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Financial Characteristics of International Real Estate Returns: Evidence from the UK, US, and Germany

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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 of national and international asset allocation decisions. However, the special characteristics of real estate assets are quite distinct from that of financial assets, such as stocks and bonds. This is also the case for real estate return distributions. Therefore, the proper integration of real estate markets into asset allocation decisions requires profound understanding of real estate returns' distributional characteristics .

Because of the particular characteristics of real estate, representing real estate markets through reliable a time-series is a complex task. Consequently, reliable real estate indices with a sufficiently long history in major international real estate markets are only scarcely available. Most of the research that has been done on real estate returns was done for the U.K. and U.S., where eligible indices exist. On the other hand, in other important real estate markets, such as Germany, either little or no research has been performed.

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 will be applied. This approach is solely based on publicly available data from German open-ended real estate investment trusts. It could also provide a solution to deriving a reliable real estate time-series for other markets.

We will extend previous analyses for the U.K. and U.S. to provide additional fundamental insights into the return characteristics of the German commercial real estate market. Despite univariate considerations, the main focus is the interrelationships between various international real estate markets, as well as between those respective markets and the international stock and bond markets.

1 Introduction

International financial market crises in recent years have 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] Evidence also demonstrates that real estate returns show low co-movements with both alternative asset classes and other real estate markets. A review in *Fletcher* (1995) of studies using CREF data indicates low correlations between commercial real estate and stocks and bonds on the U.S. national level. *Stevenson* (2000), using hedged indices, found very low return correlations within international real estate markets. Therefore, real estate could be an interesting factor for the national and especially international asset allocation decisions of an institutional investor.

Proper integration of real estate markets in the asset allocation process requires significant understanding of real estate returns' distributional characteristics. Regarding aggregated level real estate returns, real estate markets, especially the U.S. and the U.K., were the subject of several studies. Unfortunately, only a relatively small amount of research covers other major international real estate markets. This is mainly due to the poor availability of adequate time-series. While suitable real estate time-series with a reasonable history exist, particularly for the U.K. and U.S., this is not necessarily the case for other important international real estate markets, such as Germany.

This study builds upon previous research and provides further valuable insights into the distributional characteristics and interrelationships of the U.K., U.S., and German commercial real estate markets relative to each other, and relative to other asset classes. To represent the German real estate market, an index has been applied, based on the methodology of *Maurer, Sebastian* and *Stephan* (2000), which is closely related to more costly real estate indices such as the IPD or NPI. The index is an appraisal-based type, but it is founded solely on publicly available information, in contrast to other major appraisal-based indices. The index methodology could also be applied to other countries, providing a solution to generating reliable real estate time-series.

This paper is subsequently organized into three parts: sections 2,3 and 4. Section 2 provides a general overview of major approaches to representing real estate market performance with real estate indices. The major appraisal-based indices for U.K. and U.S. commercial real estate markets are discussed in detail. Finally, an alternative methodology for generating an appraisal-based real estate index, based solely on publicly available information for Germany, is provided. Section 3 provides univariate and multivariate analyses for statistical properties of the commercial real estate market's return distributions in the U.K., U.S. and Germany. Finally, Section 4 contains a summary and main conclusions.

2 Representing Real Estate Market Returns

2.1 Real Estate Market Proxies

Generally, index development for asset markets is as follows: after specifying the relevant market and selecting a representative sample of assets from this market which proxies

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[1] A recent extensive and systematic review of literature concerning direct or indirect 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).

the performance of the entire market, the 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 values of sample assets, at different equidistant points in time. In contrast to stock and bond markets, several problems occur in the development of a real estate market index . The difficulties arise from two special properties characteristics. The uniqueness of each property, and thus induced heterogeneity of real estate markets, make it difficult, if impossible, to select a representative sample of the underlying market (risk of market tracking error). Single property transactions mostly occur infrequently. Moreover, 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 far less accurate than proxying stock and bond market performance.

To avoid some of these problems, several ways to indirectly derive real estate market indices 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 a possible proxy for direct real estate market performance. Relying on capital market theory, *Gilberto* (1990), *Liang* and *Webb* (1996) and *Stevenson* (2000) use hedged indices, derived from real estate securities, to assess the relevance of real estate markets in national and international asset allocation. The use of publicly available data diminishes the problem of poor data availability on actual properties. However, all of these approaches have one thing in common: they act 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 real estate markets under investigation. Besides the limitations of these real estate market proxies, they can indeed provide a useful means of assessing questions related to the performance of broad real estate markets, if more elaborate indices are unavailable.

