal real estate return series, the dotted lines are the (long term) mean returns and the solid lines are the sine/cosine-curves which were fitted using the MAPE criterion.

It can be seen that especially for the U.S. and German real estate market the sine/cosine-representation provides a good fit for the quarterly original real estate series. For the U.K., cycle fitting was less straightforward. Different fitting criteria partly suggested substantially different fits. The U.K. cycle curve in Exhibit 5 provides the best trade-of between the respective criteria.

Table 12 reports some fitting criteria and several cycle statistics for the optimal fitted real estate cycle curves. As can be seen from the MAPEs, R²s, and correlations between the cycle returns and the original returns, the sine/cosine-representation provides a good fit espe-

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[13] See *Pyhrr*, *Roulac* and *Born* (1999) for a review of real estate cycle models and literature.

[14] See *Crawford* (2001), p. 29.

[15] See *Richardson* (2002).

cially for the U.S. and German real estate markets. While, for the U.S. and Germany, the MAPEs are very low, the R^2s and correlations are considerably high. On the other hand, the sine/cosine-curve fitting criteria for the U.K. real estate market are clearly worse than that for the U.S. and Germany.

Table 12: Cycle Statistics - U.K., U.S., and Ger. Real Estate Market (I/1987 - I/2002).

	MAPE	R²	Corr.	Cycle Period		Amplitude	Inflection Points		
				Quarters	Years				
U.K. Real Estate (IPD)	183%	0.20	0.45	46	11.5	1.61	II/'89	I/'95	IV/'00
U.S. Real Estate (NPI)	56%	0.53	0.73	62	15.5	1.70	IV/'87	II/'95	I/'03[e]
German Real Estate (IMMEX)	28%	0.38	0.61	51	12.75	0.63	III/'88	II/'95	II/'01

Notes: MAPE and R² and Corr. are the mean absolute percentage error, the R-square statistic, and the correlation between the MAPE-optimal fitted cycle curves and the respective original real estate cycle series. The cycle period ("cycle length") is two times the cycle phase (difference between to inflection points). The cycle amplitude (in %) is the absolute difference between the peak or the trough of the cycle and (here) the long term mean. The inflection points are the intersection points between the cycle curve and (here) the long term mean return. See *Pyhrr*, *Roulac*, and *Born* (1999).

For the U.K. real estate market the estimated cycle period ("cycle length") is 11.5 years, with a cycle amplitude return of 1.61% per quarter. The last inflection point, was in the fourth quarter of 2000 and it was a top-to-bottom inflection point. The U.S. real estate market indicates a cycle length of 15.5 years with an amplitude return of 1.70%. There, the last inflection point was in the second quarter of 1995 followed by a positive amplitude in the first quarter of 1999. The next top-to-bottom inflection point will be in the first quarter of 2003. For the German real estate market a cycle period of 12.75 years was estimated. The German real estate cycle amplitude return is 0.63%, i.e. far less than half the amplitude return form U.K. and U.S. real estate markets. This is also caused by the low volatility of German real estate returns (see Table 2). The last inflection point for the German real estate market, which was a bottom-to-top inflection point, was in the second quarter of 2001.

Interestingly, as can be seen from the cycle curves in Exhibit 5, the current cycle direction is different for the U.K./U.S. and Germany. While the current direction of the U.K. and U.S. cycle is downward, the current direction of the German real estate cycle is seemingly upward. The procyclical movement between U.K. and U.S. real estate, and the anticyclical movement between U.K./U.S. and German real estate was also the case for whole time period under consideration. The real estate markets in U.K. and U.S. exhibit highly positive correlated cycles (correlation of U.K. and U.S. cycle returns is 0.77). However, the German real estate market was anti-cyclical relative to the U.K. and U.S. cycles over the whole period under consideration, resulting in highly negative cycle return correlations with the U.K. and U.S. (cycle correlation U.K. vs. Germany: -0.96, cycle correlation U.S. vs. Germany 0.90). It should be also mentioned that, due to different cycle lengths, these pro- and anti-cyclical relationships should alter over time.

3.3 Multivariate Considerations

3.3.1 Contemporaneous Correlations

The presence and structure of return interrelationships between national and international asset markets is of crucial importance, e.g. regarding asset allocation decisions.[16] This

[16] See e.g. *Maurer* and *Reiner* (2002).

and the following section are dedicated to these items.[17] Common wisdom suggests that the higher the integration of international asset markets, the stronger their return comovements. One important measure of overall return interdependency is Pearson's Product Moment Correlation Coefficient, which measures the degree of linear interdependency. Table 13 shows the short-term correlation matrix for the considered international asset markets on quarterly nominal basis.

