

Correction Procedures for Appraisal-Based Real Estate Indices

by

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ABSTRACT

This study reviews and critically discusses correction-procedures (also called “unsmoothing-procedures”) for appraisal-based indices.

Indices tracking values of direct commercial real estate investments are traditionally constructed in an “appraisal-based style” : Since transactions and corresponding prices of individual properties are scarce, values from regular intervals of appraisals for each “index property” are taken for index calculation. Alas, appraisal-values neither necessarily match transaction-prices nor true market values of properties. Instead, they can deviate from market-values due to biases, which arise in appraisals and index construction processes.

In the past, some scientific authors suggested to correct (or “unsmooth”) appraisal-based indices from several types of biases. They claim that the corrected index returns should rather match the returns of true market values than the original index returns.

Primarily, appraisal-based real estate indices were calculated and published for the USA and UK. Those countries are considered as convenient target markets for investors. Due to its early launch, nowadays one long series of an appraisal-based index, which is available and appropriate for time series analysis, is the NCREIF Property Index for U.S.-properties. The ‘total’ index is composed of an ‘income’ and a ‘capital’ (or ‘appreciation’) component. So the focus of this study is in an application of the correction procedures on the NCREIF Appreciation Index. The techniques of the correction-procedures are discussed referring to the NPI. Also meaningful modifications are proposed for the correction procedures.

Introduction

Researchers claim that indices do not reflect the movements of true real estate market values in time. Concerning appraisal-based indices, there are evidences for biases (i.e. systematic errors) in index values of different origins. The causes for these biases are called ‘smoothing-phenomena’. They are due to the behaviour of surveyors in real estate-appraisals and due to the construction of appraisal-based indices. It is expected that these biases reduce the volatility of appraisal-based index returns compared to the volatility of their underlying true market returns. So the returns series of appraisal-based indices are ‘smoothed’. In recent times, some authors (for example Bond and Hwang) claim, that an ‘upward’ bias could also be possible.

While appraisals are performed for single properties, appraisal-based indices for whole real estate markets are of interest for investors and economic experts. Index values are aggregated from value-estimates for many single properties. So, it is suspected that systematic appraisal errors (i.e. ‘biases’) are transferred to index values, while pure random errors are cancelled out by diversification effects. Thus value estimates for individual properties can fall apart from true market values. It is suspected that appraisal-based indices do not reflect the true market value-movements of real estate markets.

Since appraisal-based indices are used for assessments of risks and performances of real estate investments and for asset allocation decisions, the biases induced by smoothing-phenomena can cause serious wrong decisions.

As a consequence, researchers try to find appropriate methods to identify the true market returns from appraisal-based index returns. Some authors developed correction-procedures and claim that returns generated from application of their procedures on index returns match true market returns perfectly. Or at least - they claim – the corrected returns are more akin to market returns than the original index returns.

In the literature, these correction procedures are often called ‘unsmoothing procedures’. First, Blundell and Ward (1987) were inspired by Fama’s (1970) theory of the efficient market hypothesis in developing their ‘unsmoothing procedure’. Some of the late authors criticise that the assumption of efficient markets is not correct or at least cannot be ex-ante verified. They suggest reverse-engineering procedures, multivariate methods or other approaches to estimate corrected returns.

More recently, authors - for example Bond and Hwang (2007) - doubt, that returns from appraisal-based indices are smoothed (meaning their volatility is downward biased) towards their corresponding market returns. So true market returns could be less volatile or even show the same or a higher volatility than reported returns (i.e. returns from appraisals or index returns). So reported returns are not necessarily ‘smoothed’ in the sense of showing a downward-biased volatility.

This study builds up the dissertation of Gohs (2013) which is in German language. It shows that a variety of ‘corrected’ returns series are gained by different univariate

correction-procedures. Gohs (2013) argued that the unequal returns series gained by the procedures cannot altogether be correct or reflect true market returns. In this study, the critical discussions as well as suggested modifications of the procedures which are proposed in Gohs (2013) are reproduced in English language. Beyond the univariate procedures discussed in Gohs (2013), multivariate procedures are revisited.

In the next section, the available data for this study are described. Sections three and four review smoothing-phenomena and correction-procedures which are recommended in the scientific literature. An evaluation of the correction procedures follows in the fifth section. In section six alternatives for measurement of real estate performance are discussed. The essay concludes with a presentation of the results for the corrected series.

Available Data for this Study

This study is based on times series of the ‘NCREIF Appreciation Index (NPI¹).’ The NPI refers to the U.S.-american market of commercial properties and it is updated in quarterly periodicity. At this point I would like to thank ‘National Council of Real Estate Investment Fiduciaries (NCREIF)’ for providing me the time series data. *“NCREIF is a member-driven, not-for-profit association that improves private real estate investment industry knowledge by providing transparent and consistent data, performance measurement, analytics, standards and education.”*²

Another well-known index-provider is ‘Investment Property Databank (IPD)’ - now affiliated with ‘MSCI’ - who publishes appraisal-based indices for other countries than the USA, especially European. The UK-IPD is published in several variants of periodicity. The UK-index with the highest frequency is provided in monthly periodicity and is constructed just from a fraction of the properties. For more properties - which are reappraised less frequently - also quarterly and annual indices are published. Each index contains information about properties whose values are already incorporated in indices of higher frequency.

Most literature about correction-procedures refers to the NPI or to the indices of IPD for UK. The prominence of the NPI and the UK-IPD is surely due to the importance of both countries (UK and USA) for investors as well as to the long index history. So the correction-procedures are tailored to the construction methodologies of these indices. They incorporate the typical smoothing-phenomena (see next section) which are discussed in the literature in connection with the UK- and USA-indices.

¹ The acronym ‘NPI’ ordinarily abbreviates ‘NCREIF Property Index’. Indeed the present study exclusively deals with the appreciation-component of the index. So if in the current study the term “NPI“ is used, mostly just the appreciation component and not the total index is meant.

² Mission Statement of NCREIF on <https://www.ncreif.org/about-us/missionstatement/> (call date May, 6th 2017).

While most correction-procedures can be adjusted for both, the NPI and the IPD, this essay refers to the NPI. In my dissertation (Gohs, 2013), results are provided in German language for the NPI as well as for the UK-IPD.

Some procedures (e.g. from Blundell and Ward or from Geltner) are evolved for the correction of returns series in annual periodicity. So prior to correction of the NPI, annual returns are calculated from the index series which are primarily in quarterly periodicity. This is done by aggregation of the four quarterly values of each year.

The time series in quarterly periodicity comprise returns from the first quarter 1978 until the first quarter 2016. So index values are calculated for the end of 1977 until the end of the first quarter 2016.

Furthermore a ‘Consumer Price Index – All Urban Consumers (U.S. city average, All items)’ is available for the same time frame and is used in some procedures.

Smoothing-Phenomena

The Appraisal-Smoothing

The supposed most influential and most discussed smoothing-phenomenon is the so-called ‘appraisal-smoothing’. It states that surveyors calculate current appraisal values for a property by incorporation of most recent data but also previous property values. So appraisal-values are just a mixture of past and most recent values and do not necessarily mirror current market values. Quan and Quigley (1989, 1991) (in the following abbr. QQ) argue that this behaviour of professional appraisers is not due to flaws in appraisals. Instead surveyors are insecure about true market values of properties due to imperfect information. In Quan and Quigley’s consideration, surveyors rely for appraisal purposes on information from two sources: First, prices from transactions of comparable properties in a market, and second, historical appraisal values and transaction prices of the property to be appraised. QQ argue that surveyors would rely more on historical appraisals, if there were recently just a few property transactions in the market. This is especially the case, if the recently observed property prices fluctuate strongly or past values are rather stable. Otherwise surveyors would rely more on current transaction prices of comparable properties, and especially if historical values are more volatile or recent values vary little. As a result of their considerations, QQ present a model, whereby the current appraisal value V_t is described as a weighted average from the current average transaction price M_t and the appraisal value V_{t-1} of the precedent period:³

$$V_t = \alpha_t \cdot M_t + (1 - \alpha_t) \cdot V_{t-1}, \alpha_t \in]0; 1], \forall t = 1, \dots, T \quad (1)$$

³ QQ use another notation and make inferences for optimal values of the weighting factors. Since the determination of optimal weights is no topic here, compare QQ.

The weight α_t is called ‘appraiser-alpha’ and its counterbalance $(1 - \alpha_t)$ ‘smoothing level’ or ‘smoothing-factor’.

The Temporal Aggregation

The term ‘temporal aggregation’ comprises a few types of phenomena which are named and described differently in the literature: In my terms the ‘non-synchronous appraisal’ and the ‘stale appraisals’ can be subsumed by this term.

The Non-Equidistant or Non-Synchronous Appraisals

The phenomenon of ‘non-equidistant appraisals’ arises since surveyors do not appraise all properties at the end (i. e. the last day) of a period. Instead appraisals are done during the whole period or at least during a time-frame of several days at the end of a period. But appraisal-values are reported for the end of a period, not for the appraisal day. The phenomenon of non-equidistant appraisals means, that returns for an individual property are reported for constant periods, while in fact there are different time-spans between successive appraisals.

At the index level, the phenomenon of ‘non-synchronous appraisals’ arises: This means that not all index properties are appraised at the end of a period under review. Rather – as already described - there is a time span for valuations which comprises a few days. So index values are calculated from appraisals for individual properties which are done at different time points. So the resulting index value is an aggregation of individual values from several days.

While this leads to minor effects, in that the index value is not wholly up-to-date. A higher impact results from stale appraisals.

The Stale Appraisals

Not all properties are reappraised every reporting period for which an index value is calculated. So the phenomenon ‘stale appraisals’ arises, if an index value is calculated from the most recent appraisal-values of the properties, which are spread across several periods.