A more direct and more costly way to develop real estate indices is the use of transaction or appraisal-based real estate data on actual properties. Transaction-based indices suffer from infrequent single property transactions 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. Combined with the heterogeneity 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; however, the application requires additional data and assumptions. Due to the lack of available data, transaction-based indices are mainly applied to small sub-markets.

To cover a broad segment of a real estate market through a direct real estate index, the application of appraisal-based indices proved 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 heterogeneity of a broad real estate market, a large index portfolio comprising of a large portion of all properties is required. Additionally, the appraisal of single properties is a difficult and expensive task, and thus, appraisal based indices are usually calculated using properties that must be regularly appraised due to legal requirements. (e.g. the properties held by institutional investors) The restriction of sample selection of such properties itself causes market tracking errors. However, if the sample is relatively large compared to the total market under consideration, this problem becomes less important. In any case, a large sample size for the index-portfolio is preferable, since this increases the likelihood that the index does not represent the specific risk of a single property, but rather the systematic risk of the observed real estate market in its entirety.[2]

The suitability of direct applications of appraisal-based indices used as proxies for actual property performance has received much attention in 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 be corrected for the so-called "smoothing issue", in order to reflect actual real estate market performance. For this purpose, they provide different methodologies based on several assumptions about the appraisal process, index development 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 independent 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 of 236 complete real estate portfolios with 11,900 properties in the U.K. worth € 162.2 billion. This accounts for about 75% of all U.K. institutional investors' real estate investments. The index is a value-weighted total return index of directly held, un-leveraged properties with a base of 100 starting at December 31, 1980. In December 2001, IPD switched their index methodology for calculating annual total returns to chain-linking time-weighted monthly returns. Before that, the annual returns were calculated as year-to-year money-weighted returns, due to the poor availability of monthly data.[5]

This change in methodology for the annual index now provides more 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 un-leveraged total return index. Capital growth and income return indices, as well as sectored and geographical sub indices, are also provided by IPD.

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

[3] For a critical view regarding correcting for appraisal smoothing, see *Lai* and *Wang* (1998). However, it should also be mentioned, *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).

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 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 3,880 investment grade properties which were appraised at $125.38 billion. The index is an un-leveraged 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 sub index. Sub indices for property type (apartment, industrial, office, and retail properties) and geographical area (West, Midwest, East, and South) are also available.[6] As the underlying properties are generally appraised once a year, the NPI is more an annual index which is partly updated quarterly.

German Appraisal Based Property Indices

In contrast to the U.K. and U.S., the German commercial real estate market (i.e. apartment, office, and retail properties) has no broad diversified index with a sufficiently long history available. Alongside some smaller providers, the *Deutsche Immobilien Datenbank GmbH* (DID) was founded in 1998.[7] The DID mainly collects data from insurance companies and open-ended real estate investment funds. The main commercial property index of the DID is the 'Deutscher Immobilien Index' (DIX), a money-weighted total return index on a year-to-year basis. According to DID, at the end of 2001, the DIX comprised of 2,754 properties (apartment, retail and office) with an appraised value of about € 36 billion, 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.

An alternative and indirect approach to deriving an appraisal-based real estate index for Germany was suggested by *Maurer* and *Stephan* (1995) and updated by *Maurer*, *Sebastian* and *Stephan* (2000). This approach suggests exclusively using publicly available information from German open-ended real estate investment funds. German open-ended real estate investment funds are a core 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, they also usually hold considerable portions of interest bearing assets, such as 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 adjusting the redemption-price returns on real estate investment funds for the portion of returns which are non-real estate induced, in order to arrive at an un-leveraged appraisal-based real estate total return index.

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[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.

Dependent on the remaining time to maturity, three classes of interest-bearing assets are defined: money market deposits (money), and interest bearing assets with, at the 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 corresponding 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:

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

where $x_{i,t}^{Money}$, $x_{i,t}^{A1}$, and $x_{i,t}^{A2}$ represent the proportion of total wealth of the company 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:

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

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.

By applying this methodology *Maurer*, *Sebastian,* and *Stephan* (2000) generated an (unleveraged) appraisal-based real estate total return index for Germany on a monthly basis, the IMMEX. The IMMEX covers a time period from January 1980 until today. As the NPI, the IMMEX represents an annual index which is 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
	(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 persistently low magnitude and low volatility. Additionally, there are no big differences in the magnitude and trend of the IMMEX as opposed to the more comprehensive DIX. The slight differences between DIX and IMMEX can probably be traced back to the different real estate portfolios that the indices cover.

The major drawback of the IMMEX is that no distinction is possible between the different investment sectors (apartment, office, and retail properties) or local markets. 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 until today the IMMEX is the only broad commercial real estate index available for Germany with a sufficiently long history.

