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Editorial

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Prof. Dr. K.-W. Schulte
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Would you like to learn something about "spillover" effects in the international real estate stock markets? Are you a property investor interested in public-private partnerships? Are you not au-fait with the way the life-cycle yield of a real estate investment is calculated?

If your answer to these three questions is "yes", this edition of ZIÖ is just what you are looking for. If not, you should at least skim through the contributions - and you are sure to find things worth reading in the other sections.

Some details of the three main papers:

The first paper, „Spillover Effects between International Real Estate Stock Markets" by Dr. Felix Schindler, is particularly suitable for so-called „quants", devotees of quantitative research methods. It describes an analysis of the characteristics of volatility and the interdependencies between markets, investigated using a total of 14 national indices.

The pertinent questions asked in Dr.-Ing. Susann Cordes's paper are:

What role can real estate investors take in the PPP market and in which projects should they invest? The author provides specific policy recommendations for suitable contract formulations and types of real estate and also gives suggestions for the improvement of the legal framework for open-end real estate funds and PPP mutual funds.

The subject of the paper by Dr.-Ing. Raoul Rudloff is "Life Cycle Calculation using a Modular and Process-oriented Model". This presents a possibility for assessing the life cycle of a building on a financial basis. It uses the "life cycle yield", comprising the components "life cycle costs" (construction and operation) and "life cycle returns". The procedure that has been developed links the calculations of construction costs and operating costs with each other. Taking into account the attractiveness of the property, the returns are defined, to ensure that, even at the first stages of planning, a comprehensive examination of the life cycle can be carried out.

During the gif doctoral candidates' seminar and the gif higher education lecturers' conference on 22/23 April, the editors of the Journal of Interdisciplinary Property Research will also be meeting, to discuss the further development of ZIÖ. Suggestions from gif members will be gratefully received.

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Spillover Effects between International Real Estate Stock Markets

Spillover-Effekte an den internationalen Immobilienaktienmärkten

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Zusammenfassung
Während für die breiten Aktienmärkte die Existenz von Autoregressive Conditional Heteroscedasticity (ARCH-) Effekten und deren Modellierung vielfach untersucht wurde, analysiert der vorliegende Beitrag das Volatilitätsverhalten an den internationalen Immobilienaktienmärkten. Dabei ist festzustellen, dass auch für die untersuchten Länderindizes die zu den breiten Aktienmärkten analogen ARCH-Effekte des Volatility-Clusterings und einer leptokurtischen Renditeverteilung existieren und sich überwiegend auch ein Leverage-Effekt identifizieren lässt. Nach der Spezifikation eines geeigneten Generalized Autoregressive Conditional Heteroscedasticity (GARCH-) Modells wird gezeigt, dass durch die Berücksichtigung von Spillover-Effekten für 11 von 13 Märkten weitere Verbesserungen in der Modellgüte und Prognosequalität erreicht werden können. Lediglich für die Immobilienaktienmärkte in Australien und den USA wird durch die Implementierung von Spillover-Effekten keine Verbesserung in der Modellgüte und Prognosequalität erzielt. Des Weiteren zeigt sich, dass die Spillover-Effekte in der Mittelwertgleichung wesentlich ausgeprägter sind als in der Varianzgleichung. Trotz der vorhandenen Spillover-Effekte sollten jedoch durch ein global aufgestelltes Immobilienaktienportfolio Diversifikationspotentiale realisierbar sein – auch wenn sie in schwachen Marktphasen geringer ausfallen dürften als in einem positiven Marktumfeld.

Executive Summary
This paper analyses volatility effects in real estate stock markets using selected Generalized Autoregressive Conditional Heteroscedasticity (GARCH-) based models. While several analyses of the volatility effects of international stock markets and spillover effects between national markets have been carried out previously, there are very few studies focusing on international real estate stock markets. This examination is based on a selection of GARCH models for each national market. After specifying an adequate GARCH process, it is shown that spillover effects can still improve the specification and forecasting qualities in 11 out of 13 markets. The two markets where forecasting cannot be improved by adding spillover effects to the variance equation are the Australian and U.S. markets. The results reveal a number of interesting issues in relation to volatility spillovers. Firstly, there are some volatility spillovers between national real estate stock markets. Secondly, there are also effects from broad stock markets. Spillover effects in the mean equation are much stronger than in the variance equation. Despite the spillover effects identified, there should be ample room for diversification of real estate investments. However, there is also some evidence that diversification benefits from real estate stocks are less available when they are most needed.

Keywords: REITs, Real Estate Stock Markets, Spillover, GARCH, Volatility Modelling, Forecasting
JEL-Classification: C22, C53, G11, G15

A. Introduction

Real estate investments and real estate stocks, and REITs in particular, have been attracting more and more investors in the last decade, so that real estate has become a fast growing asset class around the world. The main research has been and still is concentrated on the oldest, largest and most important securitized real estate market, the U.S. This paper expands the perspective to the level of international investors, who are interested in well-diversified real estate or mixed-asset portfolios and in the diversification benefits resulting from real estate stocks. As shown in broad stock market studies, the second moment of the return distribution of stocks and stock indices is not constant over time and therefore, time-varying volatility models, like GARCH models, are capable of capturing these time-varying effects on volatility. The motivation for this paper was derived from observations of the broad stock markets and investors' interest in the diversification benefits of an international real estate equity portfolio.

In the period under consideration, from 1990 to 2006, REIT legislation was introduced in several countries and real estate stocks in general were paid ever-increasing attention by investors in the financial markets. In the same period, in almost all countries the number of listed property companies increased and the market capitalization of the asset class grew continuously, reaching over $ 1,055 billion by the end of 2006, more than double the amount at the end of 2001, only five years earlier.[1] This tendency is not localised or country-specific: it is a worldwide phenomenon. Furthermore, while in 2001 the U.S. had a market share of more than 52% of worldwide listed real estate; by the end of 2006 the Asian and European markets had increased their market share to almost 55%, emphasizing the increasing importance of worldwide real estate equity markets to investors. Average daily trading volume in the Equity REIT sector – at least as reported for the U.S. market by Cotter and Stevenson (2008) – also increased, from approximately seven million shares per day in 1996 to over 40 million in 2005. This changing environment will have central implications for issues such as risk measurement and portfolio management, as it enforces a more integrated view of the real estate stock markets. As mentioned above, the common risk behaviour of the worldwide real estate markets is becoming more crucial. Until now, most research has been focused either on the U.S. market or on particular regions: little attention has been paid to a worldwide perspective, probably due mainly to a lack of available data in the past. This statement does not only apply to the analysis of return and volatility characteristics: it concerns forecasting volatility in particular. As Poon and Granger (2003) mentioned, forecasting volatility is a critical activity in the financial markets and has a wide sphere of influence over a range of topics, including 'investment, security valuation, risk management, and monetary policy making.'[2] This paper therefore presents an overview and comparison of different GARCH specifications for the national real estate markets, from an international perspective. To our knowledge, this is the most comprehensive and geographically extended analysis of the volatility of the real estate stock markets, including spillover effects and volatility forecasting.

The paper is laid out as follows: after reviewing the literature on volatility and spillover modelling for real estate stock markets, section C presents the data analysed and some summarizing statistics. Section D details the theoretical models, before section E presents the empirical results of the model selection and the linkages to other markets. Section F contrasts the forecast quality of models with and without inter-market linkages. Finally, the main results are summarised in section G.

B. Literature Review

The analysis of spillover effects on returns and volatilities – both between national markets and between asset classes – and their consequences for asset pricing and portfolio decision are almost as old as financial research. Central research was carried out by Black (1976) and Engle (1982). While Black (1976) describes the main empirical findings and summarises the key issues, Engle (1982) delivers a theoretical framework for modelling the volatilities of time series in general. In the following decades, innumerable extensions to the basic Autoregressive Conditional Heteroscedasticity (ARCH) model have been formulated and empirically examined for almost all assets (e.g. stocks, bonds, hedge funds), economic variables (e.g. inflation rates, interest rates, exchange rates), and different data frequencies (ultra-high, daily, weekly, monthly).[3]

Concentrating on financial assets, the empirical findings support the existence of ARCH effects in general and the usefulness of GARCH specifications in modelling these effects. For stock markets in particular, evidence of spillover effects is also provided.[4] However, until now, much less attention has been paid to the securitized real estate market. By discussing market integration and in particular linkages between markets and assets, the vast majority of studies in the field of real estate markets have focused on the first moment only. The main examinations of volatilities and spillovers in this sector have focused on the U.S. market and linkages to other U.S. assets, such as different REIT types (e.g. equity, mortgage, and hybrid); various U.S. stock markets, e.g. the S&P 500 Composite, NASDAQ, mid-cap indices; style indices for growth and value; and the bond and treasury bill markets.[5] With few exceptions, e.g. Cotter and Stevenson (2006, 2007, and 2008) and Najand et al. (2006), studies of the U.S. market have been built on low-frequency data such as monthly or quarterly figures.[6] However, in international financial markets, tradable assets should benefit from fast processing of new information and incorporation into the pricing process. Daily data contain more information than lower-frequency data and, therefore, should be able to provide deeper insight into spillover effects. In particular, broad market sentiments and their influence on real estate stocks should play a more significant role, whereas more intuitive and fundamental relationships could disappear in the short run.[7]

In contrast to the analyses related to the U.S. market, fewer examinations have considered the worldwide real estate stock markets and their linkages. Liow et al. (2005) present cross-market dynamics in property stock markets among four Asian and four European markets. By using weekly data, it is shown that mean transmission from Asian to European property stock markets is small, although there is some evidence of significant positive cross-mean spillover in the opposite direction. In terms of volatility transmission, there are only a small number of significant cross-volatility spillover effects and the conditional volatility is principally influenced by its own past. A further study by Hoesli and Serrano (2008), which includes ten real estate stock markets around the world, uses daily data. However, they assumed that the EGARCH model was the correct specification and their results were not controlled for spillover effects. The main limitations in the previous research on spillover effects and volatility modelling of real estate stock markets can therefore be found in the data frequency; the geographic extent of the studies; and the ex-ante assumption that the chosen specification results in the best fit.

