Kristin Wellner

"Transforming Markowitz portfolio theory into a realistic real estate portfolio allocation process"

– Working paper / preliminary version –

Agenda

1 Problems and status of research ........................................................................................................... 3
   1.1 Theoretical Framework ...................................................................................................................... 3
   1.2 Previous research (Literature Review) .............................................................................................. 3
   1.3 Problems of Portfolio Theory implementation in real estate economic practice .............................. 4

2 Approaches to problem solving in practice ........................................................................................... 5
   2.1 Principles of statistical calculation ................................................................................................. 5
   2.2 Cluster formation .............................................................................................................................. 7
   2.3 Restrictions of portfolio shares ...................................................................................................... 13
   2.4 Rolling calculation ........................................................................................................................... 15
   2.5 Interpretation of Results ................................................................................................................. 16

3 Organizational integration of the Strategic Asset Allocation ................................................................. 17

4 Conclusion .............................................................................................................................................. 18

References .................................................................................................................................................... 19

Data source ................................................................................................................................................... 21

Appendix ..................................................................................................................................................... 22

Contact:

Prof. Dr. rer. pol. Kristin Wellner
Assistant Professor for Real Estate Economics
Faculty of Civil and Structural Engineering
Bauhaus-University Weimar
Marienstraße 7A
99423 Weimar
Germany

Tel: +49 (0) 3643 58 4488
Fax: +49 (0) 3643 58 4565
Email: mail@kristin-wellner.de
Abstract:
Starting with a diversified international real estate portfolio by using the portfolio theory, this research paper shows a pragmatic approach to transform the findings into a real allocation process for finding a practical target portfolio for direct investments. By moving asset allocation models from the scientific theory to the investment reality, institutional real estate investors are confronted with a number of practical problems.

However, the literature of the last 20 years shows a high level of diversification effects by using the portfolio theory also for real estate portfolios. But there is still a dilemma to transform these results into a daily allocation process. The paper gives an outlook on the practicable application of the results using the Markowitz theory in consideration of the uncertain and imperfect real estate markets. In practical consideration, there are still problems regarding the properties of direct real estate investments and their markets, for example the characteristics of properties, real estate market situations and sizes. On the basis of empirical statistical tests – based on real estate total return indices – this paper aims to find a solution to overcome these difficulties.

The new transformation process – as a result of this paper – is using clustering methods and different return calculations, offering more possibilities for choosing the suitable components for an existing real estate portfolio. With a top down to bottom up procedure according to a counter-current principle, it is possible to find properties which are suitable in practice.

Key words: real estate portfolio management, asset allocation, realistic diversification.
1 Problems and status of research

Real estate is one of the most important asset categories internationally because of its diversified impact. However, as a result of special characteristics, there are a variety of problems in selecting the appropriate asset allocation for both single and multi asset portfolios. Theories known from former writings and applied in other asset classes reach their limits in real estate. The goal of the analysis presented here is to overcome these limits and convert the known theories also in the real estate portfolio into a practical implementation.

1.1 Theoretical Framework

The Markowitz Portfolio Theory (MPT) (1952/1959) evolving from the capital markets and its further developments through Sharpe (1964), Lintner (1965) and Mossin (1966) is controversial in its application in the investment practice. A countless number of empirical studies confirm this. (See among others: Black and Jensen and Scholes 1972, Fama and MacBeth 1973, Merton 1980, Chen and Roll and Ross 1986, Fama and French 1992). The theory already stands in review regarding its application on the stock market even though stock markets approach the requirements of a perfect market.. This is due to model restrictions and differences between observed and calculated expected returns in real markets. Although the effects of diversification can also be proven in real estate markets, (Wurtzebach 1994, Grauer and Hakansson 1995, Hudson-Wilson and Elbaum 1995, Wolverton and Cheng and Hardin 1998 among others) further problems are inherent in the application to real estate investments, properties and their associated markets. Like any particular theoretical model, the model, including its further development can only conditionally reflect reality, since the model simplifications do not conform to the full extent of reality. The diverse reasons for the application problems in real estate are presented below. Previously, the necessity for these examinations was justified on the grounds of lack of research of a literature review.