Table 13: Contemporaneous Correlation Coefficients for the U.K., the U.S. and German Real Estate, Bond, and Stock Markets on Quarterly Nominal Basis (I/1987 – I/2002)

		Stock Markets			Bond Markets			Real Estate		
		U.K.	U.S.	GER	U.K.	U.S.	GER	U.K.	U.S.	GER
Stock Market	U.K.	1								
	U.S.	**0.82**	1							
	GER	**0.59**	**0.62**	1						
Bond Market	U.K.	**0.35**	0.19	-0.12	1					
	U.S.	-0.17	-0.11	**-0.29**	**0.55**	1				
	GER	0.08	0.04	-0.19	**0.76**	**0.62**	1			
Real Estate	U.K.	-0.05	-0.05	0.18	-0.25	-0.20	-0.27	1		
	U.S.	-0.07	-0.03	0.07	-0.15	-0.10	-0.22	0.38	1	
	GER	-0.02	-0.07	-0.04	-0.12	-0.07	-0.19	**-0.49**	**-0.52**	1

Notes: Correlation coefficients that proofed to be different from zero, at least at the 5% level, are printed in bold types.

As expected the intra asset class correlation for the stock and bond markets is highly positive and significantly different from zero.[18] These high correlations can be attributed to the high degree of integration of these major asset markets. Also the real estate markets show intra asset class correlation coefficients which are partly significantly different from zero. Interestingly, while the correlation between the U.K. and U.S. real estate markets are considerably positive, however insignificant, the correlation between these two markets and the German real estate market are strongly negative and significant. Different international prop-

[17] All analyses in the following sections are done on basis of national returns, i.e. the interrelationships between different national asset markets are investigated assuming a perfect (currency) hedge (see e.g. *Eun* and *Resnick* 1988, 1994). Through this assumption, the results derived are independed of the reference currency of the investor and so they hold for every (perfectly hedged) investor independed of the investors' nationality.

[18] The analyses in the previous sections showed that some of the time series used in this study are non-normal distributed and/or autocorrelated. Using a standard t-test for testing the hypothesis, that a correlation coefficient is different from zero at a given level of significance, is critical in the presence of non-normal distributed or autocorrelated time-series. Non-normality leads to an unknown distribution of the t-test statistic. To address this item, each correlation coefficient for which both of the underlying series proofed to be non-normal (see *Pitman* (1937), p. 229), was tested with a simple t-test and additionally via a bootstrap BCa confidence interval with 10.000 bootstrap replications. In almost all cases both test-procedures provided the same conclusions regarding the rejection of the null, leading to the presumption that non-normality in the time series used here is less problematic for applying the usual t-test. The serial correlation in one or both of the underlying time series leads to a reduction in the degrees of freedom of the t-tests' t-distribution. To address the item of autocorrelation, especially in the real estate series, a correction for the t-test suggest by *Dawdy* and *Matalas* (1964, p. 8/87) was applied, which at least allows to control for first-order autocorrelation. This correction is applied by adjusting the t-tests' t-statistic and the degrees of freedom of the t-test-statistics' t-distribution.

erties and trough this also international real estate markets are no close substitutes for each other. This in turn suggests that the returns of these asset markets should be independed. However *Goetzmann* and *Rouwenhorst* (1999) show that national real estate returns are related to national GDP and through the integration of national economies, GDPs are internationally related. They provide empirical evidence that significant correlation among international real estate returns can be at least partly attributed to interrelations between economic growth (GDP) of different countries.

Inter asset class correlations between the different real estate markets and the stock markets are in almost all cases close to zero and not statistically significant different from zero. The average correlation is about zero. One the other hand each real estate market exhibits considerably negative correlations with every bond market, even when these correlations are all not significantly different from zero. The average correlation is –0.17.

To address the influence of real estate cycles on correlations between real estate and other asset classes the full time period of the study was (arbitrarily) divided into two subperiods of approximately equal length. Table 14 shows the results of the subperiod analysis.