3 Empirical Analyses

3.1 Data

For the analyses in the remainder of this paper, the following time-series were used, covering the time period January 1987 to March 2002. Representative of the respective stock and bond markets, the MSCI monthly gross indices and the Salmon Brothers Government Bond Indices 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. To analyze 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 than the bond and real estate markets. The real estate market return fluctuations are in approximately the same range as those of the bond markets; however, 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 the return curves for the U.K. and U.S. real estate markets indicate somewhat similar runs, 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 considered for each country, the mean returns and standard-deviations from the stock markets were always far higher than those from the corresponding bond and real

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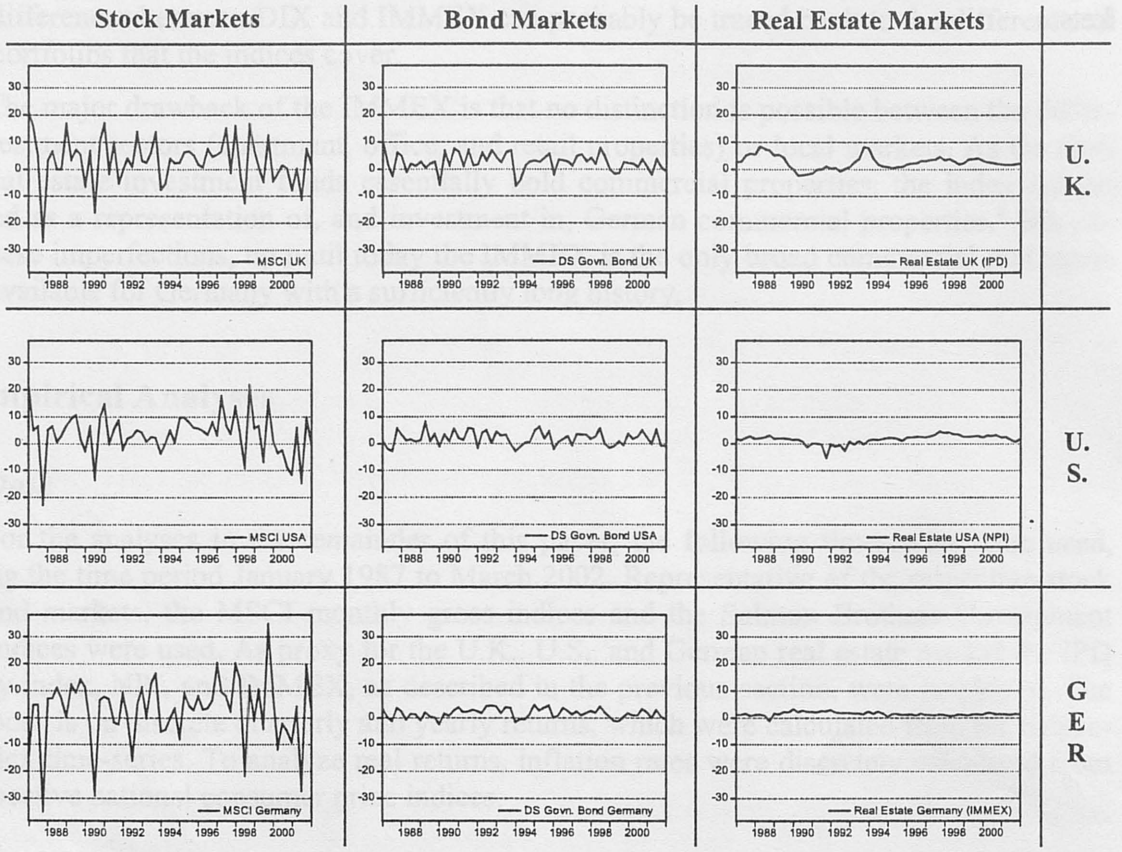
[9] One further approximation of the IMMEX should be mentioned. The portion of non-domestic real estate asset holdings of German open ended real estate investment funds has continuously been increasing in the last years. Thus, for the more recent years IMMEX returns are slightly diluted by foreign real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