The Seasonality in Appraisals

The phenomenon of ‘seasonality in appraisals’ is connected to the stale appraisal-problem: If in one phase (e.g. the fourth quarter) more properties are reappraised than in each other phase of a year, systematic value changes in this phase are pronounced. This can lead to a misimpression, that values change rather in this phase. But in fact, the striking index value changes in this phase across the years are due to appraisal rules, but not to economic influences.

Correction-Procedures

Classification of Correction-Procedures

Correction-Procedures can be grouped into univariate and multivariate. Further it can be differentiated between 'Zero-Autocorrelation'- and 'Reverse-Engineering'-procedures. Recently, procedures were suggested which contain elements of reverse-engineering-approaches complemented with advanced statistical methods.

In the following, derivations and functionalities of the correction procedures are described. Especially the relation equations between corrected and index returns are presented.⁴

The Efficient Market Hypothesis as General Idea of Zero-Autocorrelation-Correction-Procedures

Zero-Autocorrelation-Correction-Procedures are founded on Eugene Fama's (1970, p. 383) efficient market hypothesis: In efficient capital markets, the total available price-relevant information is already incorporated into prices. This is because arising new information is immediately incorporated in prices at the moment of its emergence. So there is no possibility for market participants to generate excess profits by analysis of information and usage for arbitrage dealings.

An academic discussion is about different grades of information processing: In the 'strong form' of market efficiency, even not insider information and -trading can result in excess profits. In the 'weak' information efficiency, future excess returns⁵ of a focussed risky asset cannot be forecasted⁶ by the historical market trend of the asset. However the hypothesis of the weak-form efficiency is just consistent with returns series which are not affected by (significant) autocorrelation. So it would make no sense to perform time series analysis techniques, and to analyse the autocorrelation structure for forecasting purposes.

The Blundell and Ward-Procedure

Inspired by the efficient market hypothesis, Blundell and Ward (1987) assume an informational efficient UK-market of commercial properties. This implies that true market returns of properties cannot be (significantly) autocorrelated. However, Blundell and Ward (1987, pp. 153-154) detect (significant) autocorrelation in returns of the appraisal-based Jones-Lang-Wootton (JLW) index for UK commercial properties. They explain that this observation can just be consistent with an efficient market, if all the

⁴ Gohs (2013) reports that the authors calculate with continuously compounded returns.

⁵ "Excess return" means the component of the return of a (risky) asset which is in excess of the return of a risk-free asset. Generally government bonds of some states are accepted as risk-free assets.

⁶ "Cannot" is rather colloquial. Rather academic: The best forecasting approach is the naive prognosis, according to which the forecasted price equals to the current price of an asset.

autocorrelation results from biases due to property appraisals and the index construction methodology. Moreover Blundell and Ward (in the following abbreviated as **BW**) claim, that true market returns can be gained from appraisal-based returns (which are biased) by elimination of the autocorrelation (i.e. the predictable partition of the returns).

To implement this idea, BW estimate an autoregressive model, where current returns from an appraisal-based index are regressed on earlier returns for former periods:

$$r_t = \phi_0 + \phi_1 \cdot r_{t-1} + \varepsilon_t, \varepsilon_t \sim N(\mu, \sigma), \forall t = 2, \dots, T(a) \quad (2)$$

where r_t is the return of the appraisal-based index for period t , a indicates the “annual” periodicity⁷ of the time series for T periods and the parameters ϕ_0 and ϕ_1 of the AR(1)-model as well as the regression residuals ε_t are to be estimated.

Following BW’s approach, Gohs (2013) describes the relation between corrected Blundell-Ward (BW)-returns $r_t^{c\{BW\}}$ and the estimation results as:

$$r_t^{c\{BW\}} = \frac{\widehat{\phi}_0 + \widehat{\varepsilon}_t}{1 - \widehat{\phi}_1}, \forall t = 2, \dots, T(a) \quad (3)$$

Or, representing this relation with index returns r_t instead of estimated residuals $\widehat{\varepsilon}_t$, the corrected returns $r_t^{c\{BW\}}$ are calculated as:

$$r_t^{c\{BW\}} = \frac{r_t - \widehat{\phi}_1 \cdot r_{t-1}}{1 - \widehat{\phi}_1}, \forall t = 2, \dots, T(a) \quad (4)$$

The BW-method is applied for time series in annual periodicity. Since the calculation of the current **corrected value** r_t^c requires the knowledge of the preceding value of the original time series r_{t-1} , no match r_1^c for the first observation of the original series r_1 can be calculated.

The variances of the appraisal-based returns and their corresponding corrected returns are related as follows:

$$Var(r_t^{c\{BW\}}) = \frac{1 - \phi_1^2}{(1 - \phi_1)^2} Var(r_t) \quad (5)$$

⁷ So the correction procedure is reasonably applied for annual periodicity or at least applied in this periodicity in the original study.

The Firstenberg-Ross-Zisler-Procedure

Following BW in general, Firstenberg, Ross and Zisler (1988) correct U.S. commercial property index returns in quarterly periodicity.⁸

So they suggest to estimate an AR(4) model:

$$r_t = \phi_0 + \phi_1 \cdot r_{t-1} + \phi_2 \cdot r_{t-2} + \phi_3 \cdot r_{t-3} + \phi_4 \cdot r_{t-4} + \varepsilon_t, \varepsilon_t \sim N(\mu, \sigma), \quad (6)$$

$$\forall t = 5, \dots, T(q)$$

Then the estimated regression coefficients and residuals are used to calculate the corrected index returns in the Firstenberg-Ross-Zisler-style (in the following abbr. as **FRZ**). Following this approach, Gohs (2013) describes the relation between corrected FRZ-returns $r_t^{c[FRZ]}$ and the estimation results as:

$$r_t^{c[FRZ]} = \widehat{\phi}_0 + \frac{\widehat{\varepsilon}_t}{1 - \sum_{p=1}^4 \widehat{\phi}_p} \quad (7)$$

Again, there are four observations less in the corrected returns series, since there are no precedent observations available to correct the first four observations of the original index returns.

The arithmetic mean of the corrected FRZ-returns is

$$E(r_t^{c[FRZ]}) = \widehat{\phi}_0 \quad (8)$$

And the standard deviation can be calculated as follows:

$$SD(r_t^{c[FRZ]}) = \frac{\sigma_{\widehat{\varepsilon}_t}}{1 - \sum_{p=1}^4 \widehat{\phi}_p} \quad (9)$$

Gohs (2013) suggests the following modifications of the FRZ-approach:

Discussions (on conferences) are about, if just AR-terms belonging to significant parameters should be corrected. This procedure is called here '**FRZ-type (sign. AC eliminated)**'.

Also AR-terms with estimated negative coefficients could not be considered for correction. This applies if it is assumed that smoothing phenomena solely cause positive autocorrelation.. But surely this assumption is not indisputed.

⁸ They suggested this method for a correction of the Frank Russell (FRC)- and Evaluation Associates (EAFPI)-indices in quarterly periodicity.

The Fisher-Geltner-Webb-Procedure for Inflation-Adjusted Returns

Fisher, Geltner and Webb (1994, p. 142) argue that *“return unpredictability due to weak-form informational efficiency is more theoretically sound for real returns”*.

This efforts to get real (i.e. inflation-adjusted) from nominal index returns by an elimination of the inflation component.

Since the inflation component is approximated by returns of a suitable consumer price index (**cpi**),⁹ real returns are calculated from nominal as:

$$real_t = r_t - cpi_t, \forall t = 1, \dots, T(q) \quad (10)$$

Fisher, Geltner and Webb (abbr. **FGW**) believe that values of the Russel-NCREIF (**RN**) Appreciation Index are biased compared to their correspondent true market returns due to appraisal phenomena. In this context the authors describe phenomena which are called - inter alia in Gohs (2013) - ‘appraisal-smoothing’ and ‘stale appraisal’, possibly combined with ‘seasonality in appraisals’. FGW believe that these phenomena could induce positive autocorrelation of first and fourth order into the RN-returns.¹⁰

So, for correction purposes FGW (1994, p. 142) report to estimate an AR(1,4)-model for the inflation-corrected (real) component of the RN-returns:

$$real_t = \phi_0^{real} + \phi_1^{real} \cdot real_{t-1} + \phi_4^{real} \cdot real_{t-4} + \varepsilon_t^{real}, \varepsilon_t^{real} \sim N(\mu, \sigma), \forall t = 5, \dots, T(q) \quad (11)$$

Following the description of FGW, the estimated residuals $\widehat{\varepsilon}_t^{real}$ and the regression coefficient $\widehat{\phi}_0$ are gained, and the corrected returns $r_t^{c[FGWr]}$ can be calculated. Again, corrected returns for the first four periods cannot be calculated due to missing precedent values in the original series.

While the standard deviations in the BW- and FRZ-cases are given endogenously as calculated from the corrected series, FGW suggest to determine the standard deviation of the corrected returns in advance, modell-exogenously. FGW believe that the volatility of returns of the U.S. commercial properties amounts half as much as the volatility of

⁹ Gohs (2013) takes the UK CPI All Items NADJ- and the UK PRI NADJ-indices to approximate the inflation component of UK-indices.

¹⁰ Gohs (2013) believes that autocorrelation of the first and fourth order could also be incorporated in index values during the appraisal-process. Thereby the surveyer includes the values of the preceding quarter and of the same quarter in the previous year.

Concerning the IPD index for UK, it is not definite from the available information for this essay, that the index is biased by the phenomena of stale appraisal and seasonality in appraisals.

U.S. stock returns, represented by the Standard & Poors 500 index.¹¹ To implement this, their suggested correction-procedure involves the following adaption factor w_0 :

$$w_0 = 2 \frac{\sigma_\varepsilon^{real}}{\sigma_{SP}} \quad (12)$$

with the standard deviation $\sigma_\varepsilon^{real}$ of the residuals ε_t^{real} and the standard deviation σ_{SP} of the S&P 500-index returns.