Table 14: Contemporaneous Correlation Coefficients for the Real Estate, Bond, and Stock Markets in the U.K., the U.S. and Germany on Quarterly Nominal Basis

		Stock Markets			Bond Markets			Real Estate		
		U.K.	U.S.	GER	U.K.	U.S.	GER	U.K.	U.S.	GER
Panel A: Time Period I/1987 - II/1994										
Real Estate	**U.K.**	-0.07	-0.09	0.18	-0.31	-0.25	-0.28	1		
Real Estate	**U.S.**	-0.11	-0.17	-0.01	-0.24	-0.22	**-0.42**	0.49	1	
Real Estate	**GER**	-0.06	-0.05	0.00	-0.15	-0.04	-0.15	**-0.60**	**-0.44**	1
Panel A: Time Period I/1994 - I/2002										
Real Estate	**U.K.**	0.00	0.06	0.30	-0.05	-0.11	-0.34	1		
Real Estate	**U.S.**	0.07	0.07	0.08	0.20	0.15	0.07	0.66	1	
Real Estate	**GER**	0.04	-0.08	-0.02	-0.22	-0.22	-0.36	-0.20	-0.25	1

Notes: Correlation coefficients that proofed to be different from zero, at least at the 5% level, are printed in bold types.

Regarding correlations between real estate and stock markets the magnitude of all correlation coefficients is about the same in both subperiods and in the total period. Additionally none of the coefficients is different from zero at reasonable levels of significance. These findings provide evidence of at least linear independence of real estate returns and stock market returns on national and international levels. As was the case for the total period the correlations between real estate and bond markets are mostly not significantly different from zero. However differences in correlations are of considerably more magnitude in the two subperiods than it was the case for correlations between real estate and stock markets. This is possibly due to structural changes.

The correlations between the three real estate markets in sub period one are about the same as in the total period. Again strongly positive correlations could be detected between U.K. and U.S. real estate returns and significant strongly negative correlations were found between U.K./U.S. and German real estate. In sub period two the correlation between U.K. and U.S. real estate returns is again positive and high, but not significant. Correlations between U.K./U.S. and German real estate returns are again considerably negative, however clearly weaker than in sub period one and in the total period. Also they are no more significantly different from zero. Again this can be interpreted as possible evidence for structural changes, i.e. cycles.

Real estate returns are driven by different factors, particularly rental and appreciation returns. Notionally, short run real estate returns (e.g. quarterly returns), measured by appraisal based indices, are not perfectly able to correctly reflect both return drivers, especially appreciation returns. On the other hand this problem should be lowered by considering longer run returns. Table 15 includes the correlation coefficients on yearly basis.

Table 15: Contemporaneous Correlation Coefficients for U.K., the U.S. and German Real Estate, Bond, and Stock Markets on Yearly Nominal Basis (1987 – 2001)

		Stock Markets			Bond Markets			Real Estate		
		U.K.	U.S.	GER	U.K.	U.S.	GER	U.K.	U.S.	GER
Real Estate	U.K.	0.18	0.09	0.45	-0.23	-0.30	-0.31	1		
	U.S.	-0.05	0.14	0.23	-0.25	-0.17	-0.32	0.53	1	
	GER	-0.15	-0.26	-0.33	0.01	0.13	-0.04	**-0.72**	-0.74	1

Notes: Correlation coefficients that proofed to be different from zero, at least at the 5% level, are printed in bold types.

Comparing yearly and quarterly returns (Table 13), inter asset class correlations between real estate and stock/bond markets are hardly altered in most cases. The yearly correlations are mostly of more magnitude but never statistically different from zero. The higher magnitude of correlation can also be seen for the real estate intra asset class correlations. U.K. and U.S. real estate returns are again highly positive correlated, while U.K./U.S. real estate returns are strongly negative correlated with German real estate returns. Furthermore applying a *Hotelling*/*William* Test, no significant differences between the magnitude of the respective yearly correlation coefficient and their quarterly counterparts could be detected.

As mentioned earlier the appraisal smoothing issue can lead to an underestimation of the true volatility. *Fisher*, *Geltner* and *Webb* (1994) mention that the smoothing issue can also lead to wrong estimations of correlation. Table 16 shows the unsmoothed quarterly correlations between the real estate markets and the other asset markets.

Table 16: Contemporaneous Correlations for Unsmoothed Real Estate, Bond, and Stock Returns in the U.K., the U.S. and Germany on Quarterly Nominal Basis (I/1987 – I/2002)

		Stock Markets			Bond Markets			Uns. Real Estate		
		U.K.	U.S.	GER	U.K.	U.S.	GER	U.K.	U.S.	GER
Uns. Real Estate	U.K.	0.05	0.02	0.17	0.00	-0.11	0.08	1		
	U.S.	-0.08	-0.07	0.11	-0.20	-0.20	-0.13	-0.05	1	
	GER	0.07	0.01	-0.01	-0.19	-0.17	**-0.31**	-0.18	-0.11	1

Notes: Correlation coefficients that proofed to be different from zero, at least at the 5% level, are printed in bold types.