The goal of this paper is therefore to present an adequate GARCH specification for each national real estate stock market and to control for potential spillovers, from other real estate markets and the broad stock market, on the basis of daily returns. The study, which concentrates on markets for property stock companies, not including mortgage and hybrid REITs, is based on a period of 17 years: i.e. much longer than earlier studies.

C. Data

The empirical analysis in this paper is based on the FTSE EPRA/NAREIT daily indices between January 1990 and December 2006. With the exception of Canada, the time series contain 4,435 daily data for each market. Due to a lack of data, the analysis of the Canadian market is based on 2,608 daily returns between 1997 and 2006 only.[8] The study covers the following 14 markets: Australia (AUS), Hong Kong (HK), Japan (JAP), and Singapore (SIN) in the Asia-Pacific area; Belgium (BEL), France (FRA), Germany (GER), Italy (ITA), the Netherlands (NL), Sweden (SWD), Switzerland (SWZ), and United Kingdom (U.K.) in Europe; and Canada (CAN) and the U.S. (U.S.) in Northern America. To our knowledge, it is the most comprehensive examination of volatility modelling and spillovers in real estate stock market returns. To avoid influences caused by changes in exchange rates, all returns are calculated in national currencies. When comparing the return and risk characteristics of the national real estate stock market indices, it is noticeable that the development status, the number of listed property companies, and the market capitalisation vary significantly between markets. An overview of the number of index constituents of the national EPRA indices and their market capitalisation measured by the free float is given in tables 1 and 2.[9] In general, both the numbers of real estate companies and the market capitalisation are still relatively low compared to common stock markets. Furthermore, the Anglo-Saxon-oriented markets, as well as the Asian real estate stock markets, seem to be much more developed than the continental Euro-

Table 1: Number of index constituents of the national EPRA indices

Index	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2009
AUS	5	5	7	14	19	17	23	15	30	12	11
BEL	1	2	2	3	3	2	2	4	6	6	6
CAN	1	1	0	0	5	8	8	12	21	16	16
FRA	4	7	9	9	11	6	6	4	10	10	10
GER	3	3	3	4	5	2	2	3	6	8	8
HK	17	26	25	29	19	17	10	11	25	21	21
ITA	2	3	3	4	4	2	2	3	4	3	2
JAP	9	8	11	11	7	8	8	17	26	21	21
NL	5	7	7	8	8	9	7	8	8	7	7
SIN	3	5	7	6	5	5	3	9	13	9	10
SWD	4	6	10	12	17	9	9	5	6	6	6
SWZ	2	2	2	2	2	4	4	4	4	4	5
U.K.	28	28	30	35	42	36	33	29	41	30	28
U.S.	12	19	51	88	106	114	108	110	119	99	98

Notes:
The information is provided by the European Public Real Estate Association (EPRA) and refers to the end of each year. The data for 2009 refers to July 2009.

Table 2: Market capitalisation of the national EPRA indices (€ million)

Index	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2009
AUS	7,714	8,442	10,713	16,781	22,425	25,552	24,408	40,910	74,794	26,093	31,829
BEL	322	361	411	966	1,600	1,110	1,020	1,856	2,775	2,323	2,377
CAN	932	298	n/a	n/a	3,319	7,575	6,872	11,348	22,190	9,416	11,806
FRA	4,561	5,081	6,290	7,071	11,042	9,739	6,448	9,126	20,365	15,651	18,288
GER	932	1,139	1,286	707	2,465	1,583	608	2,010	6,943	1,833	1,720
HK	16,474	39,857	48,697	100,376	51,564	88,313	15,361	24,175	55,154	39,303	69,696
ITA	582	543	415	489	960	1,659	621	1,168	3,321	597	356
JAP	22,493	19,450	27,994	24,495	17,476	24,247	16,391	31,899	78,274	45,360	48,715
NL	4,439	6,904	7,106	8,103	8,352	7,162	6,721	11,216	17,886	6,041	6,393
SIN	3,698	4,495	12,520	13,333	4,947	6,793	1,077	4,006	14,624	7,503	13,563
SWD	3,534	1,347	2,575	3,734	4,785	5,109	3,922	3,953	6,979	3,268	2,922
SWZ	667	467	677	852	1,267	1,707	1,537	2,287	3,563	2,829	3,668
U.K.	13,925	8,616	14,001	20,170	19,284	35,046	28,883	38,126	75,227	17,245	23,103
U.S.	6,130	16,526	38,983	92,900	108,144	135,641	132,785	184,722	287,537	112,883	120,977

Notes:
The information is provided by the European Public Real Estate Association (EPRA) and refers to the end of each year. The data for 2009 refers to July 2009

pean markets. While the market capitalisation and the number of traded companies increased rapidly in the early 1990s, before the onset of the Russian and Asian crises and their contagion effects, the markets in continental Europe grew only hesitantly. Listed real estate companies in many European countries are characterised by low market capitalisation and small trading volumes. Indeed, some national European indices consist of less than ten companies, with a market capitalisation of less than ten billion Euros. However, it seems, that – at least the Dutch and French real estate stock markets, in addition to the market in the U.K., have been characterised by sustainable growth since the bursting of the high-tech bubble at the beginning of the 21st century.

These facts raise the questions: to what extent do the indices really reflect national markets; and how reliable are they? Since 1990, and at least until the onset of the financial crisis, securitized real estate had been a fast growing asset class around the world. By contrast, as can be seen from tables 1 and 2, both the number of real estate companies and their market capitalisation decreased significantly between December 2006 and July 2009 in almost all countries. However, the reduction in the number of listed real estate companies is partly due to some mergers and acquisitions, which can also be an indication that the real estate stock markets are becoming more developed.

Summing up, the data limitations and the heterogeneity between the national real estate stock markets have to be kept track of when interpreting and discussing the results in section E and section F. Some differences in the time series properties between the national real estate markets could be due to these market-specific characteristics.

Table 3 gives a review of the return and risk characteristics of the 14 national real estate stock indices.[10] As can be seen, the performance of the countries' securitized real estate markets is very heterogeneous. While Canada and the U.S. have average daily returns above 0.06%, the Swedish and Japanese markets average only around a tenth of that figure. The three countries with the highest returns (Australia, Canada, U.S.) are those with the longest histories of REIT legislation. It is interesting to note that the markets with the highest returns have the lowest standard deviations, whereas the highest standard deviations are found in the relatively low-returning Asian markets. This may be a result of the domination of the Asian

Table 3: Descriptive statistics for the daily returns of the national EPRA indices

Index	Mean (%)	Min. (%)	Max. (%)	S.D.	Skewness	Kurtosis	JB
AUS	0.059	-5.554	5.278	0.007	0.033	5.885	1,539***
BEL	0.019	-7.833	9.330	0.010	0.368	13.759	21,491***
CAN	0.066	-6.074	5.632	0.009	0.011	8.213	2,953***
FRA	0.052	-4.584	8.326	0.008	0.204	8.916	6,499***
GER	0.035	-21.499	10.812	0.013	-1.180	31.394	150,015***
HK	0.047	-13.991	19.677	0.018	0.168	12.309	16,036***
ITA	0.043	-20.722	14.107	0.015	-0.569	21.632	64,389***
JAP	0.005	-10.671	13.270	0.020	0.519	7.336	3,673***
NL	0.031	-4.933	5.000	0.006	0.103	9.508	7,835***
SIN	0.021	-14.407	22.747	0.020	0.771	14.708	25,770***
SWD	0.007	-18.464	13.830	0.015	-0.246	19.276	48,999***
SWZ	0.026	-6.907	7.745	0.011	-0.124	8.708	6,032***
U.K.	0.037	-5.075	8.829	0.009	0.478	9.263	7,417***
U.S.	0.061	-5.509	4.930	0.007	-0.389	8.242	5,190***

Notes:
Min. and Max. are the minimum and maximum daily returns and S.D. is the standard deviation of the return distribution of the national real estate stock indices. ***, ** and * indicate the rejection of the null hypothesis of the Jarque-Bera test statistic (JB) for normality at the 1%, 5% and 10% levels of significance.

securitized real estate markets by property developers and construction activities. The cash flows of their businesses and consequently their equity returns are therefore more volatile than the REITs and other property companies that are dominated by rental investments.[11]

According to the first two moments of the return distribution, the Australian, Canadian, and U.S. markets appear to be preferable. However, using volatility alone as a measure of risk can only be justified if it can be assumed that the observed returns are normally distributed. However, according to the test statistics of the Jarque-Bera normality test, the null hypothesis of normally distributed returns is rejected for all indices at the 1% level of significance.[12] The third and fourth moments emphasize these findings. The evidence of leptokurtosis or positive excess kurtosis of real estate stock returns supports the existence of ARCH effects in these time series, with no exceptions, and indicates the typical characteristics of daily equity returns. In terms of skewness, the findings are mixed. While the German, Italian, Swedish, Swiss, and U.S. market show negative skewness, all the other markets are positively skewed. The leptokurtic distributed returns are a first indication of the existence of ARCH effects.