An application orientation of research is still extensively lacking in international literature. In German literature this is restricted virtually to the qualitative portfolio appendage. The best known attempt is that from Bone-Winkel (1994). All other analyses (e.g. Jandura, Rehkugler 2001, Thomas and Wellner 2007) show no transformation of the calculated results into practical implementation.

1.2 Previous research (Literature Review)

There are a number of analyses which verify the diversification effects, both in miscellaneous asset classes (Auckenthaler 1994, Bruns and Meyer-Bullerdieck 2003) and real estate (Geltner and Miller 2007, Gold 1996, Benk et. all 2009, Worzala and Bajtelsmit 1997). There are even a range of different effects being examined, depending on the purpose of diversification, whether spatial, sectoral, or based on real estate characteristics (See Fisher and Liang 2000, Eichholtz et. all 1995, Mueller and Ziering 1992). The majority of quantitative analyses however, add up to the balancing effect of real estate in mixed asset portfolios (Gilberto et. all 1999, Chua 1999, Rehiring 2011). The procedure is thereby independent of the type of asset class and real estate is treated apparently with the same appropriate indices as the other asset classes. In its implementation, this means that real estate can be assessed only by means of the market averages, and thereof a risk evaluation derived from the average return amount. This is precisely the problem of practical implementation, since real estate is very inhomogeneous and can differ greatly from these market averages. In addition, all these empirical analyses are ex-post analyses which may only substantiate the accuracy of any related decision prior to the investment (ex-ante).

How an allocation decision can be derived logically, in particular for stock portfolio evaluations, can not be implemented practicably from these theories alone.
1.3 Problems of Portfolio Theory implementation in real estate economic practice

The reasons for application problems in real estate portfolios lies both in the assumptions of the Modern Portfolio Theory (MPT) itself, as well as in the characteristics of the real estate asset class.

The initial statements defined by Markowitz (Bruns and Meyer-Bullerdiek 2003, Steiner and Bruns 2002, Poddig and Brinkmann and Seiler 2005) as a pre-requisite for the application of MPT are not executable to real assets, their markets, and the real people acting. Investors are not acting solely at adverse risk, i.e. in practice - especially in the non-transparent real estate market - they accept a higher risk even if the expected returns do not rise disproportionately. They do not strive exclusively for return maximization, and accordingly risk minimization. Consequently, investors do not base their decisions solely on the expected value of the return criteria \( \mu \) as well as the average expected return deviation \( \sigma \) and accordingly \( \sigma^2 \). In fact, not all investors are rational and risk-averse. According to the Bernoulli principle, not all investors aim to maximize economic utility. He makes a decision, based on his individually determined risk-function of use, which does not represent the decisions of the only rationally acting homo economicus. According to Markowitz, the requirement for perfect competition depends on frictionless complete markets, where assets can be divided at will without transaction costs and taxes. Particularly in real estate markets, this cannot be an issue.

According to MPT, the expected return on investment properties should be based on subjective probabilities whereas according to Markowitz it is a normal distribution. In reality, a normal distribution is very rare (see Müller and Lausberg 2010, Wellner 2003). Contrary to the daily investment practice, the planning horizon in the model is only one-periodic in order to work around discounting and reinvestment issues. This makes the calculated results difficult to evaluate in comparison to other large-scale real estate investments, and no conclusions can be drawn about the correct timing.

In addition, Markowitz is always positive in relation to the proportions of all assets in the portfolio, i.e. there is no short-selling by satisfied investors. This condition is at least largely accomplishable in real estate direct investments.