So Gohs (2013) identifies this relationship between corrected Fisher-Geltner-Webb-returns $r_t^{c\{FGWr\}}$ and their input variables:

$$r_t^{c\{FGWr\}} = (\widehat{\varepsilon}_t^{real} + \widehat{\phi}_0^{real}) \cdot \frac{\sigma_{SP}}{2 \cdot \sigma_\varepsilon^{real}} + cpi_t, \forall t = 5, \dots, T(q) \quad (13)$$

or

$$r_t^{c\{FGWr\}} = [(r_t - cpi_t) - \widehat{\phi}_1^{real} \cdot (r_{t-1} - cpi_{t-1}) - \widehat{\phi}_4^{real} \cdot (r_{t-4} - cpi_{t-4})] \frac{\sigma_{SP}}{2\sigma_\varepsilon^{real}} + cpi_t, \forall t = 5, \dots, T(q) \quad (14)$$

But - following this interpretation of the FGW-text - the volatility of the FGW-corrected returns does not amount half of the volatility of the stock index returns. This is due to the fact that the adjustment factor is applied to the real component (i.e. the real component is weighted). Alas, from the description in FGW, it is not really clear, how to handle the correction of the real returns, and on which stage in this procedure, the returns series are weighted for the volatility adjustment.

The Fisher-Geltner-Webb-Procedure for Inflation-Adjusted Returns (Another Interpretation)

Another interpretation of the Fisher-Geltner-Webb procedure (which is seen here most reasonably and so abbreviated as **FGW**) is, that the parameter estimate ϕ_0^{real} is taken from the time series of 'inflation-corrected' returns, but the weighting is applied for nominal returns r_t :

$$r_t^{c\{FGW\}} = [r_t - \widehat{\phi}_1^{real} \cdot r_{t-1} - \widehat{\phi}_4^{real} \cdot r_{t-4}] \frac{\sigma_{SP}}{2\sigma_r}, \quad \forall t = 5, \dots, T(q)$$

with weighting factor

¹¹ Gohs (2013) chooses as stock indices the Standard & Poors S&P 500 COMPOSITE - PRICE INDEX to correct the NCREIF Appreciation Index and the FTSE 100 Price Index to correct the IPD UK Monthly Capital Index.

$$w_0 = 2 \frac{\sigma_r}{\sigma_{SP}} \quad (12)$$

and σ_r is the standard deviation of the index returns r_t .

Results for this variant are currently not provided.

The Fisher-Geltner-Webb-Procedure for Inflation-Adjusted Returns (Third Interpretation)

Due to the considerations in the precedent section, a modification of the Fisher-Geltner-Webb procedure (abbreviated as **FGWv**) is suggested: To (better) target the variance of the corrected returns series, the adjustment factor could be calculated as follows, if $\sigma_{SP} > \sigma_{CPI}$:

$$w_0 = 2 \frac{\sigma_\varepsilon^{real}}{\sigma_{SP} - \sigma_{CPI}} \quad (15)$$

So the correction rule would be:

$$r_t^{c[FGWv]} = [(r_t - cpi_t) - \widehat{\phi}_1^{real} \cdot (r_{t-1} - cpi_{t-1}) - \widehat{\phi}_4^{real} \cdot (r_{t-4} - cpi_{t-4})] \frac{\sigma_{SP} - \sigma_{CPI}}{2\sigma_\varepsilon^{real}} + cpi_t, \quad (16)$$

$$\forall t = 5, \dots, T(q)$$

Results for this variant are not provided.

The Fisher-Geltner-Webb-Procedure for Nominal Returns

Due to the difficulties arising in the handling of the real component, Gohs (2013) suggests to abstain from a separate treatment of the real component and to focus on the nominal returns.

So the AR(1,4)-model is estimated for nominal returns of an appraisal-based index:

$$r_t = \phi_0 + \phi_1 \cdot r_{t-1} + \phi_4 \cdot r_{t-4} + \varepsilon_t, \varepsilon_t \sim N(\mu, \sigma), \forall t = 5, \dots, T(q) \quad (17)$$

Following this, the corrected returns (abbr. **FGWn**) are calculated as follows:

$$r_t^{c[FGW n]} = (\widehat{\varepsilon}_t + \widehat{\phi}_0) \frac{\sigma_{SP}}{2 \cdot \sigma_\varepsilon}, \forall t = 5, \dots, T(q) \quad (18)$$

Now the standard deviation of the corrected series is as targeted – it amounts half volatility of the S&P-index returns.

The Cho-Kawaguchi-Shilling-Procedure

Cho, Kawaguchi and Shilling (2001) (abbr. **CKS**) propose an extension of the Fisher-Geltner-Webb-correction procedure. They claim that their extension is necessary to correct for a bias: Namely the error term in the FGW-regression model “*does not necessarily have an expectation zero*” (Cho et al. 2001, p. 2 and 11). Cho et al. (2001, p. 2) state: “*Using inflation-adjusted appreciation returns to estimate the model helps, but does not completely solve the problem. Even with inflation-adjusted appreciation returns, a non-zero error term is possible. And a large non-zero error term that varies over time can be quite troubling (as we shall see), since it would mean that a systematic bias is present.*” Cho et al. (2001, p. 11) conclude: “*This can easily lead to biased coefficient estimates depending on the choice of sample period.*”

Cho et al. (2001, p. 11) supplement: “*A second concern is that, because valuation-based commercial property returns vary smoothly over time, a generalized-difference specification is needed to transform the resulting error terms in FGW’s unsmoothing model into a stationary series. In so doing, however, there is a potential danger that negative autocorrelation will be introduced. To account for this problem, we added a constant term to our generalized-difference transformation.*”

To correct for this bias, CKS suggest to estimate a model with “*generalized differences*”

$$\Delta r_t^* = \mu' + \phi(B) \Delta r_{t-1}^* + \epsilon_t' \quad (19)$$

with

$$\Delta r_t \equiv r_t - r_{t-2} \text{ and } E(\epsilon_t') \text{ (c.f. Cho et al. 2001, p. 4).}^{12}$$

So CKS estimate the parameters of the following model for inflation-corrected NPI Appreciation Index-returns:

$$\begin{aligned} & (real_t - real_{t-2}) \\ &= \phi_0^{CKS} + \phi_1^{CKS} (real_{t-1} - real_{t-3}) + \phi_4^{CKS} (real_{t-4} - real_{t-6}) + \epsilon_t^{real}, \end{aligned} \quad (20)$$

$$\epsilon_t^{real} \sim N(\mu, \sigma), \forall t = 7, \dots, T(q)$$

However from this estimation equation just the parameter estimates $\widehat{\phi}_1$ and $\widehat{\phi}_4$ are taken. Then a correction rule as interpreted from Fisher et al. (1994) is applied:

¹² For a better comparability with the original text, the notation of CKS is replied where r_t^* characterises the index-returns. But in the following I return to my notation, where r_t denotes index-returns.

Following these instructions of CKS, the adjustment factor w_0^{CKS} for the corrected returns series is again calculated for real returns, taking the standard deviation of the difference $r_t - \phi_1 r_{t-1} - \phi_4 r_{t-4}$:

$$w_0^{CKS} = 2\sigma \left[r_t - \widehat{\phi_1^{CKS}} r_{t-1} - \widehat{\phi_4^{CKS}} r_{t-4} \right] / \sigma_{SP} \quad (21)$$

With the adjustment factor w_0^{CKS} the following correction rule results:¹³

$$r_t^{c[CKS]} = [r_t - \widehat{\phi_1^{CKS}} \cdot r_{t-1} - \widehat{\phi_4^{CKS}} \cdot r_{t-4}] / w_0^{CKS}, \quad (22)$$

$$\forall t = 5, \dots, T(q)$$

Alternatively the correction procedure could directly be applied on nominal index returns as suggested for FGWn.

Results for the CKS-procedure are not provided in this paper.

A Proposal for a New Zero-Autocorrelation-Procedure

In my dissertation (Gohs, 2013), I suggest a new zero-autocorrelation-procedure. Therefore I considered the real component and the exogenously determined standard deviation of the corrected returns.

Again the argument of Fisher et al. (1994) is picked up that the assumption of unpredictability is adequate rather for real (i.e. inflation-corrected) than for nominal market returns. Fisher et al. (1994) think about a correction procedure which should be applied in essence on the real component of the index returns. However the authors leave it open (or at least not fully transparent), how to get the real component of an appraisal-based index. Surely, it is quite evident in an environment without biases, that real returns are gained by subtracting the inflation component (represented by the returns of a consumer price index) from nominal returns. Admittedly, this is problematic for appraisal-based values: Since appraisals are done in nominal sizes, the real and the inflation component are both biased by smoothing-phenomena. So Gohs (2013) argues: To gain the biased real component for correction purposes from biased nominal returns, also the biased inflation-component must be identified. But consumer price indices as representatives for the inflation-component are not biased by the smoothing-phenomena. So the task would be to fill in the gap between biased and unbiased inflation-returns. While this problem is characterised in Gohs (2013), it is not specified in Fisher et al. (1994) how to calculate inflation-corrected from appraisal-based returns.

¹³ Cho et al. (2001, p. 6) explain: "NCREIF [...] series are expressed in nominal terms by adding back in the inflation rate."

To solve this problem Gohs (2013) firstly considers to manipulate the series of a consumer price index by the typical appraisal-biases. This could be done in the framework of a simulation study. Afterwards the biased consumer price index can be applied on the appraisal-based index to calculate biased real returns. In a next step the biased real returns can be corrected. Surely, this proceeding requires a whole simulation study.

But then Gohs (2013) decides for another procedure which can be sketched as follows: First of all, the nominal returns of the appraisal-based index are corrected by a zero-autocorrelation-procedure. Afterwards the misleading correction of the inflation-component is withdrawn.