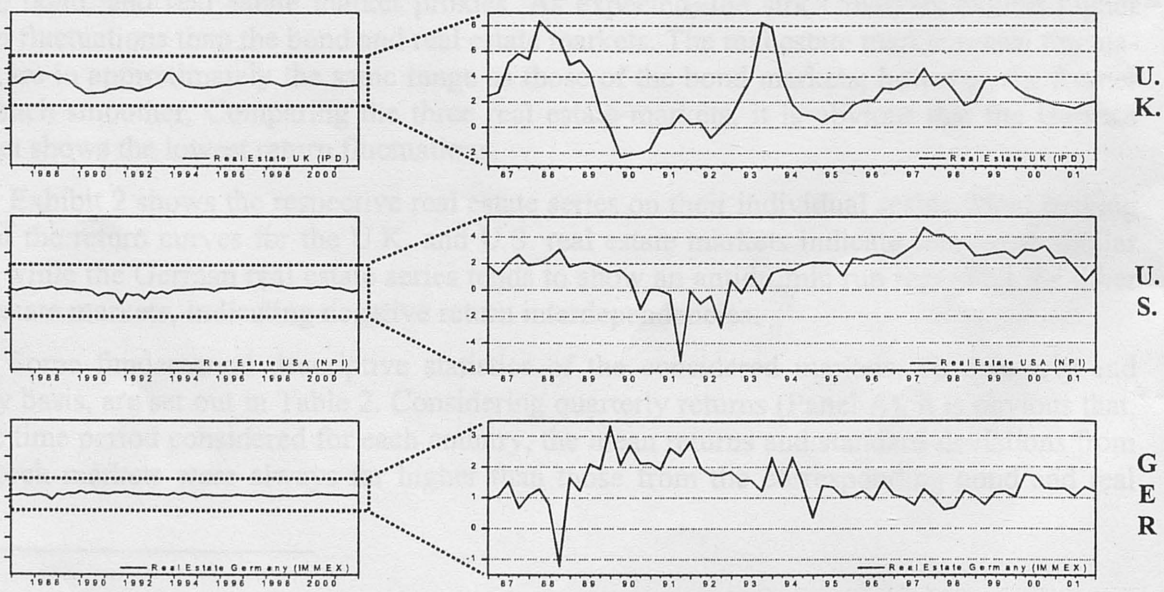
estate markets. The mean returns from the real estate markets were, for all countries, equal to or slightly lower than that of the corresponding bond markets. However, the standard deviations from these real estate time-series were far smaller than those found for the bond markets.

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. As in the case of bonds, the U.K. real estate market exhibits a substantially 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 the lowest standard deviation by far.

Table 2: Selected Descriptive Statistics on U.K., U.S., and German 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 mean returns of the stock, bond, and real estate markets are hardly altered. Again, the stock markets show much higher mean returns than the corresponding bond and real estate markets, while the means from the real estate markets are equal to, or slightly lower than, that of the corresponding bond markets. However, while the standard deviations from the stock markets are still considerably higher than those of the corresponding bond markets, the standard deviation from the yearly U.K. and U.S. real estate series are equal to, or higher than, those of the corresponding bond markets. The exception is the German real estate series, which still shows considerably lower volatility than the German bond market.

Examining this phenomenon more closely, 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 observations should be about the approximate theoretical value of 2.[10] This is true for all stock markets, as well as the U.K. and U.S. bond market. On the other hand, all real estate series and the German bond market show SDRs that are considerably higher than 2, indicating vio-

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[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.

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

In Table 3 further distributional statistics and tests for the quarterly time-series are tabulated. Considering skew and excess-kurtosis of the different quarterly series, there are tendencies for all observed stock markets to be skewed significantly leftward and leptokurtic. The skewing 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 skewed leftward and considerably leptokurtic, the German real estate market does not show much skewing, but it is significantly leptokurtic. U.K. real estate shows neither significant excess-kurtosis, nor significant skewing.

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
Skewing		**-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, *Jarque/Bera*, *Anderson/Darling*, and *Shapiro/Wilk* tests were applied. A "*" indicates that at least one of the 3 tests was able to reject the null of normality at least at the 5%-level. AC 1-4 is the empirical auto correlation coefficients for lags 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.

The assumption of normally distributed returns is central to the application of modern capital market theory. Three normality tests were applied: the *Jarque/Bera*-test, the *Anderson/Darling*-test, and the *Shapiro/Wilk*-test. In Table 3, the series in which at least one of these tests was able to reject the null of normality, minimally at the 5%-level, are marked with a "*". While none of the stock markets and the U.S. and German real estate market showed

[11] Estimating yearly variance by multiplying quarterly variance by two, fails in the presence of autocorrelation and thus 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.

normality, the null of normality could not be rejected for all bond markets and the U.K. real estate market.

However, due to the apparent autocorrelation, the inferences about skewing, excess kurtosis, and normality for the real estate series should be interpreted cautiously. Consistent with the weak form of market efficiency, the various bond and stock markets do not exhibit significant autocorrelation, although 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, with no autocorrelation up to lag 4 could be rejected for all real estate series at 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 examining 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 non-stationarity, nor reject the null of stationarity at reasonably significance levels.