Regarding the correlations between real estate and stock/bonds unsmoothing has mostly no mentionable effect on the magnitude of these correlations. Again, while the effects of unsmoothing on correlations between real estate and bonds are a bit higher, they are marginal in the case for real estate vs. stocks. These findings again suggest (linear) independence of real estate and stock market returns.

Interestingly, considering intra asset class correlations for the real estate markets, the effects of unsmoothing on correlations are drastic. After unsmoothing the correlations between all real estate markets are clearly closer to zero than before unsmoothing. None of the coefficients proofed to be significantly different from zero after unsmoothing.

3.3.2 Partial Comovements

The low return interdependencies between real estate and stock/bond market returns, found in the previous section, were calculated from the complete bivariate return distributions of the respective assets pairs. This section investigates return comovements in the tails of the total bivariate return distributions only. Due to the limited data available the focus is on probabilities rather than on comovement structures.[19] To measure the comovement of two random variables in some part of their bivariate distribution and without considering the structure of the comovement, the concept of conditional probability proofs useful.

One can define $LCP(c) := P(X \leq x_c \mid Y \leq y_c)$ as the (conditional) probability that a random variable X (here real estate returns) has a realization that is equal or below the c%-percentile conditioned that another random variable Y (here stock or bond returns, respectively) has, at the same time, a realization equal or below its c%- percentile. $UCP := P(X \geq x_c \mid Y \geq y_c)$ can be defined equivalently. If X and Y are two independent random variables, the conditional probability $LCP(c) := P(X \leq x_c \mid Y \leq y_c)$ is equal to the absolute probability $P(X \leq x_c)$ that X has a realization below or equal to x_c. And equivalently $P(X \geq x_c \mid Y \geq y_c) = P(X \geq x_c)$. Per se, the LCP(c) and UCP(c) do not allow making inferences about the statistical dependence and independence of two random variables. However LCP(c) (UCP(c)) are useful measures to quantify the risk (opportunity) that e.g. given one asset market is in bad (good) condition, the other is also.

The conditional probabilities, LCP(c) and UCP(c), can be estimated through the corresponding conditional frequencies, eLCP(c) and eUCP(c). It should be mentioned that the e.CPs are estimations of the true .CPs. Due to the small quarterly database these estimations have high standard errors, which are the higher, the smaller the percentile considered. So the e.CPs should be interpreted carefully.

In Table 17 the (conditional) relative frequencies for the considered real estate market returns to be equal or lower (higher) than their 10%-, 20%-, and 50%- (50%-, 80%-, and 90%-) percentile returns conditioned that the corresponding stock and bond market returns, respectively, also satisfy the same conditions, are tabulated. Additionally, APPENDIX A includes the relative frequencies on quarterly basis.

As can be seen from Table 17 the eLCP(20) and eLCP(10) for the U.K. and especially the German real estate market, conditional on the respective stock market returns, are of considerable magnitude. In quarters where the U.K./German stock market returns are low or very low there is also a considerable probability that the corresponding real estate market returns are also relatively low or very low, respectively. In other words, U.K. and German real estate often cannot provide a perfect alternative investment in times of poor stock market performance. On the other hand the U.S. real estate market shows low tendencies only to have relatively low or very low returns when this is true for the U.S. stock market.

eUCP(20) and eUCP(10), the tendencies for real estate to have relatively high or very high returns, when the corresponding stock markets perform also good or very good, is lower than the corresponding eLCP or even zero. I.e. In times of high stock market performance, the U.K. and German real estate market mostly do not show their best performance. Again the

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[19] Measuring the structure of dependencies in the tails of a bivariate distribution requires higher frequency data than available here. For structural measures of extreme dependencies see *Malevergne* and *Sornette* (2002).

U.S. real estate market is an exception. Its eUCP(20) and eUCP(10) are relatively high in comparison to the U.K. and German real estate market.

Considering quarters with low or very low bond market returns, all real estate markets show low tendencies to have also relatively low or very low returns. I.e. real estate seems to be, in most cases, at least no bad alternative investment when bonds perform weak. The eUCPs for U.K. and U.S. real estate conditional on the respective bond market returns are considerably high, while low for the German real estate market.