Thereby Gohs (2013) picks up the idea of Fisher et al. (1994, p. 141) to determine the volatility of the corrected returns exogenously from the correction procedure. Fisher et al. (1994) assume that the volatility of market returns of commercial properties is about half of the volatility of a corresponding stock index of this region or rather country. However, Fisher et al. (1994) leave it open how to handle this in connection with the problem of identifying the real returns. Gohs (2013) hints, that the volatility-ratio w_0 in Fisher et al. (1994) should necessarily consider the linkage between real returns and nominal returns.

In detail the procedure is as follows:

First, an AR(1,4)-model for nominal returns of the appraisal-based index is estimated:

$$r_t = \phi_0 + \phi_1 \cdot r_{t-1} + \phi_4 \cdot r_{t-4} + \varepsilon_t, \quad \varepsilon_t \sim N(\mu, \sigma), \forall t = 5, \dots, T(q) \quad (23)$$

Following Fisher et al. (1994) this lag-structure is assumed best to catch the effects of the phenomena of appraisal-smoothing and seasonality in appraisals. The AR(1,4)-parameter estimates are according to the **FGWn** model.

Afterwards the autocorrelation for time lags of one and four periods is removed from the time series of index returns. So the following series remains:

$$\hat{\varepsilon}_t + \hat{\phi}_0, \forall t = 5, \dots, T(q) \quad (24)$$

The validity of the efficient market hypothesis is presupposed for the real component but not compulsive for the inflation component of the returns series, as argued by FGW. So it is possible that autocorrelation is inherent in the inflation component, but now as well eliminated in the zero-autocorrelation returns. Actually the returns of the representative CPI contain significant autocorrelation. So there is too much autocorrelation eliminated in the zero-autocorrelation returns, since it resulted not from biases but was already inherent in the inflation-component. To replace this autocorrelation partition, the unsmoothed is substituted by the original CPI-series. So the smoothed inflation-component in the zero-autocorrelation returns is estimated by adaption of an AR(1,4)-model for the returns of the (market-representative) consumer price index:

$$cpi_t = \phi_0^{cpi} + \phi_1^{cpi} \cdot cpi_{t-1} + \phi_4^{cpi} \cdot cpi_{t-4} + \varepsilon_t^{cpi}, \varepsilon_t^{cpi} \sim N(\mu, \sigma), \forall t = 5, \dots, T(q) \quad (25)$$

From the estimate of the AR(1,4)-model the residuals as well as the parameter estimate of the constant are gained.

So the unsmoothed inflation-component from (25)

$$\widehat{\varepsilon}_t^{cpi} + \widehat{\phi}_0^{cpi}, \forall t = 5, \dots, T(q) \quad (26)$$

is exchanged from the unsmoothed returns of the appraisal-based index by the original returns of the consumer price index:

$$(\widehat{\varepsilon}_t + \widehat{\phi}_0) - (\widehat{\varepsilon}_t^{cpi} + \widehat{\phi}_0^{cpi}) + cpi_t, \forall t = 5, \dots, T(q) \quad (27)$$

If there is a demand to determine the volatility of the corrected index returns exogenously, further steps are necessary. Again it is assumed that beliefs about the volatility of property market returns certainly concern nominal returns. Anyway, to fix the volatility of nominal returns, the real component must be treated differently from the inflation component. This is because the inflation component is already given and represented by the consumer price index. So it should not be manipulated. Just the real component of the index returns is available for adjustment to control the target volatility of the nominal index returns.

The adjustment can be done by weighting the unsmoothed real component ξ_t which is calculated as difference of the unsmoothed (nominal) index returns (24) and the unsmoothed inflation component (26):

$$\xi_t = (\widehat{\varepsilon}_t + \widehat{\phi}_0) - (\widehat{\varepsilon}_t^{cpi} + \widehat{\phi}_0^{cpi}), \forall t = 5, \dots, T(q) \quad (28)$$

The standard deviation is adjusted by multiplication of the values of the time series ξ_t by the factor v . To gain the value of the factor v , it is considered that the volatility assumption relates to nominal returns, and the following equation holds for corrected nominal returns $r_t^{c[Real]}$:¹⁴

$$r_t^{c[New]} = real_t^c + cpi_t = v \cdot \xi_t + cpi_t, \forall t = 5, \dots, T(q) \quad (29)$$

The corrected returns are termed here as ‘**New**’.

Between the (co-)variances of the returns the following relationship exists (Gohs, 2013):

¹⁴ In Gohs (2013) this procedure is called ‘*Real*’, since it focusses on a special treatment of inflation-adjusted returns.

$$\sigma_{r^c}^2 = \sigma_{real^c}^2 + \sigma_{cpi}^2 + 2\sigma_{real^c,cpi} = v^2\sigma_{\xi}^2 + \sigma_{cpi}^2 + 2v\sigma_{\xi,cpi} = \overline{\sigma^2} \quad (30)$$

with

- $\sigma_{r^c}^2$: the variance of the corrected index returns
- $\sigma_{real^c}^2$: the variance of the corrected real component of the index returns
- σ_{cpi}^2 : the variance of the CPI-returns
- $\sigma_{real^c,cpi}$: the covariance between the corrected real returns and the CPI-returns
- σ_{ξ}^2 : the variance of the term ξ_t
- $\sigma_{\xi,cpi}$: the covariance between the term ξ_t and the CPI-returns
- $\overline{\sigma^2}$: the pre-determined variance of the corrected index returns
- v : a multiplier, which fulfills the equation $v^2\sigma_{\xi}^2 + \sigma_{cpi}^2 + 2v\sigma_{\xi,cpi} = \overline{\sigma^2}$.

Conversion of this equation yields:

$$v^2\sigma_{\xi}^2 + 2v\sigma_{\xi,cpi} + \sigma_{cpi}^2 - \overline{\sigma^2} = 0 \quad (31)$$

And division by σ_{ξ}^2

$$v^2 + v\frac{2\sigma_{\xi,cpi}}{\sigma_{\xi}^2} + \frac{\sigma_{cpi}^2 - \overline{\sigma^2}}{\sigma_{\xi}^2} = 0 \quad (32)$$

The value of the adjustment factor v can be gained by solving the quadratic equation:

$$v_{1/2} = -\frac{\sigma_{\xi,cpi}}{\sigma_{\xi}^2} \pm \sqrt{\left(\frac{\sigma_{\xi,cpi}}{\sigma_{\xi}^2}\right)^2 - \frac{\sigma_{cpi}^2 - \overline{\sigma^2}}{\sigma_{\xi}^2}} \quad (33)$$

This corresponds to:

$$v_{1/2} = -a \pm \sqrt{a^2 - \frac{b}{c}} \quad (34)$$

with

$$a = \frac{\sigma_{\xi, cpi}}{\sigma_{\xi}^2};$$

$$b = \sigma_{cpi}^2 - \overline{\sigma^2};$$

$$c = \sigma_{\xi}^2.$$

Requirements are $\sigma_{rc}^2 = \overline{\sigma^2}$ and $r_t^c = real_t^c + cpi_t$. Provided that $\overline{\sigma^2} \geq \sigma_{cpi}^2$, it follows that $b \leq 0$. Since variances are non-negative, $\sigma_{\xi}^2 \geq 0$, and also $-\frac{b}{c} \geq 0$. Since squared real-valued numbers are positive, $a^2 \geq 0$, and $a^2 - \frac{b}{c} \geq 0$, i. e. the square root of this expression is positive, too. So at least one real-valued solution exists for the quadratic equation. Since just values for the volatility factor are reasonable which are strictly positive, i. e. $v > 0$, exactly one solution exists, which is

$$v = -\frac{\sigma_{\xi, cpi}}{\sigma_{\xi}^2} + \sqrt{\left(\frac{\sigma_{\xi, cpi}}{\sigma_{\xi}^2}\right)^2 - \frac{\sigma_{cpi}^2 - \overline{\sigma^2}}{\sigma_{\xi}^2}} \quad (35)$$

Taking this adjustment factor, the corrected real component is calculated as follows:

$$real_t^{c[Real]} = v \xi_t = v[(\widehat{\varepsilon}_t + \widehat{\phi}_0) - (\widehat{\varepsilon}_t^{cpi} + \widehat{\phi}_0^{cpi})], \forall t = 5, \dots, T(q) \quad (36)$$

So the nominal return values are calculated as follows:

$$r_t^{c[New]} = v \xi_t + cpi_t, \forall t = 5, \dots, T(q) \quad (37)$$

Summarised:

$$r_t^{c[New]} = \left[-\frac{\sigma_{\xi, cpi}}{\sigma_{\xi}^2} + \sqrt{\left(\frac{\sigma_{\xi, cpi}}{\sigma_{\xi}^2}\right)^2 - \frac{\sigma_{cpi}^2 - \overline{\sigma^2}}{\sigma_{\xi}^2}} \right] \cdot [(\widehat{\varepsilon}_t + \widehat{\phi}_0) - (\widehat{\varepsilon}_t^{cpi} + \widehat{\phi}_0^{cpi})] + cpi_t, \quad (38)$$

$$\forall t = 5, \dots, T(q)$$

Anyway Gohs (2013) suggests to apply the Fisher et al. (1994)-procedure for nominal returns (FGWn), if there is no significant autocorrelation in the returns of the representative CPI. Then it can be assumed that all of the (significant) autocorrelation in the nominal returns results from the real component. So a separate treatment of the real component is not necessary.

Reverse-Engineering-Correction-Procedures

For construction of reverse-engineering-procedures, researchers try to track the influences of biases of different origins in the appraisal- and index calculation-processes. They evolve the relationship between market values (or returns) and their corresponding

biased (i.e. appraisal-based) values (returns). Then, this relationship is reverted and applied to appraisal-based index returns to get the alleged market returns.

The Geltner-Procedure

Geltner (1993b) refers to Case and Shiller (1989, 1990), which claim that returns of single-family homes in different separated U.S.-markets are predictable. If this was true, the information processing on these markets would not be efficient. So the application of Zero-Autocorrelation-Correction-Procedures would not be adequate.