Further evidence for the existence of ARCH effects and heteroscedasticity should be given by analyzing the squared residuals and their autocorrelation. The Engle (1982) ARCH-LM test[13] and the Ljung-Box test[14] are applied. The results of both test statistics are presented in table 4. As can be seen in both tests, all indices have significant dependencies in the squared return time series. In addition to the fat tails, the findings suggest the existence of a dependent conditional variance as well as volatility clustering. ARCH effects are therefore indicated for all time series and the results are supportive of the GARCH modelling, which is designed to capture these characteristics.[15]

Table 4: Diagnostic tests for ARCH effects using the Ljung-Box-Q statistic and the ARCH-LM test

Index	Ljung-Box-Q statistic				ARCH-LM test
	K = 5	K = 10	K = 20	K = 40	K = 5
AUS	432.95***	456.94***	518.27***	583.49***	333.72***
BEL	979.12***	1,210.40***	1,687.42***	2,027.97***	604.30***
CAN	168.56***	344.99***	520.86***	738.39***	115.66***
FRA	261.10***	286.62***	407.50***	475.95***	186.45***
GER	56.30***	86.51***	138.21***	203.06***	46.72***
HK	749.69***	996.14***	1,355.63***	1,544.92***	453.41***
ITA	240.73***	257.19***	314.75***	346.74***	213.75***
JAP	673.82***	941.59***	1,112.17***	1,213.70***	404.11***
NL	434.62***	564.47***	813.62***	889.55***	330.70***
SIN	724.96***	1,045.99***	1,875.83***	2,221.83***	414.55***
SWD	488.21***	645.04***	859.05***	1,115.92***	353.96***
SWZ	400.98***	622.15***	813.53***	1,290.61***	276.76***
U.K.	248.33***	285.48***	364.40***	536.19***	197.22***
U.S.	589.04***	815.27***	1,209.63***	1,355.40***	355.81***

Notes:
***, ** and * indicate the rejection of the null hypothesis at the 1%, 5% and 10% levels of significance. K indicates the number of lags.

D. Theoretical Framework and GARCH Modelling

The theoretical framework is built by the family of the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models, which are typically used for analyzing and modelling the volatility behaviour of international stock markets. The strength of the GARCH models is their ability to incorporate the stylized facts of financial time series, like heavy-tailed distributions, volatility clustering and the leverage effect. Furthermore, GARCH models allow for the simultaneous modelling of the first and second moments.

Thus, the modelling is based on two equations, describing the return generating process r and the conditional variance h at time t. It is assumed that rt is decomposed into a component anticipated by investors at date t-1 and an unanticipated component

$\varepsilon_t = \sqrt{h_t}u_t$:

(1) $r_t = \mu_t + \sqrt{h_t}u_t,$

where: μ_t = expected value of rt,
h_t = conditional variance,
u_t = independent and identical distributed (i.i.d.) random variable with zero mean and unit variance.

The second equation focuses on the modelling of the conditional variance ht and describes the ARCH model of the order p:

(2) $h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2$ or

(3) $\varepsilon_t = \sqrt{h_t}u_t$ and $\varepsilon_t = \sqrt{\omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 u_t}$

respectively where:
ω > 0,
αi ≥ 0.

Compared to the ARCH(p) model, the GARCH(p,q) model is more flexible and generous, allowing for a more parsimonious parameterization. For the GARCH process, the ARCH modelling of the conditional variance of the empirical time series is extended by the q conditional variances. In analogy to the ARCH model, in equation (2) the GARCH(p,q) model can be written as follows:[16]

(4) $h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \beta_i h_{t-i}.$

Related to the parameter values, the same restrictions apply to both the ARCH and the GARCH models. Additionally, the coefficient βi ≥ 0 and the GARCH(p,q) process is (variance-) stationary, if:

(5) $\sum_{i=1}^{p} \alpha_i + \sum_{i=1}^{q} \beta_i < 1.$

Extensions of the model under specific assumptions

Due to some weaknesses of ARCH and GARCH models, and the temptation to use more realistic modelling for the conditional variance of financial assets, the model selection is extended by frameworks that can capture asymmetric reactions of volatility to new information. High persistence in the time series and power ARCH models are also considered.

I. Exponential GARCH-Model (EGARCH):[17]

(6)

$$\log(h_t) = \omega + \sum_{i=1}^{p} \alpha_i \left| \frac{\varepsilon_{t-i}}{\sqrt{h_{t-i}}} \right| + \sum_{i=1}^{p} \gamma_i \frac{\varepsilon_{t-i}}{\sqrt{h_{t-i}}} + \sum_{i=1}^{q} \beta_i \log(h_{t-i})$$

One advantage of the EGARCH specification is that the conditional variance will be positive and no restrictions have to be imposed for estimation. The asymmetry is modelled by the coefficient γ_i. A negative value indicates that the conditional variance is increasing in consequence of returns below the mean.

II. Threshold GARCH-Model (TGARCH):[18]

$$(7) \quad h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{r} \gamma_i \varepsilon_{t-i}^2 I_{t-i} + \sum_{i=1}^{q} \beta_i h_{t-i}$$

where: $I_{t-i} = \begin{cases} 1 & \text{for } \varepsilon_{t-i} < 0 \\ 0 & \text{for } \varepsilon_{t-i} \geq 0 \end{cases}$.

In comparison to the GARCH model, the TGARCH model is extended by a term accounting for asymmetry. The leverage effect is considered by the coefficient γ_i in equation (7). A high value of γ_i is associated with a pronounced leverage effect.

III. Asymmetric Power-ARCH-Model (APARCH):

A further extension of the basic GARCH model is the asymmetric Power (G)ARCH model proposed by Ding et al. (1993):

$$(8) \quad \sqrt{h_t}^{\delta} = \omega + \sum_{i=1}^{p} \alpha_i \left(\left| \varepsilon_{t-i} \right| - \gamma_i \varepsilon_{t-i} \right)^{\delta} + \sum_{i=1}^{q} \beta_i \sqrt{h_{t-i}}^{\delta}$$

where: $\delta > 0$,

$\left| \gamma_i \right| \leq 1$.

In contrast to the other GARCH models, the exponent δ is not exogenous given, with a value of two, but is endogenous. This modification is motivated by the finding that, for financial time series, the model often fits better when the exponent is less than two. Again, the asymmetry is incorporated by the coefficient γ_i, whereas a positive value of γ_i describes the negative relation between the first two moments.

IV. Integrated GARCH-Model (IGARCH):

The basic GARCH model is not able to account for high persistence of shocks, because the condition in equation (5) is not satisfied. Thus, Engle and Bollerslev (1986) proposed the Integrated GARCH model (IGARCH):

$$(9) \quad h_t = \omega + \beta_1 h_{t-1} + \left(1 - \beta_1\right) \varepsilon_{t-1}^2$$

Thus, IGARCH models represent a Unit Root GARCH model and the impact of the squared residuals is persistent.

Further empirical analysis concentrates on the presented models of parametric GARCH processes. Approaches based on non- or semi-parametric methods have been excluded from the model selection process due to their weaknesses in out-of-sample forecasts. Both Pagan and Schwert (1990) and Bollerslev et al. (1994) emphasize that non-parametric models are not superior to GARCH and EGARCH models in out-of-sample forecasts. Therefore, non-parametric methods are not considered in the following modelling.