Table 17: Conditional Relative Frequencies in Several Percentiles of the Quarterly Real Estate Market Return Distributions (II/1987 - I/2002)

Lower Percentiles			Upper Percentiles		
10%	**20%**	**50%**	**50%**	**80%**	**90%**
PANEL I: Real Estate Returns Conditioned on Stock Market Returns					
IPD Returns Conditioned on MSCI U.K. Returns					
16.67	25.00	46.67	51.61	23.08	0
NPI Returns Conditioned MSCI U.S. Returns					
0	8.33	53.33	56.25	30.77	28.57
IMMEX Returns Conditioned on MSCI Germany Returns					
33.33	33.33	43.33	46.88	15.38	0
PANEL II: Real Estate Returns Conditioned on Bond Market Returns					
IPD Returns Conditioned on DS Government Bond U.K. Returns					
16.67	8.33	40.00	45.16	23.08	14.29
NPI Returns Conditioned on DS Government Bond U.S. Returns					
0	16.67	53.33	56.25	15.38	14.29
IMMEX Returns Conditioned on DS Government Bond Germany Returns					
0	8.33	43.33	50.00	7.69	0

Notes: Conditional relative frequencies (in %). The numbers in parentheses are the 10%-, 20%-, 50%-, 80%-, and 90%-Quantile Returns in % p.3m of the respective marginal return distributions.

As could be seen from the analysis of the previous chapters unsmoothing has a strong effect on volatility and correlations. As can be seen from Table 18 unsmoothing also seems to have some effect on LCP. Again while the effects are somehow similar for the U.K. and Germany, they are different for the U.S. real estate market. The unsmoothed real estate returns for the U.K. and German real estate markets show equal or lower LCP(20)s and LCP(10)s conditioned on the stock market returns, while they are higher if conditioned on the bond markets. The opposite holds true for the unsmoothed U.S. real estate returns. The effects of unsmoothing on the UCPs conditioned on the stock market returns are more drastic and in the same direction for all real estate markets. After unsmoothing the eUCP(20)s and eUCP(10)s are clearly lower for all real estate markets. On the other hand the eUCPs conditioned on the bond market returns are not or not much altered.

Table 18: Conditional Relative Frequencies in Several Percentiles of the Unsmoothed Quarterly Real Estate Return Distributions (II/1987 - I/2002)

Lower Percentiles			Upper Percentiles		
10%	**20%**	**50%**	**50%**	**80%**	**90%**
PANEL I: Real Estate Returns Conditioned on Stock Market Returns					
IPD Returns Conditioned on MSCI U.K. Returns					
0	25.00	50.00	54.84	7.69	0
NPI Returns Conditioned MSCI U.S. Returns					
0	16.67	46.67	53.13	0	0
IMMEX Returns Conditioned on MSCI Germany Returns					
16.67	33.33	53.33	56.25	7.69	0
PANEL II: Real Estate Returns Conditioned on Bond Market Returns					
IPD Returns Conditioned on DS Government Bond U.K. Returns					
33.33	16.67	40.00	41.94	23.08	14.29
NPI Returns Conditioned on DS Government Bond U.S. Returns					
0	8.33	46.67	50.00	23.08	0
IMMEX Returns Conditioned on DS Government Bond Germany Returns					
16.67	16.67	50.00	53.13	7.69	0

Notes: Conditional relative frequencies (in %). The numbers in parentheses are the respective 10%-, 20%-, 50%-, 80%-, and 90%-Quantile Returns in % p.3m of the respective marginal return distributions.

4 Summary and Conclusions

The aim of this paper was to demonstrate the special characteristics of U.K., U.S. and German real estate returns relative to each other and relative to other asset classes. For this purpose major appraisal based indices for the U.K. and U.S. were used. Due to the poor availability of adequate real estate indices with sufficient long history, for Germany an indirect appraisal based index, the IMMEX, was employed. Quarterly and yearly analysis in univariate and multivariate settings for the time period 1987 to 2002 were conducted.

Univariate analyses showed that the different real estate markets exhibit clearly different risk/return-characteristics. U.K. and U.S. real estate returns showed yearly return volatilities about the volatility of the corresponding bond markets or after unsmoothing even about the corresponding stock markets' volatility. Contrasting German real estate's volatility was in each case significantly lower than volatility of all other stock, bond, and real estate markets.

Furthermore all real estate markets showed significant serial correlation. An analysis of real returns showed, that serial correlation in German real estate returns is probably partially attributable to serial correlation in inflation rates which influences real estate returns through inflation-indexed lease contracts or systematic changes in return expectations due to changes in inflation. However no influence of inflation on U.K. and U.S. real estate returns could be detected.

Cyclical analyses clearly showed cyclical behavior of all real estate markets. Cycle lengths of about 11, 15, and 13 years for the U.K., U.S., and German real estate market could be detected. Furthermore, while currently U.K. and U.S. real estate exhibit procyclical behavior, German real estate is currently anticylical relative to the U.K. and U.S. real estate market.