Geltner (1993b) developed a reverse-engineering-procedure to correct the appreciation returns of the Russell-NCREIF-Index (**RNI**) and of the Evaluation Associates Index (**EAI**).¹⁵ Both indices refer to the U.S.-american market of commercial properties (c.f. Geltner 1993b, p. 325). Even though both indices are updated in quarterly periodicity, Geltner (1993b, p. 340) engineered his correction procedure for application on annual returns series. Hence he calculated annual returns from index values for the ends of consecutive annual fourth quarters (i.e. from the index values for Dec. 31st) (c.f. Geltner 1993b, p. 327). From application of his correction procedure he gains indices in annual periodicity for the time span end of 1978 until end of 1991 for the RNI and end of 1969 until end of 1991 for the EAI (c.f. Geltner 1993b, p. 343). Geltner (1993b, p. 326) reasons the correction of index series in annual periodicity with the fact, that not all properties of the RNI index portfolio are reappraised quarterly. Instead he assumes that each property is reappraised once a year. Also Geltner (1993b, p. 325 and 327) claims to account in this way for the effects of the smoothing-phenomena. The phenomena he describes are in my terms: The appraisal-smoothing, a type of temporal aggregation and seasonality in appraisals. He believes that these phenomena can be better treated in returns series of annual periodicity (c.f. Geltner 1993b, p. 327). Geltner (1993b, p. 333 and 337) claims that he applies his correction procedure on real returns of an appraisal-based index and then adds the returns of the inflation component. However Geltner (1993) does not justify the application of his approach on real returns. Perhaps he has similar reasons like Fisher et al. (1994). They hint that the unpredictability assumption is not necessarily true for the inflation-component. So they motivate to just correct real returns. But this argument cannot be valid for a reverse-engineering correction procedure, since these procs do not require the unpredictability assumption anyway. Neither Geltner explains how to get real from biased nominal returns. So I assume that he calculates 'real' returns by subtracting CPI-returns from the (nominal) returns of an appraisal-based index. This procedure was already criticised in connection with the FGW-procedure. So it is suggested in Gohs (2013) to apply Geltners (1993b) correction procedure for nominal returns of an appraisal-based index. Then a differentiated treatment of the inflation and of the real components of an index is not necessary.

¹⁵ C.f. Geltner (1993b, p. 343, Endnote 1) : *"The former is published by the Frank Russell Company of Tacoma, Washington for the National Association of Real Estate Investment Fiduciaries (NCREIF). The latter is published by Evaluation Associates Incorporated of Norwalk, Connecticut."*

But first of all the correction procedure is described as interpreted from the original essay.¹⁶ Then the correction rule for nominal returns is given.

The Geltner (abbr. **G**)-corrected returns $r_t^{c[G]}$ are calculated as ¹⁷

$$r_t^{c[G]} = \frac{\text{real}_t - (1 - a^\circ) \cdot \text{real}_{t-1}}{a^\circ} + \text{cpi}_t, \forall t = 2, \dots, T(a) \quad (39)$$

and real_t are inflation-corrected index returns (as in 10) : $\text{real}_t = r_t - \text{cpi}_t$,

or

$$r_t^{c[G]} = \frac{(r_t - \text{cpi}_t) - (1 - a^\circ) \cdot (r_{t-1} - \text{cpi}_{t-1})}{a^\circ} + \text{cpi}_t, \forall t = 2, \dots, T(a) \quad (40)$$

and the parameter a , whose optimal value a° can be calculated, if the values of the parameters α (which is the average appraiser-alpha in appraisals of individual properties) and f (which is the average ratio of properties reappraised in each of the first three quarters of a year) from equations (2) and (3) in Geltner (1993, p. 329) are known. The optimal value a° fulfills the following restriction:

$$a^\circ - \frac{\alpha}{2} \cdot (2 - 3f) + \sum_{t=1}^{T(q)-1} a^\circ \cdot (1 - a^\circ)^t - \frac{\alpha}{2} \cdot (2 - 2\alpha + 3\alpha f) \cdot (1 - \alpha)^{t-1} = 0 \quad (41)$$

To obtain the optimal value a° , I implement a scatter search algorithm and minimise :

$$a^\circ = \min_a \left| a - \frac{\alpha}{2} \cdot (2 - 3f) + \sum_{t=1}^{T(q)-1} a \cdot (1 - a)^t - \frac{\alpha}{2} \cdot (2 - 2\alpha + 3\alpha f) \cdot (1 - \alpha)^{t-1} \right| \quad (42)$$

Geltner (1993b, p. 331) claims that the optimal value $a^\circ = \text{opt}(a)$ amounts 0,4 for the returns of the RNI and EAI, respectively, if it can be assumed that $\alpha = 0,5$ and $f = 0,15$.¹⁸ If the returns were not biased by the phenomenon of appraisal-smoothing, the

¹⁶ The construction of the correction procedure is not detailed here but in Geltner (1993b, pp. 328).

¹⁷ Geltner (1993b, p. 340) operates with continuously compounded returns, as can be seen from the description of his constructions: From (A1a) until (A2d) (notation in the original literature) results that he calculates returns by differencing values in levels. So he must work with continuously compounded returns.

¹⁸ To get the value of the parameter f , Geltner (1993b, p. 331) proceeds as follows: *"The fact that the fourth-quarter mean is nearly 3.5 times greater than the quarterly mean for the other quarters during this period suggests that some 3.5 times more properties are typically appraised during the fourth quarter than each of the other quarter. This suggests that we apply a value of $f = .15$ in equation (2). This would imply that effectively 55% of all properties are reappraised during the fourth calendar quarter."*

value of the parameter alpha would equal to one ($\alpha = 1$). If there is no seasonality in appraisals, then $f = 1/4$. But in this case, the phenomenon of stale appraisals (as named here), could still bias the index returns.¹⁹

Gohs (2013) takes the parameter value $f=0$ to correct the IPD UK Monthly Capital Index (for both variants of the correction procedure: the variant for real returns and the variant directly applied for nominal returns). He justifies this with missing references for the phenomenon of stale appraisal (or ‘temporal aggregation’ in Geltner’s terms) in this index. Concerning the appraiser-alpha Gohs (2013) follows Geltner (1993b, p. 331) and takes $\alpha = 0,5$. Accordingly an optimal value $a = 0,5$ is calculated. To correct the returns, Gohs chooses Geltner’s model variant (2b).

To estimate the value of the parameter f for correction of the NPI-returns, Gohs (2013) follows Geltner (1993b, p. 331). From the NPI-series which was available for his study, Gohs calculated $f=0,2712$ for nominal and $f=0,2183$ for inflation-corrected returns. For the appraiser-alpha he assumes $\alpha = 0,5$ again. So to apply the original Geltner-procedure (i.e. to correct real returns) Gohs calculates a value of $a^\circ = 0,4155$. If the procedure is directly applied to nominal returns, he calculates an optimum $a^\circ = 0,3929$.

Geltner (1993b, p. 337) reports, that *“the recovered series show much less autocorrelation than the publicly reported appraisal-based index returns, but do show some evidence of positive first-order autocorrelation.”* Gohs (2013) confirms that there is no significant serial correlation in the index returns corrected with the Geltner-procedure. If the corrected returns series would actually match the true UK- and U.S.-returns perfectly, this would imply efficient UK- and U.S.-real estate markets.

The Geltner-Procedure for Nominal Returns

If nominal returns are corrected immediately, the modification of the correction rule (abbr. **Gn**) is:

$$r_t^{c[Gn]} = \frac{r_t - (1 - a^\circ) \cdot r_{t-1}}{a^\circ}, \forall t = 2, \dots, T(a) \quad (43)$$

The Barkham and Geltner-Procedure

Barkham and Geltner (1994, p. 81) (abbr. **BG**) suggest a reverse-engineering-procedure for application on the Jones Lang Wootton-index of capital values for the British market of commercial properties. They work with continuously compounded returns.

To gain a value of the parameter α , Geltner (1993b, p. 331) relies on former studies and asserts: *“Furthermore, there is a strong argument that for annual reappraisals the ‘rational’ or ‘optimal’ level for α , according to formula (1c) described previously, is near $\alpha=(1/2)$.”*

¹⁹ Geltner (1993b) explains: *“[...] then we would observe the ‘pure’ effect of temporal aggregation in the annual returns (the fact that properties are reappraised only once per year staggered at the ends of the four calendar quarters)”*

As opposed to Geltner (1993b) there is no hint in Barkham and Geltner (1994) to apply their procedure on real (i.e. inflation-corrected) returns.

In their considerations about the construction of a correction procedure, Barkham and Geltner (1994, p. 82) include the phenomena appraisal-smoothing and non-synchronous appraisal.²⁰ But then the effects of non-synchronous appraisals are not explicitly modeled. But since they correct index returns in annual periodicity,²¹ effects of both smoothing phenomena might already be alleviated.

Barkham and Geltner (1994) initially engineer a rather complex relation between index returns r_t^* and market returns r_t . But then they reduce it to the following simple equation:

$$r_t^{c[BG]} = \frac{r_t - (1 - a) \cdot r_{t-1}}{a}, \forall t = 2, \dots, T(a) \quad (44)$$

To get an adequate value for the parameter a , Barkham and Geltner (1994, p. 89) refer to Geltner (1993b): *"The unsmoothing parameter 'a' could be selected by minimizing the sum of squared differences between the coefficients in Equation 12 vs Equation 11, as suggested by Geltner (1993[b]). However, this would seem to be 'overkill' in the present context, given the 'softness' of any specific estimate of the value of α in Equation 11, and indeed the approximate nature of the mathematical form of Equation 4 which underlies the analysis."* Further Barkham and Geltner (1994, p. 87) explain: *"For example, if $\alpha=1/2$, then $a=3/4$ will enable Equation 12 to closely mimic Equation 11, and if $\alpha=1/4$ then $a=1/2$ will work very well [...]"* Gohs (2013) believes that values for the appraiser-alpha $\alpha = 3/8$ and $\alpha = 1/2$ are plausible. So to correct the UK IPD index returns, parameter values $a = 5/8$ and $a = 3/4$ are suitable. If $a = 1/2$ is chosen, the same correction rule is gained from Barkham and Geltner (1994) as well as from Geltner (1993b). This is because the Barkham and Geltner-procedure is developed for a British index in which no stale appraisal prevails (at least there was no information available for this study which hints on stale appraisal). The BG-procedure is not appropriate for the NPI, which is biased by stale appraisals.