Considering yearly returns again, it is obvious from Table 4 that all of the series no longer show significant skewing or excess-kurtosis. For all series, these moments are much closer to zero than 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
Skewing		-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	1	-0.18	0.12	-0.15	-0.26	**-0.53**	-0.21	0.35	**0.78**	**0.53**
Lag	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.

The inferences about normality are also altered. The null of normality for yearly returns could not be rejected for all bond, stock, and real estate markets at the 10% level. It is also evident that, for yearly returns, significant autocorrelation for German and U.S. real estate returns is still observable, but only for lag 1. The U.K. real estate market no longer shows significant autocorrelation. Additionally, while the U.S. bond market does 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. Moreover, 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 are tabulated between U.K., U.S., and German real and nominal real estate returns, as well as the corresponding inflation rates. For the U.K. and U.S. real estate markets, no significant contemporaneous or cross-correlation could 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, a significant negative contemporaneous relationship between the deflated real estate returns and inflation for all countries appears to exist. It seems 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 a significant interrelationship between inflation and German (nominal) real estate returns appears.

These findings are also confirmed through the distributional statistics as presented in Table 6. While there are mostly only marginal differences between skewing, excess kurtosis, autocorrelation structure and stationarity inferences for real returns (Table 6) and nominal returns (see again Table 3), considerable changes appear 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 for at least four lags. According to Table 6, it is clear that, after deflating, the German real estate series no longer exhibits significant autocorrelation, which is

[12] To see this, suppose that the discrete nominal real estate return R and the discrete inflation rate I in any 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.

also confirmed by the *Box/Lijung* Q-test. Additionally 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.

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
Skewing		**-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	1	-0.08	-0.11	-0.07	0.01	0.00	0.20	**0.82**	**0.68**	0.14
Lag	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
Skewing		-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	1	-0.20	0.11	-0.13	-0.27	**-0.58**	-0.27	0.37	**0.81**	0.16
Lag	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. As in the case of deflated monthly returns, the results are hardly altered, relative to the 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 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 with the corresponding statistics based on nominal returns, (Table 2) there are only slight differences, with the exception of the mean returns, which are considerably smaller for all series through deflating. While, in nominal terms, German real estate clearly showed 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 could observe that there is little influence of inflation on stock and bond market returns. This also holds true 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 seems that there is a strong effect of inflation on real estate returns in Germany.

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 development. To address this issue, the next section analyzes unsmoothed real estate returns.

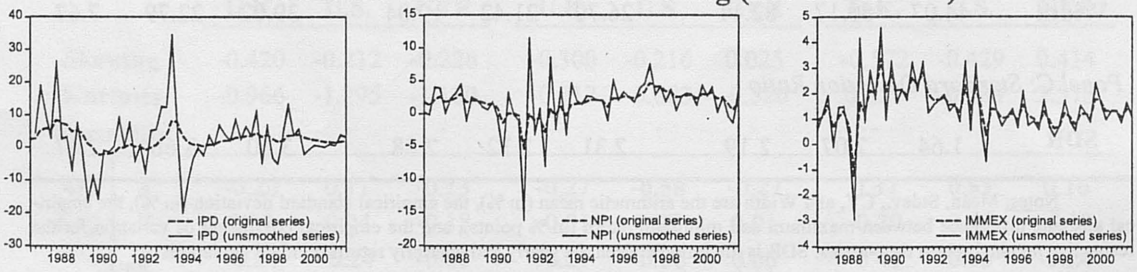
3.2.3 Analysis of Un-smoothed Returns

There is a wide consensus in literature, that returns calculated from appraisal-based real estate indices incorrectly reflect the (unobservable) actual returns of the underlying real estate markets. The use of previous valuations in generating actual valuations and the temporal aggregation of valuations, which occur mostly once a 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 exist, which rely on different assumptions to correct appraisal-based real estate series for smoothing effects and to generate the true series. The choice of an appropriate un-smoothing procedure is always somewhat arbitrary. In this section, the *Blundell/Ward* (1987) un-smoothing methodology was applied to address the issue of analyzing un-smoothed real estate returns. This methodology assumes that the real estate markets are - at least - weakly information efficient, i.e. the respective real estate return time-series should be not serially correlated. In technical terms, this approach tries to correct the original series for serial correlation in order to arrive at an un-smoothed (not serial correlated) series. Therefore, an AR(1)-process is assumed for the original series. The hypothesis of a weak form of market efficiency for real estate markets is questioned by more current research. On the other hand, as already mentioned, the choice of the appropriate un-smoothing methodology is always somewhat arbitrary. Furthermore, the *Blundell/Ward* (1987) procedure is an easy approach to use, which should be able to neutralize a large portion of smoothing effects in the considered real estate series.