Before presenting the empirical results from applying GARCH models, it should be mentioned that basic GARCH models and their several extensions – like almost every method applied to empirically analysing economic theories and relationships – have limitations for which they are criticised. The crucial points are well discussed in several studies, inter alia Andersen and Bollerslev (1998), Andersen et al. (2001, 2003, and 2004), and Hansen and Lunde (2005). Beside the fact that (G)ARCH models depend on specific distributional assumptions, Andersen et al. (2001) point out that 'squared returns are also a very noisy volatility indicator and hence do not allow for reliable inference regarding the true underlying latent volatility.' In contrast, realized volatility is an unbiased and more efficient estimator of return volatility. This becomes obvious when the true volatility sharply increases one day after a period of low volatility. While realized volatility sharply increases as well, GARCH models tend to not change since they depend on squared returns from previous days only.

One further major drawback is the forecast quality of GARCH models compared to other volatility models, such as models based on integrated or realized volatility. Volatility forecasting is also evaluated from both a theoretical and an empirical perspective in the studies mentioned above. While integrated volatility models suffer from not being directly observable, most of the studies conclude that realized volatility models are superior to standard volatility models when considering forecasting accuracy. However, Andersen and Bollerslev (1998) show that well specified (G)ARCH models provide good volatility forecasts, for exchange rates at least. This finding is in line with the conclusion by Hansen and Lunde (2005). They also support the application of a GARCH model when analysing exchange rate data, but find contradictory results from analysing stock return volatility. Thus, relevant literature mainly states that (G) ARCH models provide inferior volatility forecasts compared to other volatility models, even though the conclusions are not completely coincident.

However, due to the lack of high-frequency intraday returns, in particular with respect to data on real estate stock markets, the empirical application of integrated or realized volatility models based on intraday data is sharply limited, if not even impossible. These shortcomings of the family of GARCH models should be taken into consideration when interpreting the results in the following sections.[19]

E. Empirical Analysis

In the first step, after showing that ARCH effects exist in the return series of the national real estate stock markets, the conditional second moment is modelled by using and testing several variations of the GARCH process originally suggested by Bollerslev (1986). The model with the best fit is selected and used for spillover modelling. The following models are tested and compared to each other:

- 9 ARCH models (p = 1, 2, …, 9)
- 4 (I)GARCH models ((p,q) = {(1,1); (2,1); (1,2); (2,2)})
- 1 EGARCH (1,1) model with one asymmetric term
- 1 TGARCH (1,1) model with one asymmetric term
- 1 APARCH (1,1) model with one asymmetric term and no restrictions on the exponent
- All 16 models are tested with three different distribution assumptions (normal distributed, student's-t-distributed, and GED-distributed conditional residuals).

Approximate maximum likelihood estimates of the parameters in the model were obtained by using the Berndt, Hall, Hall, and Hausman (1974) algorithm. Standard errors were computed using the robust method of Bollerslev and Wooldridge (1992). The selection of the dominant model was made using the information criteria of Akaike (1973) and Schwarz (1978) as well as the log-likelihood-function.

Except for the three central European markets, France, Germany, and the Netherlands, the appropriate model contains an asymmetric term with respect to the leverage effect. Both the positive coefficients for asymmetry in the TGARCH and APARCH and the equivalent negative coefficient in the EGARCH model are consistent with financial theory.[20] Among the asymmetric models, the TGARCH process is superior to the EGARCH, which is in line with the results of Engle and Ng (1993). Hence, real estate equity markets respond to negative and positive shocks in a similar way to the broad equity markets. The favoured model for France and the Netherlands is a GARCH (1,2) model, while an IGARCH (1,1) process best fits the German real estate stock market. The reason for the IGARCH process could be found in the high kurtosis (31.39) of the return distribution, consistent with the findings of Bollerslev et al. (1994). All selected GARCH models fit more closely the GED or the student's-t distribution than to the normal distribution. The estimated characteristic GED coefficient is lower than two for each model. These results are consistent with Tsay (2005) and Allen and Bali (2007). Since the selected GARCH process for Australia, Belgium, Canada, and Switzerland is not able to capture the ARCH effects, the specification was modified. However, with one exception (Switzerland), the models of the markets mentioned do not change completely: the asymmetry is still modelled and is significant. The process for the Swiss real estate stock market is switched from IGARCH to TGARCH: this procedure seems plausible in comparison to the results for the other markets.

By again using the Engle (1982)-LM test and the Ljung-Box test, the quality of the modelling is evaluated. For that purpose, the squared residuals are tested for ARCH effects after fitting the GARCH specification. As can be seen in table 5, the diagnostic tests show that the selected model for each market is generally well specified. With the exception of the markets in Japan and Singapore, both tests for ARCH effects indicate the removal of significant dependence of the squared residuals for all series. Even for the two Asian markets in

Japan and Singapore, the values of the test statistics are much smaller than before.[21] Therefore, both the theoretical considerations and the empirical results are consistent with each other and the specification of the GARCH process and the fitting of the model seem to be plausible and appropriate. The weaknesses of the selected GARCH model for capturing volatility effects of real estate stock markets in Japan and Singapore could be attributed to potential structural breaks in the return series (e.g. the Asian crisis in 1997 and 1998). Thus, the application of fractionally integrated time series models could result in a better fit and is an interesting topic for further research.

Up to this point, no linkages between the national markets and the stock markets have been considered. However, when considering risk management and for investors constructing a portfolio, these potential linkages between different assets and markets become a crucial point. Therefore, the next step is to implement the effects from other markets into the model. For this purpose both the mean and the variance equation are augmented by spillover variables. The following effects are tested:

- Effects from the most closely-related markets (geographically and economically). Australia is attached to the Asian markets and, for Europe, the markets with the highest real estate stock market capitalization (France, the Netherlands, and the United Kingdom) are used to reduce the number of variables.
- Effects from the same continent are controlled by implementing the EPRA indices for each continent. Due to data limitations, it is not possible to use the index excluding the markets already implemented, which would be preferable from a theoretical point of view.
- Effects from the world real estate stock market, excluding the continent in which the country examined is located.
- Due to its size and importance, the U.S. real estate stock market is a separate variable in each specification.
- Finally, to control for spillover effects from the stock market, the national MSCI country index and the MSCI World index are also used.

Table 5: Checking for ARCH effects in the squared residuals

Index	Ljung-Box-Q statistic				ARCH-LM test
	K = 5	K = 10	K = 20	K = 40	K = 5
AUS	8.24	14.76	26.23	35.85	8.02
BEL	8.91	22.89**	31.03*	53.35*	9.10
CAN	7.36	11.38	16.66	100.50***	7.45
FRA	1.13	3.98	4.86	17.61	1.12
GER	0.53	0.72	1.31	2.73	0.54
HK	2.15	6.03	10.38	21.02	2.20
ITA	1.24	3.05	6.92	13.81	1.24
JAP	21.67***	28.65***	39.75***	63.69**	21.06***
NL	5.62	7.93	12.73	20.24	5.75
SIN	16.16***	22.60**	33.27**	56.38**	16.61***
SWD	7.97	11.61	30.87*	201.56***	8.12
SWZ	2.86	3.92	9.61	17.42	2.80
U.K.	9.04	10.68	21.00	45.73	9.23
U.S.	5.65	11.79	19.08	29.97	5.41

Notes:
***, ** and * indicate the rejection of the null hypothesis at the 1%, 5% and 10% levels of significance. K indicates the number of lags.

Furthermore, it is assumed that spillover effects occur with a lag of one trading day only. Longer time periods and lags are not considered, taking into account the fast information processing in the international financial markets. The analysis of contemporaneous spillover effects – between regions and markets with different time zones in particular – could be of interest to investors. However, this information could not be exploited between markets in the same time zone. Thus, in order to provide the analysis with a consistent framework, contemporaneous spillover effects have not been examined.

The specification takes place by a simultaneous estimation of the mean and variance equation with the appropriate variables. Spillover effects are implemented by adding the returns and squared returns of the relevant market index to the mean and variance equation respectively. The first estimation considers all effects described above. For the subsequent estimation all insignificant variables are excluded, with the exception of the intercept in the mean and variance equation. The procedure is repeated until only significant variables are left and is therefore similar to the approach chosen by Liow et al. (2005). The augmented specification of the mean and variance equation by implementing spillover effects results in insignificant asymmetry-coefficients in the case of Australia, Italy, and Switzerland. However, due to the better fit of these models compared to other GARCH models, the TGARCH (for Australia) and APARCH (for Italy and Switzerland) models have been retained. The models with the best fit finally specified are presented in table 6 and table 7.