Multivariate Analysis showed that there are no significant correlations between the different real estate markets and the corresponding stock and bond markets, respectively. However as cyclical analysis already suggested U.K. and U.S. real estate show significantly positive correlations with each other. Contrasting, German real estate returns are significantly negative correlated with U.K. and U.S. real estate returns, respectively.

Analyses of extreme comovements showed that U.K., U.S., and German real estate exhibit relations to stock and bond markets in extreme situations.

All in all, the characteristics of international real estate returns are significantly different form the return characteristics of other asset classes like stocks and bonds. Real estate returns provide features, which are not observable for other asset classes and which should be carefully taken into account in (international) asset allocation decision making.

APPENDIX A

Table 19: Percentile Returns (II/1987 till I/2002)

Lower Quantiles				Upper Quantiles					
5%	10%	20%	50%	50%	80%	90%	95%	Min.	Max.
Quarterly Nominal IPD Returns									
-2.01	-0.09	0.43	2.10	2.10	4.00	5.35	7.55	-2.33	8.39
Quarterly Nominal NPI Returns									
-1.43	-0.33	0.67	2.00	2.00	2.81	3.33	3.55	-5.33	4.71
Quarterly Nominal Unsmoothed IPD Returns									
-15.79	-8.04	-3.03	2.49	2.49	7.07	11.50	13.37	-20.01	34.59
Quarterly Nominal Unsmoothed NPI Returns									
-6.37	-2.44	-0.29	2.05	2.05	3.93	4.55	5.25	-16.20	11.50
Quarterly Nominal IMMEX Returns									
0.61	0.77	1.01	1.30	1.30	1.93	2.31	2.63	-1.22	3.35
Quarterly Nominal Unsmoothed IMMEX Returns									
-0.11	0.53	0.73	1.30	1.30	2.09	3.16	3.26	-2.95	4.58
Quarterly Nominal Stock Market Returns U.K. - MSCI									
-12.57	-7.64	-1.84	2.86	2.86	7.67	13.90	16.00	-26.96	17.15
Quarterly Nominal Stock Market Returns U.S. - MSCI									
-13.47	-8.69	-2.29	4.32	4.32	8.78	10.59	16.42	-22.80	21.90
Quarterly Nominal Stock Market Returns Germany - MSCI									
-27.36	-14.01	-4.42	4.43	4.43	11.18	14.01	19.70	-34.83	34.94
Quarterly Nominal Bond Market Returns U.K. – DS Government Bond									
-3.89	-2.10	0.31	2.47	2.47	4.82	6.32	6.96	-6.38	7.86
Quarterly Nominal Bond Market Returns U.S. – DS Government Bond									
-2.21	-1.59	-0.78	1.55	1.55	4.44	5.48	5.75	-2.99	8.18
Quarterly Nominal Bond Market Returns Germany – DS Government Bond									
-1.49	-0.97	-0.05	1.67	1.67	3.25	3.90	4.29	-2.55	4.77

Notes: All numbers in % p.3M.

APPENDIX B

Table 20: Relative Frequencies in Several Percentiles of the Monthly Real Estate Market Return Distributions Conditional on the Monthly Nominal Stock Market Return Distribution (Jan. 1987 till March 2002)

Lower Percentiles				Upper Percentiles					
5%	10%	20%	50%	50%	80%	90%	95%	Min.	Max.
Monthly Nominal IPD Returns									
11.11	16.67	25.00	53.85	55.43	24.32	10.53	10.00	-1.77	2.89
Monthly Nominal IMMEX Returns									
11.11	22.22	27.78	41.76	44.09	8.11	0	0	-1.76	1.81

Notes: Conditional relative frequencies (in %). The numbers in parentheses are the respective 5%-, 10%-, 50%-, 90%-, and 95%-Quantile Returns in % p.m. Min. and Max. are the respective minimum and maximum returns in % p.m.

Table 21: Relative Frequencies in Several Percentiles of the Monthly Real Estate Market Return Distributions Conditional on the Monthly Nominal Stock Market Return Distribution (Jan. 1987 till March 2002)

Lower Percentiles				Upper Percentiles					
5%	10%	20%	50%	50%	80%	90%	95%	Min.	Max.
Monthly Nominal IPD Returns									
0	5.56	19.44	51.65	53.26	13.51	10.53	10.00	-1.77	2.89
Monthly Nominal IMMEX Returns									
11.11	5.56	13.89	32.97	35.48	5.41	0	0	-1.76	1.81

Notes: Conditional relative frequencies (in %). The numbers in parentheses are the respective 5%-, 10%-, 50%-, 90%-, and 95%-Quantile Returns in % p.m. Min. and Max. are the respective minimum and maximum returns in % p.m.