The Portfolio Theory of Markowitz is often denied use in the real estate business practice, especially as real estate and related markets are considered as imperfect. The assumptions made by Markowitz as a requirement for implementation of the Theory are less fulfilled in real estate markets than in other asset classes. Real estate markets are considered to be extremely non-transparent, inert and dependent on the upstream and downstream markets (Geltner and Miller 2007). That, on the other hand, is up to the real estate itself, which is characterized by its long-term use and the substantial investment volume. In addition, high taxes and transaction costs as well as high management fees are incurred in real estate transactions. This leads to limited transaction frequencies and consequently also an absent appraisal in the market by means of real prices. The result is often only valuation based real estate indices with too short time-frames for statistically reliable calculations. The quality and availability of data is lower in comparison to other asset classes.

Furthermore, the implementation of the Markowitz Theory is regarded as complicated, time consuming and costly, as it relates to several organizational levels in an organization. But above all, the practicality of the Portfolio Theory is questioned, and the results of Portfolio Theory calculation for real estate portfolios are called into question. In newly developed portfolios the MPT is more likely to come into use rather than for the optimization of existing stocks. Why that so is in practice will be illustrated on the following pages. Even if the implementation is difficult in practical day to day business operations, it is not without benefit to the user. The aim of the following explanation is to demonstrate and highlight possible selection criteria.
2 Approaches to problem solving in practice

The following considerations should offer assistance in practice. Even if a practical use is not possible without pragmatic adjustment, it is still recommended, as the presented approach contributes to support the decision process and can provide information regarding the future development of the selected portfolio constellations.

2.1 Principles of statistical calculation

In the approach shown here the basic figures - known from the basic Markowitz Model – are the total return and risk, calculated using a standard deviation. Due to the described implementation problems, an application of other, possibly more appropriate, risk measures (Cheng 2001, Cheng 2005, Byrne and Lee 2004, Müller and Lausberg 2010) are not necessary.

The total return of the portfolio, respectively the portfolio return, is the sum of the expected returns of individual assets \( E(r) \), weighted by their share of \( x_\) in the portfolio:

\[
E(R) = \sum_{i=1}^{n} x_i E(r_i) = \sum_{i=1}^{n} x_i \mu_i
\]

- \( E(R) \) = expected return of Portfolio
- \( E(r_i) = \mu = \) expected return of asset \( i \)
- \( n = \) number of items
- \( r_i = \) rate of return of the item in period \( n \)
- \( R = \) expected return value or
- \( x_i = \) value share of the property's total portfolio

Equation 1: Expected portfolio return

The portfolio risk is in contrast dependent on the return level of the individual portfolio items (average variation), their individual risk (amplitude of variation, expressed by the standard deviation \( \sigma \)) and in particular the correlation \( c_{ik} \) of their returns one to another (phase difference). Furthermore, the risk, as well as the return of the shares by value \( x \) of the individual item, is affected by the overall portfolio.

\[
\sigma_p^2 = \sum_{i=1}^{n} \sum_{k=1}^{n} x_i x_k \sigma_i \sigma_k c_{ik} = \sum_{i=1}^{n} x_i^2 \sigma_i^2 + 2 \sum_{i=1}^{n-1} \sum_{k=i+1}^{n} x_i x_k COV_{ik}
\]

with \( \sum_{i=1}^{n} x_i = \sum_{k=1}^{n} x_k = 1 \)

- \( c_{ik} = \) correlation coefficient between asset \( i \) and \( k \)
- \( COV_{ik} = \) covariance between asset \( i \) and \( k \)
- \( x = \) value share of the property's total portfolio
- \( \sigma = \) standard deviation of return

Equation 2: Calculation of portfolio risks
Source: Bruns and Meyer-Bullerdick 2003, p. 70.