Exhibit 3 shows the original and un-smoothed quarterly nominal real estate return series for the U.K., U.S., and Germany. As expected, the un-smoothed series exhibit much more volatility than the original series, the high's and low's are of considerably more magnitude.

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



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

Comparing the un-smoothed real estate returns from Table 9 with the original series in Table 2, it is obvious that the un-smoothed returns are much more volatile than the original ones. The standard deviation for un-smoothed quarterly U.K., U.S., and German real estate returns is about 264%, 132%, and 65% higher than for the original series. After un-smoothing, the quarterly standard deviation of the IPD is somewhat higher than those of the corresponding stock market series. Additionally, the NPI series is between the corresponding bond and stock market series. Also, for the German series, the quarterly standard deviation increases about 65%, but it still remains much lower than the standard deviation from the German bond and stock market series. For yearly returns, through un-smoothing, there is a growth in standard deviation of about 47%, 196%, and 90% for the U.K., U.S., and Germany relative to the original series observable.

Table 9: Selected Descriptive Statistics on U.K., U.S., and German Un-smoothed (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 than the yearly U.S. stock market's standard deviation.

Considering the autocorrelation coefficients for the un-smoothed quarterly and yearly real estate series, as given in Table 10, it is clear that un-smoothing eliminated a large proportion of the serial correlation in the original series. Autocorrelation can no longer be observed for annual returns.

Table 10: Distributional Statistics and Tests for Un-smoothed Nominal U.K., U.S., and German Real Estate Returns.

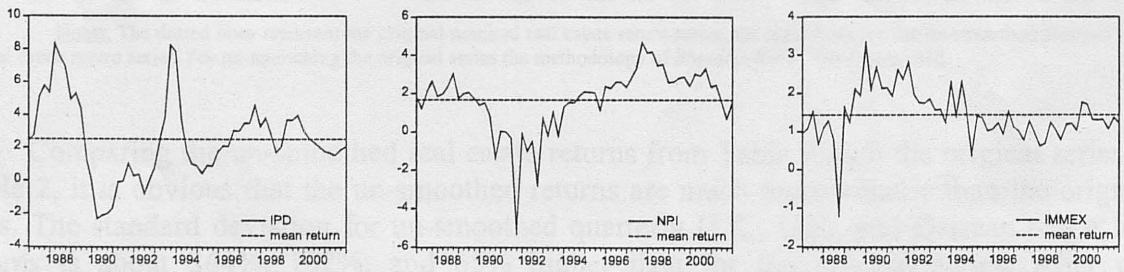
		Quarterly Returns (I/1987 - I/2002)			Yearly Returns (1987 - 2001)		
		U.K.	**U.S.**	**GER**	**U.K.**	**U.S.**	**GER**
Skewing		**0.613**	**-1.692**	**-0.46**	0.037	-0.798	0.416
Kurtosis		**2.821**	**6.920**	**4.513**	0.674	-0.351	-0.409
Normality		*	*	*	-	-	-
AC	**1**	**0.30**	**-0.30**	-0.06	0.06	0.41	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 around 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, which indicates 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 the 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 means 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 fit to the respective real estate time-series via ols-regression:[15]

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

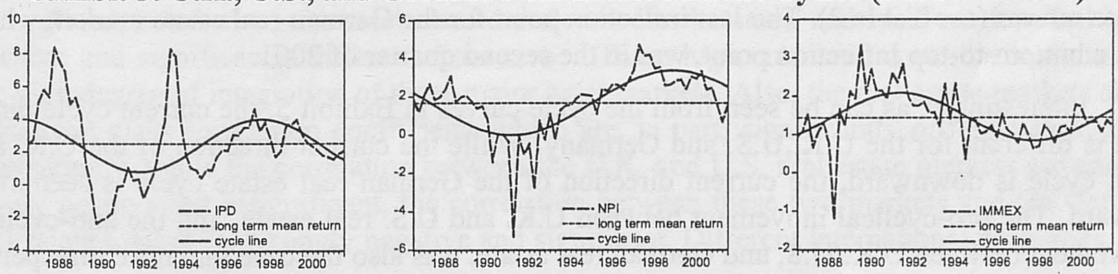
The a's are regression coefficients and t is the time index, i.e. $t = 1, 2, 3, \ldots$ for the first, second, third, ... observation. SL is the season period parameter, and CL the cycle period ("cycle length") parameter, i.e. the cycle length is $CL/4$ years for quarterly data.