²⁰ In their terms 'temporal aggregation', which in my terms comprises 'stale appraisal' besides 'non-synchronous appraisal'. However Barkham and Geltner (1994, p. 82) explain: *"The source of index smoothing is twofold. First, it may result from temporal aggregation. If the returns for a particular month are based on valuations which are carried out at different times during that month, then some smoothing will result from this in a monthly return index. Second, and more fundamentally, smoothing results from the way in which valuers arrive at their individual property valuations."*

²¹ Barkham and Geltner (1994, p. 86) explain: *"The desire to work with annual returns is motivated in part by the availability of annual return data farther back in time. It is also a convenient way to eliminate most of the temporal aggregation smoothing caused purely by the aggregation of individual valuations within the index."*

Barkham and Geltner (1994, p. 86) add: *"This reduction of frequency in the returns series eliminates most of the smoothing effect caused purely by the aggregation within the index of properties valued at various times during the quarter, as described by Brown (1985) and Geltner (1993b)."*

More advanced Correction-Procedures

To gain reverse-engineering-correction procedures, researchers try to model the relationship (or ‘gap’, dependend on one’s perspective) between market returns and index returns, resulting from the influences of biases. The identified relationship is then reverted and applied as correction rule for time series of appraisal values or indices. This general idea is also the foundation of the Bond and Hwang-procedure. Bond and Hwang (2007) attend the calculation of index series from time series of individual properties. The authors emphasise that the cross-sectional aggregation of stochastic processes can better be captured by ARFIMA-models than by the reversion of deterministic equations.

The Bond and Hwang-Procedure

Former researchers presumed, that the smoothing level of index returns equals to the average smoothing level in returns series of individual properties.²² Bond and Hwang (2007, p. 373) (abbr. **BoHw**) explain that this assumption could result in a *“serious upward bias”* of the actual average smoothing level ϕ_{si} of returns series for individual properties.²³

In constructing their correction procedure, Bond and Hwang (2007, p. 381) consider the phenomena appraisal-smoothing and non-synchronous appraisal.

Bond and Hwang (2007) claim, that the average smoothing level in returns series of individual properties can be estimated by the parameter of fractional integration d of an ARFIMA(p,d,q)-model for index returns.²⁴ Thereby, they claim, the effects of the smoothing-phenomenon non-synchronous appraisal is captured by the moving average (MA)-component. They assert, that the autoregressive (AR)-parameter reflects the persistence of the market component which is common to all properties of a market. So the AR-component would reflect the inertia of information processing (i.e. the market

²² For example, this is assumed in Barkham and Geltner (1994).

Edelstein and Quan (2005) empirically research the relation between smoothing levels in series for individual properties and indices for real estate markets. Edelstein and Quan (2005, p. 5) state: *“To the best of our knowledge, no one has statistically modeled and quantified the effects of aggregation errors upon real estate rates of return indexes.”*

²³ Bond and Hwang (2007) note the smoothing level as ϕ_{si} . Individual properties are marked by the lower index i .

Bond and Hwang (2007, p. 361) refer to Gouriéroux and Monfort (1997, p. 444) and explain: *„For $0 < \phi_{si} < 1 \forall i$, the aggregated process, r_{mt} , is more smooth than the average smoothing level of the individual assets.”* Bond and Hwang (2007, p. 362) complement: *“[An] appraisal-based index which is constructed by cross-sectionally aggregating individual appraisals would show a higher persistence than the average smoothing level of individual assets.”* Bond and Hwang (2007, p. 361) add: *“The conventional assumption that the smoothing level estimated from an appraisal-based index represents the average smoothing level of individual properties is appropriate only when all individual properties have the same smoothing level. [...] Under this assumption an AR(1) process can be used to unsmooth the index. However, the smoothing levels of individual properties are not same. Bond, Hwang and Marcato (2006) report that the $\hat{\phi}_{si}$ s have a large standard deviation, that is, 0.6, from more than 2,000 individual properties in the IPD index.”*

²⁴ C.f. Bond et al. (2005) and Bond et al. (2006).

inefficiency) in a market. So if an analyst would assume an efficient market, she estimates an ARFIMA(0,d,1)-model. Otherwise if she would consider absent market efficiency, she estimates an ARFIMA(1,d,1)-model. Additionally autoregressive terms can be included into the regression model. For example, for returns series in quarterly periodicity, AR-components for up to four periods make sense. These may capture seasonal effects in the market component.

The results of Bond and Hwang (2007, pp. 370) indicate significant market inefficiency for the UK, but not for the USA. This result is contradictory to the results of Geltner (1993b) and Barkham and Geltner (1994). Their results indicate an efficient UK-commercial property market (c.f. Barkham and Geltner 1994, p. 92) and -inefficient U.S.-market.

Concerning the appraisal-smoothing Bond and Hwang (2007) report: *“The average levels of smoothing approximated by the estimates of the long memory parameter are around 0.4 [...]”*. The results of Bond and Hwang (2007, p. 373) *“show no evidence of nonsynchronous appraisal in the NCREIF index returns. [But] we find weak evidence of nonsynchronous appraisal in the monthly IPD index returns.”*

Gohs (2013) applies the BoHw-procedure again for the UK-IPD in monthly periodicity and for the NPI. Gohs (2013) suggests modifications of the BoHw-procedure and provides estimation results.

The estimation results of the ARFIMA(p,d,q)-models are incorporated into the correction procedure:

The ARFIMA(1,d,1)-process can be represented as follows (Bond and Hwang, 2007, p. 363):²⁵

$$(1 - L\phi_f)(1 - L)^d(r_{mt} - \mu_m) = \theta\epsilon_{t-1}^* + \epsilon_t^* \quad (45)$$

with

- L : lag-operator
- ϕ_f : ar-parameter which reflects the persistence in the “unobserved common factor“ (Bond and Hwang, 2007, p. 363)
- r_{mt} : return of the real estate market (“unobserved common factor“) in period t
- μ_m : mean return of r_{mt}
- d : “long memory parameter“ which reflects the average smoothing level in the returns series of individual properties

²⁵ The notation is transferred from Bond and Hwang (2007, p. 363) for better comparability.

- ϵ_t^* : residual for period t
- θ : MA-parameter which reflects the effect of non-synchronous appraisals.

If an efficient market is presumed, an ARFIMA(0,d,1)-model is adequate:

$$(1 - L)^d(r_{mt} - \mu_m) = \theta\epsilon_{t-1}^* + \epsilon_t^* \quad (46)$$

In the following, I return from the notation in the original text to my own notation :

To correct the returns r_t of an appraisal-based index, the estimation results of the following ARFIMA(p,d,q)-model are gained:

$$(1 + \phi(L))(1 - L)^d r_t = (1 + \theta(L))\epsilon_t \quad (47)$$

In this general notation, the lag-operator is incorporated into the function $\phi(L)$. Solving this function yields:

$$(1 - \phi_1 L - \dots - \phi_p L^p)(1 - L)^d r_t = (1 + \theta_1 L + \dots + \theta_q L^q)\epsilon_t \quad (48)$$

with

- r_t : return of the appraisal-based index in period t , adjusted by the mean return μ
- ϕ_p : ar-coefficient for a time-lag of p periods
- L : lag-operator
- d : parameter of fractional integration
- θ_q : ma-coefficient for a time-lag of q periods
- ϵ_t : residual for period t

Gohs (2013) estimates ARFIMA-models with different lags p and q of the AR(p)- and MA(q)-terms.

For correction purposes, it is necessary to get the fractional differenced returns r_t^{diff} of the index returns r_t in a next step:

$$r_t^{diff} = (1 - L)^d r_t \quad (49)$$

AR-terms (for up to p time-lags) are incorporated into the ARFIMA-models if it is assumed to be possible that market inefficiency prevails. Then the estimation of the ar-

coefficient(s) is necessary to get no biased estimation results. But the ar-parameter estimates are not incorporated into the correction-rule: Since market inefficiency is possible, autocorrelation is not removed in the calculation of market returns.

However Gohs (2013) suggests even to eliminate autocorrelation for time-lags v and w , if autocorrelation is alternatively assumed to be incorporated by smoothing-phenomena (precise: seasonality in appraisals) into index returns r_t . So Gohs (2013) suggests to apply the following modified Bond and Hwang-correction rule to account for seasonality in appraisals:

$$r_t^{diff*} = r_t^{diff} - \hat{\phi}_v \cdot r_{t-v}^{diff} - \hat{\phi}_w \cdot r_{t-w}^{diff}, \quad (50)$$

$$\wedge v, w \leq p, \forall t = (w + 1), \dots, T$$

For correction purposes, Bond and Hwang estimate ARFIMA(p,d,q)-models with lag $q = 1$ for the MA-term. According to Bond and Hwang (2007), the ma1-term catches the effect of non-synchronous appraisals. Gohs (2013) assumes, that the MA-term could also absorb the effect of the stale appraisal-phenomenon which is also inherent in NPI-returns.

The effect of the non-synchronous appraisals is removed from the index returns:

$$r_t^{c[BoHw]*} = r_t^{diff*} - \hat{\theta}_1 \cdot r_{t-1}^{c[BoHw]*}, \forall t = (w + 2), \dots, T \quad (51)$$

$$\wedge r_{w+1}^{c[BoHw]*} = \frac{r_{w+1}^{diff*}}{1 + \hat{\theta}_1}$$

with

- $\hat{\theta}_1$: ma1-parameter estimated from ARFIMA(p,d,1)-model
- $r_t^{c[BoHw]*}$ preliminary corrected return for period t to be reprocessed.