The result of these calculations is an efficient frontier with an infinite number of efficient portfolio outfits. Using the CAPM, it can calculate the Sharpe ratios from which the optimal model portfolio is derived. The composition
in the Maximum Sharpe Ratio Portfolio (MSRP) does not conform in practice to a marketable portfolio, because the exact detailed denomination is unworkable and often does not make sense. The purchase of properties in the required markets is possibly not feasible, as the markets are not fungible, or it may currently be the wrong time to enter into this market, (timing) or there is simply not an appropriate property that represents the market and matches the required risk-return criteria. Further implementation obstacles are barriers to enter the market, lack of market knowledge, high transaction costs and adverse financial conditions.

Figure 1: Calculation of optimal portfolios from 76 markets
Source: PMA, Total Return, Office und Retail, 1995-2010.
Before these practical constraints are taken into account, the basic model should be presented first, which is a calculation example on the basis of empirical data exemplified in Figure 1. The data basis for this transaction is based on the annual Total Returns for 76 European sub-markets on the use of Office (O = Office) and retail (R = Retail) by PMA from 1995-2010. These data are collected from real estate brokers from their real transactions in these 76 markets. There is a restriction by providing these data, knowing that using statistics, like mean and standard deviation, for such a short time frame will result in problems, because the 16 annual returns are not standard normal distributed.

As a first step, the problems with properties and the MPT in their purest form are shown by using the familiar Markowitz algorithm. Of the original 76 markets available, only 16 markets present efficient portfolios. The optimal portfolio composition in the MSRP in fact comprises only nine markets. Thus, diversification and time-frame in this market is indeed given theoretically. In practice, however, potential is wasted by further additions due to the strict logic of calculation and the topic and restricted course of time. But what if homogeneous clusters from the available output markets were formed? Some largely identical sub-segments of the clusters could be individually selected for practical considerations which can then be substituted depending on the actual availability and timing issues. The cluster formation is necessary as a first adjustment to implementation.

2.2 Cluster formation

Following the methodology described in the previous section, effective structures can be derived for large real estate portfolios in many different market segments in theory. As a result of the precise mathematical and statistical calculations, markets of similar quality with few lower returns or minimally higher risk are falling out of optimization. These differences have no importance in practice, and for these cases solutions are to be found. In addition, a wide range of market data - different types of use, regions, locations, real estate characteristics, etc. - different lengths of time and data quality are available, must be incorporated into the practical adjustments.

![Figure 2: Components of risk analysis](image)

Such adaptation presents the creation of homogeneous clusters of these markets. These should, where possible, show the uniform risk-return characteristics, and in particular, show rectified correlations of the return time series. The clustering could also occur according to different fundamental criteria, such as property locations, sector, type of use, or even type of investment. Technical analysis is recommended here as the chosen technology for clustering, considers in particular the correlating return curves in addition to the fundamental unity of the individual sub-markets.

The homogeneity of the clusters is merged on the basis of three criteria. The cluster markets should have the same yield level (Return Level) and a single risk level (Amplitude) as well as be positively correlated (no phase
difference) analogous to Figure 2. A mathematical basis forms the correlation coefficient (c\textsubscript{ik}) according to Pearson in Equation 3:

\[
c_{ik} = \frac{\frac{1}{n-1} \sum (r_i - \mu_i) (r_k - \mu_k)}{\sqrt{\frac{1}{n-1} \sum (r_i - \mu_i)^2} \sqrt{\frac{1}{n-1} \sum (r_k - \mu_k)^2}} = \frac{\text{COV}_{ik}}{\sigma_i \sigma_k}
\]

Equation 3: Linear correlation coefficient according to Pearson


Several sub-steps are necessary to cluster. Firstly, the correlation of the return time series should be identified as the basis of the homogeneity of the clusters, see Figure 3. The positively correlated clusters can, for example, be determined by cluster analysis. The aim of this cluster analysis is to provide support for deciding for a select group summary. The markets positively correlated with return time series are divided into a reasonable number of groups. Here the average agglomeration method was chosen, so clusters formed in which the distance between two groups results from the mean distance of all the possible connections of its members. Within these homogeneous markets, the clusters are so consolidated, that the process of returns are rectified. The clusters are represented graphically by the dendrogram in Figure 4. Hierarchical clustering classifies cases into groups, and further into smaller groups, forming a tree (dendrogram). Each additional report expands the group and makes it thereby less homogeneous. The calculated correlations between the markets in Figure 3 form the basis for the dendrogram.