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, proved most adequate for the considered real estate time-series. Also, various fitting criteria were applied and evaluated. The MAPE (mean percentage squared error) was most adequate and indicated nearly the same results, as e.g. the R^2-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 suggested partly substantially different fits. The U.K. cycle curve in Exhibit 5 provides the best trade-off between the respective criteria.

Table 11 reports some fitting criteria and several cycle statistics for the optimally fitted real estate cycle curves. As can be seen from the MAPEs, R^2s, 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 the MAPEs are very low for the U.S. and Germany, 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 of the U.S. and Germany.

Table 11: Cycle Statistics - U.K., U.S., and Ger. Real Estate Market (I/1987 - I/2002).

	MAPE	R^2	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 R^2 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 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 from 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 pro-cyclical movement between U.K. and U.S. real estate, and the anti-cyclical movement between U.K./U.S. and German real estate, was also the case for entire time period considered. The real estate markets in U.K. and U.S. exhibit high positively 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 entire 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 change 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 co-movements are. One important measure of overall return interdependency is Pearson's Product Moment Correlation Coefficient, which measures the degree of linear interdependency. Table 12 shows the short-term correlation matrix for the considered international asset markets on quarterly nominal basis.

Table 12: 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, in part, significantly different from zero. Interestingly, while the correlation between the U.K. and U.S. real estate markets are considerably positive but insignificant, the correlation between these two markets and the German real estate market are strongly negative and significant. Different international properties, and

[17] All analyses in the following sections are done on the 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 independent of the reference currency of the investor and so they hold for every (perfectly hedged) investor independent 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 auto-correlated. 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 auto-correlated 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 proved 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 for control of the 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.

through this also international real estate markets, are not close substitutes for each other. This, in turn, suggests that the returns of these asset markets should be independent. 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 the 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 significantly different from zero. The average correlation is approximately zero. One the other hand, each real estate market exhibits considerably negative correlations with every bond market, even when these correlations are not all 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 sub-periods of approximately equal length. Table 13 shows the results of the sub-period analysis.

Table 13: 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		
	U.S.	-0.11	-0.17	-0.01	-0.24	-0.22	**-0.42**	0.49	1	
	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		
	U.S.	0.07	0.07	0.08	0.20	0.15	0.07	0.66	1	
	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 the correlations between real estate and stock markets, the magnitude of all correlation coefficients is about the same in both sub-periods and in the total period. Additionally, none of the coefficients are different from zero at reasonable levels of significance. These findings provide evidence of at least a 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 insignificantly different from zero. However, differences in correlations are considerably more significant in the two sub-periods than 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 significantly strong 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, although clearly weaker than in sub-period one and in the total period. Furthermore, 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, cannot perfectly reflect both return drivers, especially appreciation returns. On the other hand this problem should be lowered by considering longer run returns. Table 14 includes the correlation coefficients on yearly basis.

Table 14: 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 proved to be different from zero, at least at the 5% level, are printed in bold types.

Comparing yearly and quarterly returns (Table 12), 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 negatively 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 correlation estimations. Table 15 shows the un-smoothed quarterly correlations between the real estate markets and the other asset markets.

Table 15: Contemporaneous Correlations for Un-smoothed 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 un-smoothing has, by and large, no mentionable effect on the magnitude of these correlations. Again, while the effects of un-smoothing on correlations between real estate and bonds are somewhat higher, they are marginal in the case of real estate vs. stocks. These findings suggest (linear) independence of real estate and stock market returns.

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

3.3.2 Partial Co-movements

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 co-movements in the tails of the total bivariate return distributions only. Due to the limited data available, the key focus will be on probabilities, rather than on co-movement structures.[19] To measure the co-movement of two random variables in some part of their bivariate distribution, without considering the structure of the co-movement, the concept of conditional probability proves 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 equal to, or below, the c%-percentile on the condition that, at the same time, another random variable Y has (here stock or bond returns, respectively) a realization equal to, 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, $P(X \geq x_c \mid Y \geq y_c) = P(X \geq x_c)$. The LCP(c) and UCP(c) do not, per se, allow for inferences about the statistical dependence and independence of two random variables. However, LCP(c) (UCP(c)) are useful measures to quantify the risk (opportunity), for example, 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 eCP's are estimations of the true CP's. Due to the small quarterly database, these estimations have high standard errors, whereby the higher they are, the smaller the percentile considered. So the eCP's should be interpreted carefully.