As can be seen, there are spillover effects in the mean or variance equation in all markets. However, the U.S. real estate market appears to be functioning as a leading market. This market is influenced by the world stock market only and not by any other real estate market, which is plausible. In contrast, all other markets are influenced by at least one real estate market, predominantly by the U.S. market. With Switzerland being a notable exception, all significant coefficients related to the U.S. market in both the mean and variance equation are positive, suggesting positive spillover effects. Extremely high coefficients can be found for the neighbouring market in Canada and the Asia-Pacific markets. In Europe, the markets in Sweden and the United Kingdom show the highest linkage to the U.S. market, whereas the central European markets show low, but significantly positive coefficients. These findings are consistent with the examinations by Michayluk et al. (2006) related to the linkages between the U.S. market and the market of the United Kingdom.[22]

Similar to Liow et al. (2005), the empirical results present linkages between the two emerging Asian markets, Hong Kong and Singapore, where the lagged returns in Hong Kong influence the returns of the market in Singapore. The opposite effect is found for the variance spillover. The German real estate market is the only market with no spillovers in the returns and weak linkages in the variances, which could be due to the IGARCH modelling. For the other European markets with the exception of Switzerland, the U.S. real estate market return exerts a dominant influence. From a perspective of international diversification, it is interesting to mention that the linkages between the European markets are weak in the first and second moment, which should leave ample room for diversification benefits. Even the three big markets (France, the Netherlands, and the United Kingdom) have no strong leading function for their neighbouring markets. In conclusion, the analysis of the European markets does not show any consistent pattern of spillover effects, either in the mean equation or in the variance equation.

While there are some strong linkages in the return series and a dominating influence from the U.S. market, the linkages in the second moment are much weaker, less significant, and show no systematic structure. Liow et al. (2005) find similar results in their less extended analysis of the Asian and European markets. Therefore, their conclusion is strongly supported: ‘[T]he presence of small numbers of significant cross-volatility effects implies that conditional volatility in these property stock markets is mainly influenced by their own past-volatility shocks, i.e. they are not “imported” from abroad. This evidence again provides some support that there is lack of integration in the international property stock markets.’[23] One reason for these findings could be the fact that property companies operate mainly in their domestic markets, so that their business is less affected by economic events from abroad. Additionally, depending on the model specification, one caveat must be mentioned. The lack of systematic spillover effects in volatility could also be due to incorrectly

Table 6: Model specification including spillover effects (I)

Index	AUS	CAN	HK	JAP	SIN	U.S.
Model	TGARCH (1,1)	TGARCH (1,1)	TGARCH (1,1)	TGARCH (1,1)	APARCH (1,1)	EGARCH (1,1)
Mean equation						
c	0.0005 (0.0001) [4.6777]	0.0005 (0.0001) [3.7551]	0.0003 (0.0002) [1.4163]	-0.0007 (0.0002) [-3.3025]	-0.0001 (0.0002) [-0.4453])	0.0005 (0.0000) [6.7491]
$\beta_{i,\,i,\,t\text{-}1}$			0.1417 (0.305) [4.6402]	0.0399 (0.0151) [2.6430]		0.1950 (0.0152) [12.8663]
$\beta_{i,\,AUS,\,t\text{-}1}$					-0.0540 (0.0275) [-1.9652]	
$\beta_{i,\,HK,\,t\text{-}1}$					0.0789 (0.0182) [4.3318]	
$\beta_{i,\,JAP,\,t\text{-}1}$			-0.0554 (0.0108) [-5.1068]			
$\beta_{i,\,U.S.,\,t\text{-}1}$	0.1331 (0.0149) [8.9479]	0.1267 (0.0166) [7.6131]	0.1969 (0.0268) [7.3517]	0.1098 (0.0321) [3.4248]	0.1908 (0.0252) [7.5717]	
$\beta_{i,\,Continent\ of\ i,\,t\text{-}1}$	-0.0234 (0.0096) [-2.4387]				-0.1314 (0.0263) [-5.0014]	
$\beta_{i,\,MSCI\ i,\,t\text{-}1}$	-0.0242 (0.0133) [-1.8209)	0.0324 (0.0157) [2.0602]	-0.1117 (0.0359) [-3.1143]		0.0833 (0.0230) [3.6164]	
$\beta_{i,\,MSCI\ World,\,t\text{-}1}$	0.1088 (0.0136) [8.0137]	-0.0432 (0.0169) [-2.5629]	0.3096 (0.0264) [11.7270]	0.2745 (0.0311) [8.8246]	0.2810 (0.0294) [9.5591]	-0.0232 (0.0100) [-2.3195]
Variance equation						
ω	0.0000 (0.0000) [4.7965]	0.0000 (0.0000) [3.7207]	0.0000 (0.0000) [4.6518]	0.0000 (0.0000) [3.2717]	0.0000 (0.0000) [1.1972]	-0.3532 (0.0476) [-7.4224]
α_1	0.0523 (0.0100) [5.2501]	0.0651 (0.0137) [4.7612]	0.0586 (0.0123) [4.7680]	0.0525 (0.0105) [4.9744]	0.1187 (0.0118) [10.0923]	0.2044 (0.0177) [11.5541]
β_1	0.8555 (0.0184) [46.3819]	0.8414 (0.0204) [41.2875]	0.8469 (0.0135) [62.8957]	0.8634 (0.0136) [63.3813]	0.8838 (0.0104) [84.9333]	0.9802 (0.0041) [240.4661]
γ	0.0182 (0.0131) [1.3854]	0.0654 (0.0236) [2.7767]	0.0746 (0.0173) [4.3200]	0.0817 (0.0188) [4.3528]	0.1475 (0.0434) [3.3998]	-0.0286 (0.0098) [-2.9098]
δ					15.112 (0.1984) [7.6182]	
$\alpha_{i,\,SIN,\,t\text{-}1}$			0.0167 (0.0052) [3.1908]			
$\alpha_{i,\,U.S.,\,t\text{-}1}$				0.0783 (0.0316) [2.4820]		
$\alpha_{i,\,Continent\ of\ i,\,t\text{-}1}$	0.0050 (0.0014) [3.6188]					
$\alpha_{i,\,World\ ex\ continent,\,t\text{-}1}$	0.0148 (0.0045) [3.3224]	0.0257 (0.0073) [3.5448]		-0.1394 (0.0523) [-2.6635]		
$\alpha_{i,\,MSCI\ i,\,t\text{-}1}$				0.0566 (0.0213) [2.6565]		
$\alpha_{i,\,MSCI\ World,\,t\text{-}1}$	-0.0054 (0.0025) [-2.1318]		0.0613 (0.0167) [3.6650]	0.0958 (0.0289) [3.3222]		
LB-Q-Statistic	6.73	9.11	1.69	15.25***	12.37**	6.10
ARCH-LM-Test	6.58	9.03	1.72	15.14***	12.68**	5.99

The standard errors are shown in parentheses and the test statistics in square brackets. Both the LB-Q statistic and the ARCH-LM test are calculated for lag k equal to 5.

Table 7: Model specification including spillover effects (II)

Index	BEL	FRA	GER	ITA	NL	SWD	SWZ	U.K.
Model	TGARCH (1,1)	GARCH (1,2)	IGARCH (1,1)	APARCH (1,1)	GARCH (1,2)	APARCH (1,1)	TGARCH (1,1)	EGARCH (1,1)
Mean equation								
c	0.0000 (0.0001) [0.2190]	0.0004 (0.0001) [3.7302]	0.0000 (0.0001) [0.0004]	-0.0001 (0.0001) [-0.7076]	0.0000 (0.0000) [0.6722]	0.0002 (0.0001) [2.1858]	0.0001 (0.0002) [0.3185]	0.0003 (0.0001) [2.9049]
$\beta_{i, i, t-1}$	-0.0918 (0.0117) [-7.8185]	-0.0775 (0.0170) [-4.5764]			0.0783 (0.0139) [5.6185]		-0.1237 (0.0238) [-5.2084]	
$\beta_{i, NL, t-1}$		0.0527 (0.0185) [2.8504]						
$\beta_{i, U.K., t-1}$							-0.1450 (0.0320) [-4.5247]	
$\beta_{i, U.S., t-1}$	0.0367 (0.0092) [3.9972]	0.0757 (0.0159) [4.7504]		0.0472 (0.0171) [2.7554]	0.0513 (0.0109) [4.7153]	0.1099 (0.0157) [7.0049]		0.1044 (0.0165) [6.3341]
$\beta_{i, Europe, t-1}$		0.0732 (0.0236) [3.0979]					0.1840 (0.0515) [3.5707]	
$\beta_{i, World\ ex\ Europe, t-1}$					-0.0222 (0.0081) [-2.7422]	-0.0532 (0.0146) [-3.6510]		
$\beta_{i, MSCI\ i, t-1}$				0.0410 (0.0120) [3.4030]				
$\beta_{i, MSCI\ World, t-1}$		0.0359 (0.0124) [2.8853]			0.0518 (0.0094) [5.4865]	0.0787 (0.0147) [5.3621]	0.1413 (0.0224) [6.3000]	0.0685 (0.0129) [5.3035]
Variance equation								
ω	0.0000 (0.0000) [4.4078]	0.0000 (0.0000) [5.1657]		0.0007 (0.0004) [1.5895]	0.0000 (0.0000) [5.7528]	0.0000 (0.0000) [1.6390]	0.0000 (0.0000) [9.3096]	-0.3566 (0.0575) [-6.2045]
α_1	0.0978 (0.0164) [5.9706]	0.1296 (0.0208) [6.2194]	0.0147 (0.0013) [11.1501]	0.1551 (0.0153) [10.1268]	0.2166 (0.0297) [7.2816]	0.1058 (0.0100) [10.5642]	0.2051 (0.0326) [6.2852]	0.1180 (0.0155) [7.5971]
α_2[a]				0.0340 (0.0572) [0.5948]		0.0845 (0.0468) [1.8050]		
β_1	0.8264 (0.0156) [52.8956]	0.2871 (0.1068) [2.6878]	0.9853 (0.0013) [748.3696]	0.8283 (0.0173) [47.7542]	0.2931 (0.0930) [3.1525]	0.9047 (0.0085) [106.09]	0.5308 (0.0367) [14.4540]	0.9728 (0.0054) [178.81]
β_2		0.3807 (0.0959) [3.9694]			0.3071 (0.0793) [3.8723]			
γ	0.1116 (0.0281) [3.9758]						0.0599 (0.0453) [1.3224]	-0.0177 (0.0082) [-2.1544]
δ				10.056 (0.1227) [8.1974]		13.678 (0.1411) [9.6955]		
$\alpha_{i, NL, t-1}$							-0.0500 (0.0099) [-5.0335]	840.936 -541.801 [54.1801]
$\alpha_{i, U.K., t-1}$							0.0332 (0.0140) [2.3707]	
$\alpha_{i, U.S., t-1}$		0.0224 (0.0097) [2.3208]			0.0377 (0.0090) [4.1858]		-0.0425 (0.0092) [-4.6334]	
$\alpha_{i, Europe, t-1}$		0.1018 (0.0271) [3.7581]			0.0529 (0.0159) [3.3256]			
$\alpha_{i, World\ ex\ Europe, t-1}$	0.0069 (0.0038) [1.8076]		-0.0053 (0.0007) [-7.3437]				0.0758 (0.0123) [6.1714]	1,126.278 -322.951 [3.4875]
$\alpha_{i, MSCI\ i, t-1}$				0.9677 (0.4948) [1.9556]				650.725 -377.207 [1.7251]
$\alpha_{i, MSCI\ World, t-1}$			0.0100 (0.0016) [6.1241]				-0.0310 (0.0050) [-6.1464]	-1,573.053 -615.152 [-2.5572]
LB-Q-Statistic	8.73	1.45	2.54	2.28	5.35	14.21**	2.45	8.09
ARCH-LM-Test	9.03	1.44	2.56	2.28	5.37	14.36**	2.45	8.13