Further, to get the corrected index returns $r_t^{c[BoHw]}$, the volatility is adjusted: The returns $r_t^{c[BoHw]*}$ are divided by the ratio of standard deviations $\frac{\sigma_{ci}}{\sigma_i}$. Moreover the mean μ of the index returns is added:

$$r_t^{c[BoHw]} = r_t^{c[BoHw]*} \cdot \frac{\sigma_i}{\sigma_{ci}} + \mu, \forall t = (w + 1), \dots, T \quad (52)$$

Therefore Bond and Hwang (2007, pp. 351, 358 and 361) find the following relationship between the standard deviation σ_i of the market returns of an individual property i and

the standard deviation σ_{ci} of individual property returns which are biased by the phenomena appraisal-smoothing and non-equidistant appraisals:²⁶

$$\frac{\sigma_{ci}}{\sigma_i} = (1 - \phi_{si}) \sqrt{\frac{1}{2} [1 + 2v_i^2 \lambda_i^2 + \sqrt{1 + 4v_i^2 \lambda_i^2}]} \quad (53)$$

To calculate the volatility-ratio, the values for the average smoothing-level ϕ_{si} and for the term $2v_i^2 \lambda_i^2$ are estimated.²⁷ For the value of the average smoothing-level ϕ_{si} the estimation of the fractional integrated parameter d is taken. The value of the term $2v_i^2 \lambda_i^2$ can be identified from equation (11) in Bond and Hwang (2007, p. 357):

$$\theta_i = - \frac{2v_i^2 \lambda_i^2}{1 + 2v_i^2 \lambda_i^2 + \sqrt{1 + 4v_i^2 \lambda_i^2}} \quad (54)$$

If the MA-parameter θ_i is estimated, the term $2v_i^2 \lambda_i^2$ remains solely unknown. The optimal value of $2v_i^2 \lambda_i^2$ can be found without knowing the ingredients v_i and λ_i .

Regime-Switching-Procedures

In this study the regime-switching-procedure of Lizieri, Satchel and Wongwachara (2010) is presented. Lizieri et al. (2010, p. 2) report that earlier “*Chaplin (1997) attempted to incorporate regimes into the unsmoothing methodology.*”²⁸ Moreover Lizieri et al. (2010, p. 2) hint to “*Brown & Matysiak (1997) who offer a smoothing model with a time varying alpha based on rolling window serial correlations.*” Lizieri et al. (2010, p. 2) explain: “*Our methodology is more general in two main aspects. First, regimes may be defined in terms of property returns themselves (e.g. into periods of high, average, and low returns as Chaplin (1997) does) or in terms of exogenous variables driving property performance such as macroeconomic factors, credit conditions, and similar factors. Second, the threshold value can be estimated, rather than imposed.*”

²⁶ This results from equation (21) in Bond and Hwang (2007, p. 361). The notation is taken from Bond and Hwang (2007) for a better comparability.

²⁷ Thereby λ_i^2 is the variance of a ‘non-synchronous variable’, which represents the stochastic time-intervall between two appraisals, and which is assumed to be distributed as negative exponential (Bond und Hwang, 2007, p. 356).

And $v_i = \frac{\mu_i}{\sigma_i}$ is the sharpe-ratio, which is calculated as the mean return divided by the standard deviation of the market returns for an individual property (Bond and Hwang 2007, p. 357).

²⁸ Moreover Lizieri et al. (2010, p. 2) explain: “[Chaplin] *divided* [real estate returns series] *into six regimes with predetermined unsmoothing parameters (his theoretical framework follows Quan and Quigley’s approach, but the values are asserted not estimated).*”

The Lizieri-Satchel-Wongwachara-Procedure Using Threshold Autoregressive Models

Lizieri et al. (2010) propose a correction procedure based on a regime-switching threshold autoregressive (TAR)-model. They assume that true returns can follow a TAR-process.²⁹ Different variables are proven as regime indicators, and returns of an FT-index and GDP growth outperform the other indicators. Moreover a switching behaviour for the appraiser is permitted.

Multivariate Correction-Procedures

As opposed to univariate, multivariate correction-procedures incorporate several time series which provide information to find the 'true' real estate market returns. So regime-switching-procedures can be univariate, if the decision about the partition of the series depends on its own characteristics. Or they are classified as multivariate, if additional variables are incorporated, beyond the time series to be corrected.

Surely, results for the corrected series might also depend more or less sensitive on the other variables incorporated in the procedure, beside the appraisal-based index. So an evaluation of multivariate procedures might be somewhat more challenging, since the resulting corrected returns series are sensitive to the selection of the other time series.³⁰

Wang (1998) suggests to identify returns of real estate markets from a cointegration (abbr. CI) relationship. As cointegrated variables he takes an appraisal-based index and another time series, containing information about the real estate market.

The Wang-Procedure Using Cointegration Relationships

Wang (1998, p. 358) proposes a correction procedure which *“is multivariate and utilises information in other economic and financial variables implied by the cointegration relationship.”*

Wang (1998, p. 358) corrects JLW- and IPD-index series. Wang's (1998, p. 359) idea is (in my interpretation of the Wang-text) that the (true) market values are not observable, but must be cointegrated with the values of the appraisal-based index.

In the model of Wang (1998, p. 359), *“the variation in the true return is larger than that in the index return.”*

²⁹ Lizieri et al. (2010, pp. 1-2) explain: *“Regime switching behaviour seems highly plausible for real estate returns which exhibit episodes of booms and busts due to the cyclical nature of property and credit markets. Instead of modelling the underlying real estate returns as an ARMA process, as in the previous studies, we employ a family of Threshold Autoregressive (TAR) models (Tong 1978, 1990), in effect, allowing for some non-stationarity. TAR models have been used in real estate applications previously (Lizieri et al. 1998, Brooks & Maitland-Smith 1999): we provide an extension and application to return measurement.”*

³⁰ C.f. Wang (1998, p. 358).

Since the true market values are not available, this CI-relationship cannot be estimated. So Wang (1998, p. 359) tries to find a third variable “*which has fundamental economic relationship with property returns.*” Wang (1998, p. 359) explains that this economic variable must be CI with the true market values if it is CI with the index values.

Wang (1998, p. 361) estimates the following model:³¹

$$\gamma S_t - P_{a,t-1} - c = \frac{1}{\alpha} \Delta P_{a,t} + v_t \quad (55)$$

and $S_t = g_t S'_t$ with

- $P_{a,t}$: value of the appraisal-based index in time t
- S_t : value of the economic variable in time t which is assumed to be cointegrated with the index value $P_{a,t-1}$
- g_t : a gearing parameter which fulfills $S_t = g_t S'_t$
- γ : a parameter which fulfills that S'_t and $P_{a,t-1}$ are cointegrated with CI-vector $[\gamma g, -1]$
- c : intercept
- v_t : a residual variable which is stationary and may be serially correlated.

The rate of return of the appraisal-based index is calculated as $r_{a,t} = \Delta P_{a,t} = P_{a,t} - P_{a,t-1}$.³²

$P_{a,t}$ and S_t are I(1) and $\Delta P_{a,t}$ is I(0).

If the residuals v_t and $\mu_t = \frac{1}{\alpha} \Delta P_{a,t} + v_t$ are autocorrelated, the model can be estimated within an ARMA-framework (c.f. Wang, 1998, p. 360). Wang (1998, p. 361) explains that the factor g_t can have effects on the CI-vector but not on the parameter α which is of interest in the estimation.

Wang (1998, p.361) proceeds as follows: From the cointegration-regression between the economic variable - which is fundamentally related with the real estate market – and the appraisal-based index, he receives the residuals μ_t .

$$\gamma S_t - P_{a,t-1} = c + \mu_t \quad (56)$$

³¹ For a better comparability the notation of the original text is replicated.

³² C.f. Wang (1998, p. 359). From this equation it follows that Wang calculates with log-returns.

Then the coefficient $b = \frac{1}{\alpha}$ for the continuously compounded returns $\Delta P_{a,t}$ is estimated from equation:

$$\mu_t = \frac{1}{\alpha} \Delta P_{a,t} + v_t \quad (57)$$

Wang (1998, p. 361) selects as economic variable the Financial Times all share index FTAP for indirect property investments which is cointegrated to the JLW- and IPD-indices.

While this is not explicitly stated, I assume that he gains the corrected series by equation (3) in Wang (1998, p. 359) which is:

$$P_t = \frac{1}{\alpha} P_{a,t} - \frac{1 - \alpha}{\alpha} P_{a,t-1} \quad (58)$$

and P_t is the corrected log-index and in my notation the corrected index returns in Wang-style are $r_t^{c[Wang]} = P_t - P_{t-1}$.

Results for the Wang-procedure are not provided here.

An Evaluation of the Correction Procedures

Zero-Autocorrelation-Correction-Procedures

Results of studies indicate that some real estate-markets are not efficient. So serially correlated market returns are possible. But applications of zero-autocorrelation-correction procedures on time series of appraisal-based returns postulate efficient markets. So autocorrelation in appraisal-based returns series must completely originate from the smoothing-phenomena and cannot be inherent in market returns.

Surely, it can be criticised that users of correction-procedures may select the lag-structure of the AR-terms and the targeted volatility (via adjustment-factor) of the corrected series.

Reverse-Engineering-Correction-Procedures

Concerning the qualification of the Geltner-approach for correction of the UK IPD Monthly Index and the NCREIF Appreciation Index, the following is criticised:

Geltner's claim that all properties are reappraised exactly once a year is not necessarily accurate for NPI-properties. Additionally Geltner (1993b, p. 340) presumes that a

property is reappraised at the same quarter each year. This is not necessarily correct (c.f. section 3.2 in Gohs, 2013).