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

As can be seen from Table 16, the eLCP(20) and eLCP(10) for the U.K., and especially the German real estate market, are of considerable magnitude, depending upon the respective stock market returns. In quarters where the U.K./German stock market returns are low to very low, there is also a considerably high probability that the corresponding real estate market returns are also relatively low to very low. 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 does not necessarily tend to put out low to very low returns when this is true for the U.S. stock market.

eUCP(20) and eUCP(10) - the tendency for real estate to have high to very high returns, while the corresponding stock markets perform well to very well - is lower than the corresponding eLCP, or even zero. In other words, in times of high stock market performance, the

[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.K. and German real estate market do not usually show their best performance. Again, the U.S. real estate market is an exception. Its eUCP(20) and eUCP(10) are relatively high compared to the U.K. and German real estate market.

In quarters when bond market returns are low to very low, real estate markets tend to perform better. In other words, real estate markets, in most cases, seem to be a better alternative investment when bonds are performing weakly. If bond market returns are high, then the eUCP's for U.K. and U.S. real estate markets are high, while those of the German real estate market are low.

Table 16: 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 Dependent on Stock Market Returns					
IPD Returns Dependent on MSCI U.K. Returns					
16.67	25.00	46.67	51.61	23.08	0
NPI Returns Dependent on MSCI U.S. Returns					
0	8.33	53.33	56.25	30.77	28.57
IMMEX Returns Dependent on MSCI Germany Returns					
33.33	33.33	43.33	46.88	15.38	0
PANEL II: Real Estate Returns Dependent on Bond Market Returns					
IPD Returns Dependent on DS Government Bond U.K. Returns					
16.67	8.33	40.00	45.16	23.08	14.29
NPI Returns Dependent on DS Government Bond U.S. Returns					
0	16.67	53.33	56.25	15.38	14.29
IMMEX Returns Dependent 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, un-smoothing has a strong effect on volatility and correlations. Table 17 illustrates that un-smoothing also seems to have some effect on LCP. Again, while the effects are somewhat similar for the U.K. and Germany, they are different for the U.S. real estate market. The un-smoothed real estate returns for the U.K. and German real estate markets show equal or lower LCP(20)s and LCP(10)s, dependent on the stock market returns, while they are higher if dependent on the bond markets. The opposite holds true for the un-smoothed U.S. real estate returns. The effects of un-smoothing on the UCPs dependent on the stock market returns are more drastic and in the same direction for all real estate markets. After un-smoothing, the eUCP(20)s and eUCP(10)s are clearly lower for all real estate markets. On the other hand, the eUCPs dependent on the bond market returns are not, or only slightly, altered.

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

Lower Percentiles			Upper Percentiles		
10%	**20%**	**50%**	**50%**	**80%**	**90%**
PANEL I: Real Estate Returns Dependent on Stock Market Returns					
IPD Returns Dependent on MSCI U.K. Returns					
0	25.00	50.00	54.84	7.69	0
NPI Returns Dependent on MSCI U.S. Returns					
0	16.67	46.67	53.13	0	0
IMMEX Returns Dependent on MSCI Germany Returns					
16.67	33.33	53.33	56.25	7.69	0
PANEL II: Real Estate Returns Dependent *on Bond Market Returns*					
IPD Returns Dependent on DS Government Bond U.K. Returns					
33.33	16.67	40.00	41.94	23.08	14.29
NPI Returns Dependent on DS Government Bond U.S. Returns					
0	8.33	46.67	50.00	23.08	0
IMMEX Returns Dependent 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 a sufficiently long history, for Germany an indirect appraisal-based index, the IMMEX, was employed. Quarterly and yearly analyses 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 around the volatility of the corresponding bond markets, or after un-smoothing, even around the corresponding stock markets' volatility. In contrast, the 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. This 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 markets could be detected. Furthermore, while currently U.K. and U.S. real estate exhibit pro-cyclical behavior, German real estate is currently anti-cyclical relative to the U.K. and U.S. real estate markets.

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

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

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

APPENDIX A

Table 18: Percentile Returns (II/1987 to 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 Un-smoothed IPD Returns									
-15.79	-8.04	-3.03	2.49	2.49	7.07	11.50	13.37	-20.01	34.59
Quarterly Nominal Un-smoothed 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 Un-smoothed 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 19: Relative Frequencies in Several Percentiles of the Monthly Real Estate Market Return Distributions Conditional to the Monthly Nominal Stock Market Return Distribution (Jan. 1987 to 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 20: Relative Frequencies in Several Percentiles of the Monthly Real Estate Market Return Distributions Conditional to the Monthly Nominal Stock Market Return Distribution (Jan. 1987 to 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.

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