References

Ball, *M.*; *C. Lizieri*; *B. D. MacGregor* (1998): "The Economics of Commercial Property Markets", Routldege, London.

Barkham, *R.*; *D. Geltner* (1995):"The Performance of the U.K. Property Sector: A Guide to Investing in British Property via the Public Stock Market", in: Real Estate Finance, 12 (1), 90-98.

Benjamin, J. D.; G. Stacy Sirmans; Emily N. Zietz (2001): "Returns and Risk on Real Estate and Other Investments: More Evidence", in: Journal of Real Estate Portfolio Management, 7 (3), 183-214.

Brown, *G. R.*; *G. A. Matysiak* (1998): "Valuation Smoothing without Temporal Aggregation", in: Journal of Property Research, 15, 89-103.

Burns, *W. L.*; *D. R. Epley* (1982): "The Performance of Portfolios of REITs and Stocks", in Journal of Portfolio Management, Spring 1982, 37-42.

Blundell, R.; C. W. R. Ward (1987): "Property Portfolio Allocation: A Multifactor Model", in: Land Development Studies, 4, 145-156.

Brooks, *C.*; *H. M. Kat* (2001): "The Statistical Properties of Hedge Fund Index Returns and Their Implications for Investors", Working Paper, University of Reading.

Chau, *K. W.*; *B. D. MacGregor*; *G. M. Schwann* (1998): "Price Discovery in the Hong Kong Real Estate Market", paper presented at the European Real Estate Society/American Real Estate and Urban Economics Association conference, Maastricht, The Netherlands, 10-13 June.

Chan, *K. C.*; *P. H. Hendershott*; *A. B. Sanders* (1990): "Risk and Return on Real Estate: Evidence from Equity REITs", in: AREUEA Journal, 18 (4), 431-52.

Cheng, P. (2001): "Comparing Downside-Risk and Mean-Variance Analysis Using Bootstrap Simulation", in: Journal of Real Estate Portfolio Management, 7 (3), 225-238.

Cheng, *P.*; *A. J. Ziobrowski*; *R. W. Caines*; *B. J. Ziobrowski* (1999): "Uncertainty and Foreign Real Estate Investment", in: Journal of Real Estate Research, 18 (3), 463-479.

Crawford, *M.* (2001): "Is the Business Cycle Still Alive?", in: The Business Economist, 32 (3), 22-36.

Dawdy, *D. R.*; *N. C. Matalas* (1964): "Statistical and probability analysis of hydrologic data", part III: "Analysis of variance, covariance and time-series", in *Ven Te Chow* (ed.), Handbook of applied hydrology, a compendium of water-resources technology, New York, McGraw-Hill.

Eun, *C.*; *B. G. Resnick* (1988): "Exchange Rate Uncertainty, Forward Contracts, and International Portfolio Selection", in: Journal of Finance, 43, 197-215.

Eun, *C.*; *B. G. Resnick* (1994): "International Diversification of Investment Portfolios: U.S. and Japanese Perspectives", in: Management Science, 40, 140-161.

Fisher, *J. D.*; *D. M. Geltner*; *R. B. Webb* (1994): „Value Indices of Commercial Real Estate: A Comparison of Index Construction Methods", in: Journal of Real Estate Finance and Economics, 9, 137-164.

Fletcher, S. (1995): "Commercial Real Estate Investments and Returns: A Review of Literature Using CREF Data", in: *Schwartz, A.* and *Kapplin, S.* (eds) *Alternative Ideas in Real Estate Investment*, Dordrecht and Boston: Kluwer Academic Publishers.

Geltner, *D. M.* (1993): "Estimating Market Values from Appraised Values without Assuming an Efficient Market", in: Journal of Real Estate Research, 8 (3), 325-345.

Geltner, *D. M.* (1999): "Appraisal Smoothing: The Other Side of The Story – A Comment", Working paper, University of Cincinnati.

Gilberto, *S. M.* (1993): "Measuring Real Estate Returns: The Hedged REIT Index", in: Journal of Portfolio Management, Spring 1993, 94-99.

Goetzmann, *W.*; *K. G. Rouwenhorst* (1999): "Global Real Estate Markets – Cycles and Fundamentals", Working Paper, Bradford Case, Yale University.

Hartzell, *D.*; *J. S. Hekman*; *M. E. Miles* (1986): "Diversification Categories in Investment Real Estate", in: AREUEA Journal, 14, 230-253.