The dendrogram in Figure 4 states: the greater the distance of the connecting arm (distance of the correlation) of two group members from the axis, the less homogeneous the group members. Group members with short connections (eg highest positive correlation between Paris: Central_O and Paris: CBD_O \(\rightarrow\) with \(c_{ik}=0.99\)) represent strong positive correlations, out of which a reasonable number of clusters should be chosen that allow an appropriate summary of the markets, which just barely ensures the homogeneity. Identical risk-return categories of sub-markets were also necessary to influence the clustering in addition to the correlation.

The cluster classification was made final on the basis of the chart in Figure 5. Each cluster was assigned manually to the sub-markets. A cluster formed from sub-markets, through its positive correlation - represented by different colours in Figure 5 - and the other by similar risk-return parameters -graphically in close proximity markets.
In the example, from the raw data of return time series, mean values and the correlation matrix in Figure 3, exactly 32 clusters were of different group size were identified, as shown in Figure 6. As a result of their strong negative correlation, some clusters were not able to be assigned to any other groups and thus form a separate single cluster, such as the one-market-clusters 27, 29 and 31.
Figure 4: Dendrogram showing the correlation of 76 markets
Source: Own compilation using data from PMA, Total Return, Office and Retail, 1995-2010.
Figure 5: Return-Risk-Diagram with correlation (same colour = high positive correlation)
Source: Own compilation using data from PMA, Total Return, Office and Retail, 1995-2010.

Figure 6: Composition of the 32 clusters
Source: Own compilation using data from PMA, Total Return, Office and Retail, 1995-2010.
As a result this means that the calculation is using only 32 records instead of 76. This is a subjective decision. Another classification, with more or fewer clusters would have been just as possible and justifiable. The 32 clusters are pragmatic and manageable in this case.

For the chosen cluster already explained according to Markowitz, the average group returns and their standard deviations are to be calculated and used as model inputs. The following results are shown having been calculated using the 32 clusters:

![Figure 7: Calculation of optimal portfolios from 32 clusters](image)

Source: Own compilation using data from PMA, Total Return, Office and Retail, 1995-2010.
The reading of the calculated results is identical to that in Figure 1. When comparing the two calculations for the same output data in Figure 1 and Figure 7, one can obtain the following findings: As suspected, the extremes of risk and return in the MVP and MRP were restricted by the formation of the clusters. This can be explained by the averaging and the inherent existing indirect naive diversification within the clusters. There are now a total of 26 sub-markets, represented by 10 clusters, in efficient portfolios, and 20 sub-markets, represented by seven clusters included in the MSRP.

Comparing the composition along the efficient frontier in detail, the following change is detected: Twelve sub-markets, which previously belonged to the non-clustered efficient portfolio, are now part of the new effective area, 14 markets have been newly added and four markets are no longer a part of it. Identical changes affect the composition of the optimal portfolio in the MSRP. A slightly different combination can therewith be recognized. In conclusion, markets that count as efficient in both portfolios are more secure than the other components.

Clustering allows for better implementation of the model portfolios in a realistic target portfolio in practice. If for example, buying a retail property in Frankfurt from cluster 28 is derived from the asset allocation, then also a different commercial property in Germany (Cluster 28: Berlin, Cologne, Hamburg or Munich) can be selected as an alternative, subject to availability, timing, and property-specific investment quality and other company-specific decision criteria. The five German retail markets (see Figure 8) provide for a balanced portfolio of equivalent alternative. That these five different sub-markets are to be assessed in detail differently should not be misleading. A single item analysis and aptitude test for the formation of a portfolio cannot be replaced by this decision aid. It just shows the different choices that allow for a better asset allocation based on market averages in the light of balancing risk development as well.