[a] The estimated coefficient α2 corresponds to the coefficient α1γ1 in equation 8. The standard errors are shown in parentheses and the test statistics in square brackets. Both the LB-Q statistic and the ARCH-LM test are calculated for lag k equal to 5.

specified GARCH models, if there were a common factor driving the markets that had been omitted from the model specification.

In general, the lack of integration implies, 'that investors would benefit from diversifying property stock portfolios internationally in Asia and Europe.'[24] Additionally, there is some evidence that this conclusion by Liow et al. (2005) can be extended to the markets in Northern America as well. Hence, investors' interest in international real estate is expected to increase. However, against the background of the data limitations and its weaknesses mentioned in section C, the findings referring to the European real estate stock markets in particular must not be overstated and should be treated carefully. Nevertheless, the topic of spillover effects between national real estate stock markets is of essential relevance for international diversification and further analysis based on more suitable data from mature markets might shed further light on spillover effects and their implications for investors in the future.

F. Conditional Variance Forecasts

What would be the gain for the investor from a (complex) financial model if it does not make any useful predictions? The forecast quality of the specified model is therefore evaluated after having selected the GARCH model with the best fit and having considered potential spillover effects between national real estate markets and from broader stock markets.

To compute variance forecasts, the parameters of the estimated GARCH models as well as the observations of the squared residuals and the conditional variance can be used. The quality of the forecasts is measured by the difference between estimated conditional variance and the variance forecast by the model. The main difference between the testing methods depends on the type of difference being considered, e.g. absolute difference (mean error, ME), relative difference (mean percentage error, MPE), and squared difference (mean squared error, MSE). Additionally, two measures adjusting for heteroscedasticity (heteroscedasticity adjusted mean absolute error (HMAE) and mean squared error (HMSE))[25] and the Theil Inequality Coefficient (TIC)[26] are computed. The TIC is favourable compared to the other methods since it is normalized between 0 and 1 and therefore allows for comparisons. All testing methods have in common that lower values indicate better forecast performance.

Starting with November 30, 2006 as the last sample observation, a recursive daily out-of-sample forecast for the next 22 days (the number of trading days in December 2006) is computed. The results for the different testing methods are shown in table 8 and table 9. Due to the selection of an IGARCH specification for the German real estate stock market and IGARCH's characteristic of a unit root process, there is no useful forecast of the conditional variance in the German market. The forecast conditional variances of all markets, France and Switzerland being notable exceptions, overestimate the variance. The result is similar to the findings of Balaban et al. (2006) for the broad stock markets. By adding spillover effects, underestimation results for the Australian and French markets. As mentioned, the TIC is used in order to judge the quality of the forecast. In particular for the markets in Australia, France, Singapore, and the United Kingdom, the TIC is very low, indicating a good forecast; whereas Belgium, Canada, and Hong Kong have the highest TICs, although still with values around 0.30. Therefore, the forecast quality of all 13 markets is suitable and supportive of the GARCH process specification.

By implementing spillover effects, the forecasts improve further for 11 out of 13 markets. Only the Australian and the U.S. market show small increases in the TIC. However, the Australian market still has the smallest TIC and the increase for the U.S. market is marginal. The Australian and the U.S. markets are the oldest and are both relatively highly capitalized markets. Corresponding to the broad equity markets, this might be a plausible reason why these markets have a leading function and why their forecast quality does not further improve by adding other markets. The main advantages due to the spillover effect are evident in the markets of Belgium, Canada, Italy, Japan, Switzerland, and the United Kingdom, where the enhancement is a more-than-25% reduction in the TIC. On average, the TIC decreases by 17.46%, in a range from an increase of 17.86% for Australia and a decrease of 36.32% for the United Kingdom.

Summarizing the forecast results, two central points, which strongly support the previous results in this paper, should be highlighted. First, the forecasting quality of the conditional variance confirms the adequacy of the GARCH process for modelling volatility of the real estate stock markets. Second, by implementing spillover effects in the mean and variance equation, it is shown that the forecast can be improved for 11 out of 13 markets.

Table 8: Forecast results for the variances of the EPRA indices excluding spillovers

Index	ME	MPE	MSE	HMAE	HMSE	TIC
AUS	2.84×10^{-6}	0.0589	3.53×10^{-11}	0.0803	0.0099	0.0487
BEL	3.73×10^{-5}	0.8655	1.91×10^{-09}	0.4024	0.2018	0.3184
CAN	3.36×10^{-5}	0.8756	1.33×10^{-09}	0.4225	0.2085	0.2901
FRA	-7.45×10^{-7}	0.0423	3.43×10^{-10}	0.1760	0.0564	0.1187
GER	n/a	n/a	n/a	n/a	n/a	n/a
HK	1.15×10^{-4}	0.8685	1.59×10^{-08}	0.4195	0.2076	0.2941
ITA	8.46×10^{-5}	0.6718	8.13×10^{-09}	0.3715	0.1571	0.2395
JAP	1.31×10^{-4}	0.7976	2.04×10^{-09}	0.4065	0.1913	0.2860
NL	4.11×10^{-5}	0.2090	3.87×10^{-10}	0.2797	0.1369	0.1807
SIN	4.17×10^{-5}	0.1859	4.64×10^{-09}	0.1536	0.0410	0.1087
SWD	4.67×10^{-5}	0.4040	3.04×10^{-09}	0.2512	0.0874	0.1666
SWZ	-1.21×10^{-5}	-0.3284	2.11×10^{-10}	0.5953	0.4803	0.2740
U.K.	1.61×10^{-5}	0.2634	3.19×10^{-10}	0.1982	0.0473	0.1228
U.S.	2.91×10^{-5}	0.3709	1.10×10^{-09}	0.2465	0.0798	0.1533

Notes:
ME = Mean Error; MPE = Mean Percentage Error; MSE = Mean Squared Error; HMAE = Heteroscedasticity Adjusted Mean Absolute Error; HMSE = Heteroscedasticity Adjusted Mean Squared Error; TIC = Theil Inequality Coefficient.