IPD (2001): "Understanding the new formula for annual total return to be introduced in U.K. annual benchmark and market reports with effect from December 2001", in: IPD Technical Note, Re-issued December 2001.

Jarque, *C. M.*; *A. K. Bera* (1987): "A Test for Normality of Observations and Regression Residuals, in: International Statistical Review", 55, 163-172.

Lai, *T.-Y.*; *K. Wang* (1998): "Appraisal Smoothing: The other Side of the Story", in: Real Estate Economics, 26 (3), 511-535.

Liang, *Y.*; *J. R. Webb* (1996): "The Hedged REIT Index and Mixed-Asset Portfolios", in: Journal of Real Estate Portfolio Management, 2 (1), 55-61.

Liu, *C.* (1988): "Market Imperfections, Omitted Asset Markets, and Abnormal Real Estate Returns", Ph. D. Diss., University of Texas at Austin.

Malevergne, *Y.*; *D. Sornette* (2002): "Investigating Extreme Dependencies: Concepts and Tools", working paper, University of Nice.

Maurer, *R.*; *S. Sebastian*; *T. G. Stephan* (2000): "Immobilienindizes im Portfolio-Management", in: Deutsche Gesellschaft für Versicherungsmathematik (ed.), Investmentmodelle für das Asset-Liability-Modeling für Versicherungsgesellschaften, 255-283.

Maurer, *R.*; *F. Reiner* (2002): "International Asset Allocation with Real Estate Securities in a Shortfall Risk Framework: The Viewpoint of German and U.S. Investors", in: Journal of Real Estate Portfolio Management, 8 (1), 27-43.

Maurer, *R.*; *S. Sebastian* (2002): "Inflation Risk Analysis of European Real Estate Securities", in: Journal of Real Estate Research, 24 (1), 47-77.

Maurer, *R.* and *T. Stephan* (1995): "Immobilien-Rendite-Benchmark für deutsche Fonds", in: Die Bank, 491-495.

Morrell, G. (1991): "Property Performance Analysis and Performance Indices: A Review", in: Journal of Property Research 8 (1), 29-57.

Norman, E. J.; *G. S. Sirmans*; *J. D. Benjamin* (1995): "The Historical Environment of Real Estate Returns", in: Journal of Real Estate Portfolio Management, 1 (1), 1-24.

Newell, G.; *J. MacFarlane* (1995): "Improved Risk Estimation Using Appraisal Smoothed Real Estate Returns", in: Journal of Real Estate Portfolio Management, 1 (1), 51-57.

Newell, G.; *J. Webb* (1996): "Assessing Risk for International Real Estate Investments", in: Journal of Real Estate Research, 11 (2), 103-115.

Myer, F. C. N.; *J. Webb* (1994): "Statistical Properties of Returns: Financial Assets Versus Commercial Real Estate", in: Journal of Real Estate Finance and Economics, 8 (3), 267-282.

Pagliari, J. L. Jr.; *F. Lieblich*; *M. Schaner*; *J. R. Webb* (1998): „Twenty Years of the NCREIF Property Index", working draft, SSR Realty Advisors.

Pitman, E. J. G. (1937): "Significance Tests Which May be Applied to Samples from any Populations. II. The Correlation Coefficient Test", in: Supplement to the Journal of the Royal Statistical Society 4 (2), 225-232.

Pyhrr S. A.; *S. E. Roulac*; *W. L. Born (1999)*: "Real Estate Cycles and Their Strategic Implications for Investors and Portfolio Managers in the Global Economy", in: Journal of Real Estate Research, 18 (1), 7-68.

Randles, R. H.; *M. A. Fligner*; *G. E. Policello II*; *D. A. Wolfe* (1980): An Asymptotically Distribution-Free Test for Symmetry Versus Asymmetry, in: Journal of the American Statistical Association 75 (369), 168-172.

Richardson, J. W. (2002): "Simulation for Applied Risk Management", Department of Agricultural Economics, Texas, A&M University.

Ross, S. A.; *R. Zisler* (1991): "Risk and Return in Real Estate", in: Journal of Real Estate Finance and Economics, 4, 175-190.

Royal Institution of Chartered Surveyors (RICS) Report (1994): "Understanding the Property Cycle", Main Report: Economic Cycles and Property Cycles, London: The Royal Institution of Chartered Surveyors.

Sirmans, G. S.; *C. F. Sirmans* (1987): "The Historical Perspective of Real Estate Returns", in: Journal of Portfolio Management, 13 (3), 22-31.

Stevenson, S. (2000): "International Real Estate Diversification: Empirical Tests Using Hedged Indices", in: Journal of Real Estate Research, 19 (1), 105-131.