![Returns in Cluster 28](image)

Figure 8: Time-Frame Return in cluster 28 (5 German retail markets)
Source: Own compilation using data from PMA, Total Return, Retail, 1995-2010.

Clustering is certainly one of the larger calculation steps, but recommended for very large sets of data. Other less complex pragmatic adjustments are possible, as shown below.

### 2.3 Restrictions of portfolio shares

The purely pragmatic restriction of the possible share of a sub-segment within a portfolio to a maximum counts towards a less costly adjustment. So it is conceivable that a minimum number of assets is required to avoid concentrations of risk, or to generate economies of scale in management results. It is sensible for maximum amounts of e.g. ¼ or 20% to appear. The example given here with 20% maximum takes into account the motives of a na"ıve diversification with a minimum of five assets in the portfolio. The following portfolio results, as shown in Figure 9, therefore arise: Through the restriction to a maximum of 20%, 34 sub-segments were shown in efficient portfolios. As a result of this restriction of course, no more extreme portfolio returns are possible,
since 100% cannot be invested in the maximum return of the sub-segment market, but now only a maximum of 20%.

The efficient frontiers extremity of the efficiency range is between 6.37% and 8.55% in the MVP, and to a lesser risk in the MRP. Since the calculation has now been carried out again based on the cluster, a direct comparison is possible between the two calculations (compare Figure 7 and Figure 9). Among the 26 sub-segments already
identified as being efficient on the second calculation, in the third cluster variation 3 clusters with 8 sub-segments are added. The clusters of the two MSR-portfolios are identical, they differ only in weighting. The choice with this calculation variant increases, but so does the uncertainty of the decision.

Through the "naive" restriction, markets are prevented from predominance, simply because of their positive past data as future development might look different. Thus, this represents a further risk limitation, which is naturally associated with yield losses.

Because of real constraints, it might be necessary to restrict the maximum portfolio shares to a reasonable level. This measure can secure for example, market sizes, market maturity and transparency of the market and transaction costs. That is, for example, to learn that the not yet fully developed Eastern European markets, which often simultaneously represent smaller markets, experience a negative subordination towards large mature western European markets. This results in more realistic and therefore more practicable weighting in the model portfolio, although it incorporates elements of naïve diversification.

2.4 Rolling calculation

The measures shown to date do not, though, reflect, the great influence of the selection of the yield return time-frame on the results. How extreme this can be is demonstrated by a rolling calculation of 32 clusters in seven 10-year increments from 1995-2010. In comparison, in the bar chart in Figure 10, the respective MSRP compositions are shown in a 10-year data series compared to the total period (first bar).

Although the database in Figure 10 from bar to bar diverges by only one year, the changes in the composition of the optimal portfolio in the MSRP are significant. It is partially even so extreme, that individual components can be eliminated or come again completely new in years to come. Compared to the total period, as shown in the first
bar, there are even clusters, which are replaced in individual years from neighbouring clusters. Clusters 22 and 26 are replaced each year in different proportions by the clusters 23, 24, 25 and 27.

Therefore, sensitive attention has to be given to the database and not just a single calculation can be taken as the basis for a relevant decision. Markets that show efficient results in all four calculations are reliable in the selection of optimal target portfolios rather than a just once occurring sub-segment.

Likewise, this would be the case if one were to include forecasts instead of the rotating calculation of historical data. A smoothing can be expected from the forecast, but in principle the forecast evaluation can expand and secure the basis for a decision.