Table 9: Forecast results for the variances of the EPRA indices including spillovers

Index	ME	MPE	MSE	HMAE	HMSE	TIC
AUS	-3.38×10^{-6}	-0.0587	3.24×10^{-11}	0.0834	0.0149	0.0574
BEL	2.36×10^{-5}	0.5787	7.22×10^{-10}	0.3279	0.1351	0.2303
CAN	1.92×10^{-5}	0.5427	4.31×10^{-10}	0.3270	0.1255	0.2074
FRA	-3.54×10^{-6}	-0.0087	2.51×10^{-10}	0.1410	0.0390	0.1032
GER	n/a	n/a	n/a	n/a	n/a	n/a
HK	8.07×10^{-5}	0.6904	7.35×10^{-09}	0.3811	0.1656	0.2449
ITA	4.32×10^{-5}	0.3735	2.64×10^{-09}	0.2405	0.0808	0.1612
JAP	8.08×10^{-5}	0.5453	7.51×10^{-09}	0.3282	0.1254	0.2051
NL	1.75×10^{-6}	0.1404	2.72×10^{-10}	0.2507	0.1114	0.1580
SIN	3.50×10^{-5}	0.1707	3.44×10^{-09}	0.1515	0.0377	0.1041
SWD	3.31×10^{-5}	0.2916	1.53×10^{-09}	0.2040	0.0574	0.1335
SWZ	4.43×10^{-5}	0.4682	2.33×10^{-09}	0.3034	0.1040	0.2024
U.K.	8.86×10^{-6}	0.1452	1.21×10^{-10}	0.1206	0.0215	0.0782
U.S.	2.94×10^{-5}	0.3773	1.12×10^{-09}	0.2492	0.0817	0.1551

Notes:
ME = Mean Error; MPE = Mean Percentage Error; MSE = Mean Squared Error; HMAE = Heteroscedasticity Adjusted Mean Absolute Error; HMSE = Heteroscedasticity Adjusted Mean Squared Error; TIC = Theil Inequality Coefficient.

G. Conclusion

This paper, which has examined the volatility behaviour of 14 national real estate stock markets worldwide, is to our knowledge the most comprehensive study so far. It shows that the returns of real estate stock markets contain almost the same ARCH effects as the broad stock markets, which can be captured by the selection of the most adequate ARCH model. In 11 out of 14 national markets an asymmetric model, controlling for the leverage effect, results in the best fit. In comparison to previous studies, the results highlight the linkages between the national real estate and the broad stock markets on a daily basis. The findings of this extensive international analysis show that there are some linkages between the broad stock market and the real estate stock market and also between the national real estate markets in the short run. The main influence results from the MSCI World and the equivalent real estate index. It also appears that the U.S. real estate stock market is less influenced by the other markets and functions as a leading market for many other national real estate markets, which is in line with the general theory in finance. Furthermore, in 11 out of 13 cases the forecast quality of the selected GARCH model was improved by the implementation of spillover effects, which therefore emphasizes its justification.

Despite the findings of some spillover effects and the caveat mentioned above, the linkages between the national markets are not very strong and should leave ample room for diversification. Hence, the investors' interest in international real estate and the necessity of adding some securitized real estate to their portfolios should increase. While not analyzing time varying correlations in particular, due to the dominance of asymmetric GARCH models and spillover effects there is, however, some evidence that diversification benefits from real estate stock markets and between national real estate stock markets are less available when diversification is most needed. A detailed examination of that topic, by applying conditional correlation models and the specific influence of the financial market crisis, which presents challenging questions for both practitioners and academics, may be left for further research. In the context of a multi-asset framework, the analysis could also be extended by testing for intraday spillover effects and spillover effects with other asset markets like bonds, small and large caps, or value and growth stocks. When this study was conducted, however, there were some limitations with respect to the data, because the relevant time series are not available for all 14 countries for the whole sample period.

Endnotes

1 See EPRA (2006).
2 Poon and Granger (2003), p. 478.
3 A variety of ARCH models is described in section 4.
4 See Hamao et al. (1990), Lin et al. (1994), and Bekaert and Harvey (1997).
5 See Stevenson (2002) and Cotter and Stevenson (2006, 2007, and 2008).
6 See Devaney (2001) and Stevenson (2002).
7 See the findings of Cotter and Stevenson (2007).
8 See table 1 and table 2.
9 An overview of the criteria for index constituents and ground rules of index calculation are provided by EPRA (2009).
10 The stationarity of all return indices is tested by using the Augmented Dickey Fuller (ADF) unit root test. The price indices are not stationary, but the first differences of the logarithmised price indices are stationary. Avoiding spurious results and conclusions the further analysis concentrates on the return series.
11 See Newell and Chau (1996), Liow (1997), and Hoesli and Serrano (2008) as well.
12 See Brounen et al. (2008) as well.
13 See Engle (1982).
14 See McLeod and Li (1983) and Hamilton (1994).
15 See Engle (2004), p. 407: '[U]npredictability, fat tails, and volatility clustering. These are precisely the characteristics for which an ARCH model is designed.' For the limitations of ARCH modelling see Poon and Granger (2003).
16 See Bollerslev (1986).
17 See Nelson (1991).
18 See Glosten et al (1993).
19 The author is grateful to an anonymous referee for offering this suggestion.
20 See Poon and Granger (2003) as well.
21 Compare the results in table 4 and table 5.
22 See Michayluk et al. (2006), p. 128: 'The U.S. market also seems to exert more influence over the United Kingdom than vice versa.'
23 Liow et al. (2005), p. 73.
24 Liow et al. (2005), p. 74.
25 See Andersen et al. (1999) and Martens (2002).
26 See Theil (1958).

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Öffentlich Private Partnerschaften (ÖPP) als neues Geschäftsfeld für Immobilien-investoren

Public Private Partnerships as a new business field for real estate investors

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Zusammenfassung

Der vorliegende Artikel befasst sich mit Öffentlich Privaten Partnerschaften im Hochbau als interessante Investitionsalternative für Immobilieninvestoren. Es werden konkrete Handlungsempfehlungen zu den geeigneten ÖPP-Vertragsmodellen und ÖPP-Immobilienarten gegeben und dargelegt, in welchen ÖPP-Wertschöpfungsphasen Immobilieninvestoren aktiv werden sollten und welche der Handlungsoptionen auf dem ÖPP-Markt für sie geeignet sind. Zudem liefert der Artikel Gestaltungsempfehlungen für den rechtlichen Rahmen. Die theoretische Analyse basiert auf den Erkenntnissen der Neuen Institutionenökonomik, insbesondere der Prinzipal-Agent-Theorie. Dabei wird davon ausgegangen, dass die Eignung eines Immobilieninvestors für Investitionen in ein spezifisches ÖPP-Projekt davon abhängt, wie groß dessen definierter Gestaltungsrahmen ist und ob sich dieser mit dem erforderlichen Gesamtgestaltungsrahmen des ÖPP-Projektes deckt.

Abstract

This article analyses the role of real estate investors in the German market for Public Private Partnership projects. Real estate investors studied include Open and Closed End Property Funds, Real Estate Investment Trusts and Real Estate Private Equity Funds. The inquiry's theoretical framework draws on insights derived from New Institutional Economics. Its central point is the consideration of real estate investment vehicles as institutional arrangements of principal-agent relationships that are characterised by delegation of capital investments of mostly private investors as principals to institutional real estate investors as agents.

The admissible business activities of the real estate investor are determined by a defined scope of action, i.e. the legal framework. The concrete design of the principal-agent relationship, i.e. the principal's rights and the agent's incentives, also influences the possible business activities of the real estate investor. These two categories then constitute the overall "defined frame of discretion". This sets the frame of a real estate investor's business activities and determines its options as to PPP investments. Hence, the suitability of a real estate investor for a PPP investment depends on whether the "defined frame of discretion" is congruent with the "necessary frame of discretion" for a particular PPP project. The latter is determined by the PPP contract model, the PPP sector, and the phase of value creation as well as the investor's options for action on the PPP market.

Table A1 shows the categorisation of real estate investors according to the defined frame of discretion.

Table A2 depicts the categorisation of the factors that determine the necessary frame of discretion of a PPP project.

Derived from the results shown above, the article develops several theoretical PPP investment models that demonstrate which real estate inves-

Table A1: The categorisation of real estate investors

	Defined frame of discretion		
	very small / small	medium	large
Real estate investors	Open End Property Funds Open End PPP Funds Open End Special Funds	Closed End Property Funds Real Estate Investment Trusts	Real Estate Private Equity Funds

Table A2: Categorisation of determinants of a PPP project

	Necessary frame of discretion		
	very small / small	medium	large
Investor's options for action on the PPP market	Indirect investment in a real estate investment vehicle Capital participation in a PPP project company	PPP project development in cooperation	PPP project development at one's own risk
Phase of value creation	Operation phase	Ramp up phase Exploitation phase	Bidding phase Planning and construction phase
PPP contract model	PPP owner model PPP purchaser model	PPP renting model PPP leasing model	PPP concession model
PPP sector	PPP administration buildings PPP school buildings	PPP culture and recreation buildings Non sophisticated PPP health care or university buildings Other PPP buildings	PPP prison and army buildings Sophisticated PPP health care or university buildings

tors should invest in particular types of PPP project. Recommendations are given regarding the investor's business options: the phase of value creation in which a real estate investor should invest. Suitable PPP contract models and PPP sectors are shown.