Geltner (1993b) claims to apply his correction procedure on real returns (after subtraction of inflation), but he reports no motivation for his proclamation. Perhaps he has similar arguments as Fisher et al. (1994) which postulate to correct real returns. But the correction of real returns makes no sense for reverse engineering-procedures. Anyway Geltner (1993b) as well as Fisher et al. (1994) leave it open how to extract real from biased nominal returns.

Concerning the appraiser-alpha α the question arises which value is plausible for correction purposes. While Geltner (1993b, p. 331) considers an optimal value α , the actual (average) appraiser-alpha applied in property appraisals might not be optimal.

Further the appraiser-alpha results not as an estimate from the application of the correction-procedure but has to be determined model-exogenously. This value alpha α in turn serves as input to determine another model-parameter a . Geltner (1993b) even gives a rather rough value for the parameter a . Surely one can argue that it makes no sense to construct a very detailed and complex model, if the data for its parametrisation are not available or are of minor quality. Admittedly, following this argument, it seems comparatively, that Geltner is capable to reduce his initial complex model (of the relationship between the market and index returns) up to a rather simple equation.

Geltner (1993b, p. 343) provides results for several different parameterisations. Interestingly for different parameter values (a and alpha) he receives corrected indices which are very similar.

The Bond and Hwang-Procedure

Bond and Hwang hint on shortages in the earlier zero-autocorrelation- as well as reverse-engineering-procedures and account for them. Results about market efficiency from application of the BoHw-procedure are in contradiction to the results from reverse-engineering-procedures.

Gohs (2013) proposes modifications of the Bond and Hwang-approach. This is a hint that questions are still open, even for the sophisticated BoHw-procedure.

Overall Assessment

Gohs (2013) reports that results for the correction-procedures are not stable. He recommends to take the original series of an appraisal-based index. The original series can be supplemented by the corrected series but not replaced by them.

The universe of correction-procedures opens a wide scope for the illustration of investment risks and returns on real estate markets (Gohs, 2013).

Alternatives to (Corrected) Appraisal-Based Indices

Transaction-Based Indices

Transaction-based indices are calculated from transaction prices of properties. Alas, individual properties are infrequently transacted. Some properties are transacted once in decades of years. Moreover, transaction prices are often not publicly available. So time series for transaction prices of individual properties are not available. Either price differences between properties which are transacted in shorter time intervals, appropriate for index calculation, are not fully due to changes in market conditions but also due to differences of hedonic characteristics of the properties. But the index values should just track changes in market conditions. Especially commercial properties are heterogeneous in their hedonic characteristics. The most popular hedonic characteristic of properties is the location. The location is exclusive for a property and a heavy weight for its market value. And not just the macro but also the micro location has often enormous price effects. So even prices of very similar properties cannot fully deducted to changes in market conditions between the time interval of both transactions. Moreover typical facilities of properties change in time. However, in the literature construction methods for hedonic indices are suggested. They aim to isolate the effects of differences between hedonic characteristics of properties, leaving just the effects of changes in market conditions in the index.³³

Further, even transaction prices are not market values and can deviate significantly from them in illiquid market phases.

These reasons make it difficult to calculate transaction-based indices. So in the past organisations (index provider) did not calculate transaction-based indices for commercial property markets.

The MIT-TBI

Besides the NPI, NCREIF publishes a 'Transaction-Based-Index (TBI)' for commercial properties. The construction methodology of the TBI is developed at the Massachusetts Institute of Technology (MIT). The functioning of the index calculation is in essence to model the relation between the appraisal-values of all NCREIF-properties, and transaction prices which are just available for some properties. From the estimated relationship, the transaction prices of all properties are estimated for index calculation purposes.

A detailed reconstruction of the TBI for evaluation purposes is prevented, since values of the individual NCREIF-properties are not published.

³³ Another solution to fix hedonic characteristics is to construct 'Repeat-Sale'-Indices. The idea is to calculate indices just from data of propertie which are repeated transacted. The handicap is that the data basis for these properties is rather small and perhaps not representative for all properties of a market.

Latent-Variable-Models

Ling, Naranjo and Nimalendran (2000) suggest a latent variable model. The idea of this multivariate method is rather to filter true market returns as information from several other time series than to correct the returns from an appraisal-based index. In Ling et al. (2000) at least one of the index series is an appraisal-based index. The other input variables are also time series which partly contain information about the real estate market values, for example stock indices for real estate investment companies. Latent variable models can also be applied to a bundle of time series, which contain partly information about the real estate market, but no one of them is appraisal-based. The intersection of the manifest variables (observable input variables) can also contain information about several other factor variables. So more than one factor variable can result from the application of a latent variable model. Latent variable models are deployed in any sciences, where the measurement of unobservable (or 'latent') variables is demanded. Latent variable models distinguish from the correction-procedures which are especially constructed for appraisal-based indices.

Results for Correction ('Unsmoothing')-Procedures

In the following the NCREIF Appreciation Index as original and manipulated with selected correction-procedures are pictured.

Since for some correction procedures no corrected data for the first four quarters can be calculated, all indices are equated to 100 for the end of the fourth quarter 1978 (1978 = 100). However the original NPI starts at the end of 1977.

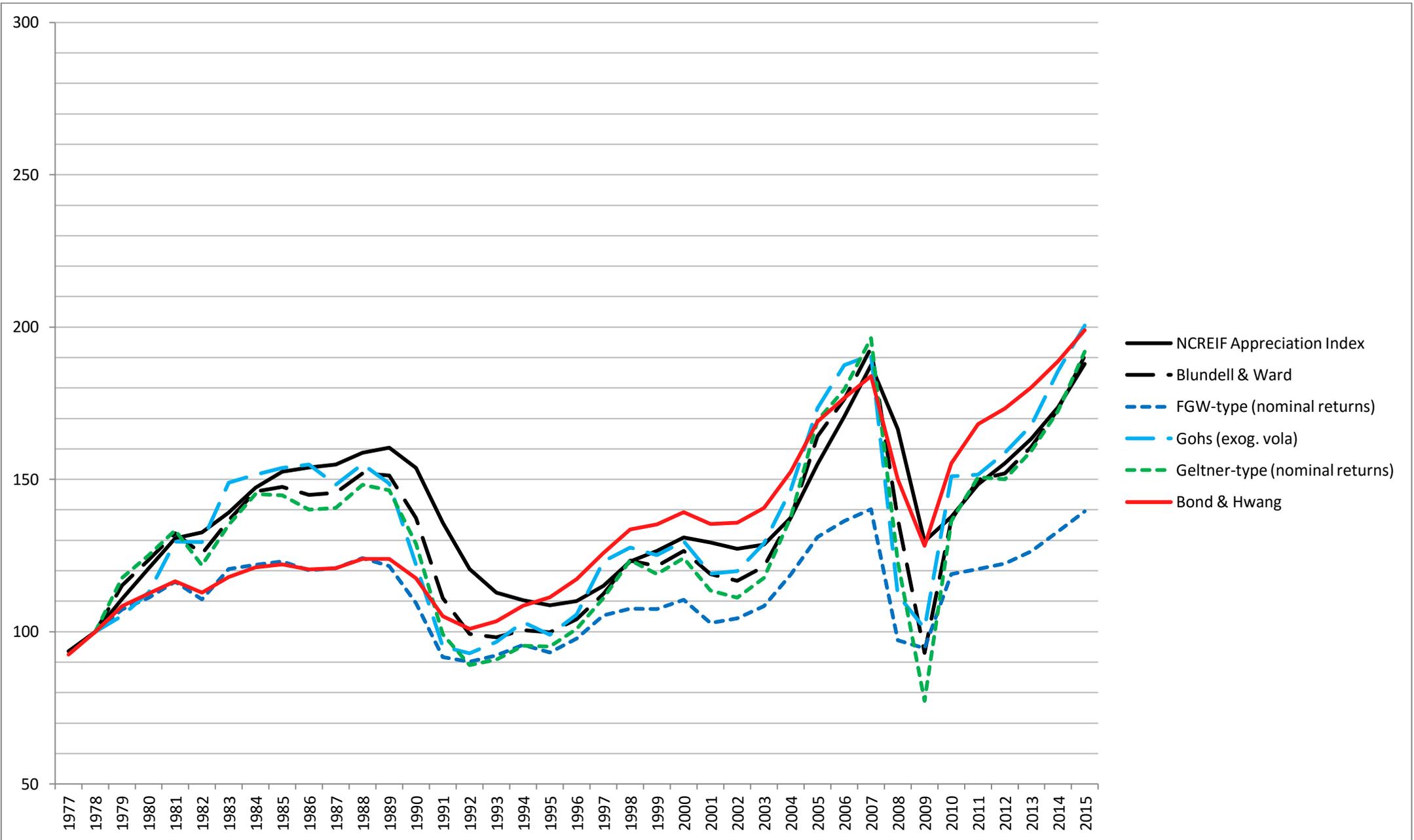
Since the FRZ-corrected index runs away it is not displayed. Some other indices wander off in intermediate time-sections. So they surely do not represent true market values.

Instead the corrected index of a modified FRZ-procedure is displayed: Just the autocorrelation of the time-lags with significant ar-coefficients is removed.

Concerning Bond and Hwang, results for the original procedure are suggested as well as for modifications suggested in Gohs (2013): For the models 'market-factor' and 'appraisal-seasonality' ARFIMA(4,d,q)-models are estimated. In the market-factor-variant the autoregression of time-lag 4 is interpreted as component of the common market factor of the true market returns. In the appraisal-seasonality the autoregression of time-lag 4 is interpreted as resulting from the phenomenon of seasonality in appraisals and so removed. So 'annual returns'-modification contains an estimation of ARFIMA-models for index returns in annual periodicity. It is assumed that the phenomenon of stale appraisals can (better) be captured in this periodicity.

Statistics for the corrected series will be provided in an updated version of this paper. For the NPI- and Monthly UK-IPD-indices, numbers (which are not fully up-to-date) are reported in Gohs (2013).

Figure 3 Selected Indices



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