2.5 Interpretation of empirical results

The results achieved from the empirical semi-analyses can be summarized as follows:

- **Cluster formation**
  - Allows a substitution of homogeneous markets
  - Allows for a pragmatic implementation as several possible markets fulfil conditions, depending on actual availability
  - Prevents a strict elimination of markets of similar quality at slightly lower returns or minimal higher risk, since in practice, these minimal differences are of no real importance

- **Restriction of all portfolio components to a maximum rate (of e.g. 20%)**
  - Integration of naive diversification in the mathematical calculation
  - Reduced dependence on theoretical, technical-statistical results that analyze the future only ex post
  - Restriction of the statistical increase in grades of error of "pragmatic significance"

- **Rolling calculations**
  - Show the sensitivity of the selected time-frame
  - Markets that sustain in multiple calculations, should also be represented in the target portfolio
  - Make the selection of efficient portfolio building blocks more secure and independent regardless of the selected time-frame
  - Can make individual influences and statistical outliers visible in the time-frame to eliminate them

- **Analysis of historical time-frames and their forecasts**
  - Show the sensitivity of the selected time-frame
  - Markets that sustain in both time-frames (i.e., are good for an optimal portfolio in the past and the future), should also be represented in the target portfolio
3 Organizational integration of the Strategic Asset Allocation

To implement the awareness of modern portfolio theory to real estate investment, practical conditions in the company are to be fulfilled in addition to the previously identified variants of calculation and the adjustment of the theoretically determined model portfolios. This applies to both property selection processes and organizational implementation. This is achieved by combining the theoretical top-down observation with a practical bottom-up perception in a counter-current principle (see Figure 11).

In the top-down approach, the key objectives of the asset allocation are fixed. As a framework of the development of the investment strategy, a target system with the parameters of the theoretical target portfolio is defined in a way, which also takes the corporate, investment- and portfolio-specific objectives into account. One objective forms the delineated investment universe with possible locations and types of use. Other requirements include the planned target return, the related investment style, legal form of tax assessment and financing goals.

The Portfolio Theory is developed on the mathematical basis of Strategic Asset Allocation, which generates several ideal, but theoretical model portfolio meeting the objectives. These model portfolios are identical in their empirical analysis to the calculations presented here. From the multiple evaluations, a theoretical model portfolio is crystallized (Theoretical Asset Allocation) based on several recurring portfolio share calculations.

The continuous chronological parallel bottom-up approach involves the actual selection of properties on the basis of further implemented analysis, such as profitability analysis and investment appraisal, as well as the experience in the operating entities. Here, the knowledge and actual conditions in the company, such as organizational structure, IT and market connections are the benchmark for the success of the implementation of the theoretical model portfolios. If a new product is not developed, the data from the portfolio stock are to be included in the planning. That represents the biggest challenge, as real individual property data cannot be compared with market averages. In the process, the property characteristics are to be matched with the parameters of the ideal market average, until a reasonable approximation to the Model Portfolio is created. Here it requires operational experience as well as good market and property knowledge. The coordinates of the calculated portfolios are now being implemented in the portfolio development strategies. The right timing is also to be observed as Portfolio Selection Theory does not offer solutions in this matter. It only represents potential markets in the principle of diversification, but not what point of time would be the best investment.
It should be emphasized again that in property investments, a 100 percent implementation of the model portfolio is not possible. An adjustment is achievable, but only with a time lag because of the well-known long search and transaction periods. Further reasons for this discrepancy lie in the non-existent ideal indexes as the basis of the calculations and in the unavoidable heterogeneity of the investment properties. The real individual properties do not match the market index, which represents only an average in terms of yield, risk, size and investment volume of the market segment considered. The real key figure of the individual property can even exceed the risk-return criteria of the market. Thus, individual properties in inefficient markets may very well make sense from an investment perspective. Therefore, accurate analysis in advance of the purchase of standing investment is absolutely essential. These include investment and divestment appraisals including various action alternatives or respective scenarios regarding future implied market development and the allocation of resources.