Furthermore, design recommendations for the legal framework are derived from the analysis, especially for Open End Funds. Closed End Property Funds, Real Estate Investment Trusts and Real Estate Private Equity Funds are identified as potential cooperation partners on the PPP primary market, particularly for small and medium sized companies. They may even function as competitors for construction and operation companies that already act on the PPP market. In contrast, Open End Property Funds, Open End PPP Funds and Open End Special Funds play an important role as exit-partners for a commitment on secondary markets. The article's subject matter is also of interest to public authorities and government institutions. One of their central goals is to foster the involvement of small and medium sized companies in the realisation of PPP projects. Moreover, the entry of alternative investors in PPP projects spurs competition in the PPP market and results in improved conditions for PPP contracts.

Table A3: Suitability of real estate investors for PPP investments

	Open End Property Funds	Open End PPP Funds	Open End Special Funds	Closed End Property Funds	Real Estate Investment Trusts	Real Estate Private Equity Funds
Investor's options for action on the PPP market						
PPP project development at one's own risk	--	-	-	+	+	++
PPP project development in cooperation	--	-	+	++	++	++
Capital participation in a PPP project company	+	++	++	+	+	+
Indirect investment in a real estate investment vehicle	++	+	+	--	--	--
Phase of value creation						
Bidding phase	--	-	+/-	+	+	++
Planning and construction phase	--	-	+/-	+	+	++
Ramp up phase	--	+	++	++	++	-
Operation phase	++	++	++	++	++	-
Exploitation phase	+/-	+	++	++	++	-
PPP contract model						
PPP owner model	++	++	+	-	-	-
PPP purchaser model	++	++	+	-	-	-
PPP leasing model	+	+	++	++	++	+/-
PPP renting model	+	+	++	++	++	+/-
PPP concession model	--	--	-	+/-	+/-	++
PPP sector						
PPP administration buildings	++	++	+	+/-	-	--
PPP school buildings	++	++	+	+/-	-	--
PPP culture and recreation buildings	--	-	+/-	+	++	+
Non sophisticated PPP health care or university buildings	--	-	+/-	+	++	+
Other PPP buildings	--	-	+/-	+	++	+
PPP prison and army buildings	--	--	--	-	-	++
Sophisticated PPP health care or university buildings	--	--	--	-	-	++

++ Most suitable + Very suitable +/- Suitable - Suitable to only a limited extend -- Unsuitable

Lebenszykluskalkulation mit einem Modul- und Prozessmodell

Lifecycle cost estimation with a module- and process-model

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Zusammenfassung

Die Entscheidung für eine Investition in eine Immobilie wird durch die zu erwartende Rendite bestimmt. Die Lebenszyklusrendite setzt sich aus den Komponenten „Lebenszykluskosten“ (Herstellung und Betrieb) und „Lebenszykluserlös“ zusammen.

Die Herstellungskalkulation mit standardisierten Verfahren liefert schon in der Planung relativ genaue Prognosen für die Bauphase. Die anschließende Betriebskalkulation basiert auf der geplanten Gebäudevariante und betrachtet zumeist nur eine repräsentative Betriebsperiode. Es fehlt die Kopplung zwischen der Herstellungs- und der Betriebskalkulation. Ein Grund hierfür ist, dass Herstellungskalkulationen zumeist nach Menge von Bauteilen und die Betriebskalkulation nach Nutzung von Räumlichkeiten erstellt werden. Erschwerend kommt hinzu, dass die innerbetrieblichen Organisationseinheiten der Herstellungs- und der Betriebskalkulation i. d. R. getrennt operieren. Die Erträge werden erst in einem dritten Schritt ermittelt. Es fehlt eine integrierte Lösung.

Basierend auf einem Modul- und Prozessmodell[1] wird ein Verfahren beschrieben, das Herstellungskalkulation und Betriebskalkulation verbindet sowie unter Berücksichtigung der Attraktivität der Immobilie die Erträge bestimmt, um eine umfassende Lebenszyklusbetrachtung schon mit den ersten Planungsschritten zu gewährleisten. Durch diese Methode wird der Planer in die Lage versetzt, mit der Berechnung der Herstellungskosten zugleich eine Lebenszykluskalkulation durchzuführen. Mehrere Bauwerksalternativen lassen sich in einem Arbeitsgang vergleichen, die Gebäudelösung wird nachhaltig optimiert. Die Ergebnisse aus der Berechnung können als Gradmesser für eine grundlegende Investitionsentscheidung herangezogen werden. Bauherr und Eigner bekommen schon zu Beginn der Planung einen Überblick über die gesamte Lebenszyklusrendite.

Abstract

The decision to invest in a real estate property is determined by the return on investment that can be expected. The return on investment over the lifecycle of real estate is made up of the components "lifecycle cost" (construction and operation) and "lifecycle income".

Lifecycle considerations pose a great challenge for the parties involved in a construction project. In the process, the goals of 'planning certainty', 'risk minimization', 'cost optimization', and 'sustainability' will be at the focus of considerations. The calculation of lifecycle cost and the assessment of lifecycle income are essential valuation criteria for the selected building solution.

Construction cost calculations are an integral component in the provision of construction services. The detailed calculation of lifecycle cost and lifecycle income, though, is a fairly recently established specialty in the building trade. The calculated factors include construction cost and, separately from each other, the lifecycle net income and the associated economic vagaries of the prognoses, with the lifecycle analysis normally being based on one selected construction variant that is not compared to alternatives.

Construction cost calculation by standardized methods yields relatively exact prognoses for the construction phase even during the planning stage. Subsequent operating cost calculation is based on the building variant planned, and mostly looks at one representative operating cycle only. If proceeding in this way – which is common practice – the economic optimization of a building involves a very extensive effort because both types of calculation need to be repeated many times, one after the other. There is no connection between construction cost calculations and operating cost calculations. One reason for this is that construction cost calculations are in most cases computed on the basis of the quantity of structural elements, while operating costs are calculated based on the use of rooms and premises. To make matters worse, the internal organizational units responsible for construction and operating cost calculations generally operate separately from each other. Only in a third step will the returns on investment be computed. What is lacking is an integrated solution.

Based on a module and process model [cf. Rudloff / Schwarz, 2008] a method is described that ensures a comprehensive lifecycle analysis already in the initial planning process.

The objective is to use an integrated procedure that links construction cost calculation, which is oriented towards the chosen method of construction, with operating cost calculation, which is oriented towards the use of a building, for the purpose of factoring them into a comprehensive lifecycle computation.

This process is based on standardized calculation methods for the construction of a building and a new module and process model.

The method uses a three-step approach:

- *Integration of construction cost calculations into the module and process model*
- *Operating cost calculation setup and integration into the module and process model*
- *Automation of lifecycle computation.*

In the first step, the standardized calculation method, including the planning costs, is coupled to the module and process model. Construction cost calculation, which is oriented towards the chosen method of construction and is calculated based on quantities and services, provides the basis for price determination. Based on defined cost types, calculated unit prices will be processed so that they may be used for the purpose of incremental automated lifecycle computation.

In the second step, the necessary costs of use when in operation are calculated. Costs of use are determined by the type of use, combined with the floor areas and/or cubic volumes of rooms and the characte-

ristics of construction materials. For this purpose, a new method had to be developed, to process the results in such a way that they can be correlated with construction cost calculations. Also, the proceeds are integrated into the second step.

The third step combines the of construction cost and operating cost calculations in a comprehensive procedure. Couplings are defined so as to link construction cost calculation and operating cost calculation in one procedure. Thus, a comprehensive lifecycle computation is performed in one processing step, showing the return on investment as a result.

This method enables the planner to simultaneously carry out construction cost and lifecycle computations. Building variants may be compared by changing the construction modules, which allows the building to be optimized in accordance with the demands of the developer or the occupier. Several building variants can be compared in a single process, and a sustained optimization of the building solution is achieved. The results of the calculation may serve as a yardstick for making a fundamental investment decision. Both the developer and the owner obtain an overview of the return on investment over the entire lifecycle at the beginning of the planning process. In operation, the model may be used as a support tool to monitor the operating processes. Any departures from the prognosis that occur during the operating phase can directly be fed into the model to obtain continuous information on changes in the return on investment.

Grundsätze und Ziele

Die Zeitschrift für Immobilienökonomie (ZIÖ) ist die offizielle Vereinszeitschrift der Gesellschaft für Immobilienwirtschaftliche Forschung gif e. V. Die Zielsetzung der Zeitschrift ist es, die Forschung auf dem Gebiet der Immobilienökonomie zu fördern, zur Verbreitung und Umsetzung der Ergebnisse beizutragen und dem internationalen Niveau anzunähern. Die ZIÖ verfolgt einen interdisziplinären Ansatz und strebt die Zusammenarbeit von Wissenschaft und Unternehmenspraxis in der Immobilienwirtschaft und verwandten Wirtschaftszweigen an.

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