Of absolute importance is a synthesis of both approaches by applying the so-called counter-flow process, as shown in Figure 11, in that the top-down model portfolio is determined by the replenishment of bottom-up oriented individual analysis. The goal is a step-by-step approximation of the model portfolio, respectively, an approximation of the portfolio stock to the benchmark portfolio. The implementation is not difficult when a new portfolio is being set up. For existing portfolio stock, a comparison with the model portfolio is much more difficult. This is always complex procedure and only practicable by using a computerized real estate asset and portfolio management system. As well as a periodic stock analysis, this system allows the calculation of new portfolio parameters with the selected properties of the stock portfolio including possible purchase and sale items. This includes the experience and market contacts of operating units, which are essential. The process of property portfolio management requires an organizational integration in the corporate structure and operation. An eliminated portfolio strategy department cannot afford this.

A final monitoring and control of the achievement is made by comparing the characteristics of the actual portfolio with the target portfolio. Since in practice, there cannot, in be a precise achievement of an efficient portfolio, the basis of current actual period values continues, ever advancing as output variables of the revolving process of real estate portfolio management.

4 Conclusion

The fundamental conclusion of this analysis is that a single evaluation of an optimal portfolio from which a real target portfolio can be derived, would be grossly negligent. There are always a number of simulations to be carried out over the course of time with the help of different raw data, varying indices, ex post and ex ante data and pragmatic adjustments such as cluster formation and the restriction of maximum shares. Knowledge can be gained initially through much evaluation, and should serve to support any decision for defining the marketable target portfolio from the theoretical model portfolios.

By modifying and integrating theoretical evaluations in the decisions of the daily business, it is thus possible to implement the findings of the Portfolio Theory in practice and make investment decisions safer and more independent from subjective influences. Since this is not possible without human, financial and time resources, the implementation so far has proceeded rather half-heartedly. New requirements and the response to current questions could henceforth entail a rethink, and bring more attention to the Portfolio Theory in real estate practice in the future.
References


Grauer, R. R./ Hakansson, N. H.: Gains from Diversifying into Real Estate: Three Decades of Portfolio Returns


Data source

### Appendix

#### Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O 0,70,50</td>
<td>60,30</td>
<td>50,70</td>
<td>80,40</td>
<td>40,50</td>
<td>70,40</td>
<td>30,50</td>
<td>60,30</td>
<td>70,50</td>
<td>80,40</td>
<td>40,50</td>
<td>30,50</td>
<td>70,40</td>
<td>60,30</td>
<td>50,70</td>
<td>80,40</td>
<td>40,50</td>
<td>30,50</td>
<td>70,40</td>
<td>80,40</td>
<td>70,50</td>
<td>50,70</td>
<td>30,50</td>
<td>70,40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30,50</td>
<td>70,40</td>
<td>30,50</td>
<td>70,40</td>
<td>40,50</td>
<td>50,70</td>
<td>40,50</td>
<td>70,40</td>
<td>80,40</td>
<td>40,50</td>
<td>30,50</td>
<td>70,40</td>
<td>40,50</td>
<td>50,70</td>
<td>30,50</td>
<td>70,40</td>
<td>40,50</td>
<td>30,50</td>
<td>70,40</td>
<td>80,40</td>
<td>70,50</td>
<td>50,70</td>
<td>30,50</td>
<td>70,40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>80,40</td>
<td>40,50</td>
<td>30,50</td>
<td>70,40</td>
<td>40,50</td>
<td>70,40</td>
<td>40,50</td>
<td>70,40</td>
<td>80,40</td>
<td>40,50</td>
<td>30,50</td>
<td>70,40</td>
<td>40,50</td>
<td>50,70</td>
<td>30,50</td>
<td>70,40</td>
<td>40,50</td>
<td>30,50</td>
<td>70,40</td>
<td>80,40</td>
<td>70,50</td>
<td>50,70</td>
<td>30,50</td>
<td>70,40</td>
<td></td>
</tr>
</tbody>
</table>