University of Twente
Enschede - The Netherlands

SNS REAAL

Real Estate & Hedge Fund

"Modelling the Risk Profile of Real Estate & Alternative Investment Strategies"

Salih Bağcı
MASTER THESIS

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Industrial Engineering & Management
Track: Financial Engineering & Management

"In Risk management, the expected value
is not to be expected"

Bryis, de Varenne (2001)

MASTER THESIS

University of Twente
School of Management and Governance

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"Modelling the Risk Profile of Real Estate & Alternative Investment Strategies"
Period February-August 2008

Research on the authority of:

SNS REAAL
Balance Sheet & Risk Management

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Utrecht, August 2008

Management Summary

One of the most important steps to build a successful portfolio is properly dividing assets among different types of investments. The most important asset classes are stocks, bonds, and (in)direct real estate and alternative investments (e.g. hedge funds). Direct real estate and alternative investments are trendy asset classes within the investment world. They show low volatility and low correlation with the traditional investments (i.e. stocks and bonds). However, these asset classes have some biases that should be solved to build a successful portfolio. The presented report describes the research of the impact of solving these biases by using "unsmoothing" techniques and dealing with the skewness & kurtosis on real estate- and hedge fund return series to take decisions on asset-allocation.

In general it is thought that reported value-based real estate returns are "smoother" than returns that would be derived from transaction-based real estate indices. Unsmoothing techniques could be used to develop real estate return series that are believed to be more accurate representation of underlying transaction prices. If this is done, the resulting data reveals greater volatility of real estate returns. In an asset allocation context, the presence of inaccurate volatility shows a distorted view of the allocation. When the unsmoothing data is applied to portfolio selection methods, they reveal a reduced allocation to value-based real estate in efficient portfolios.

Another issue is the assumption of normal distribution of the assets. Asset returns are not distributed normally in general. The probability distribution followed by the returns is often characterized by skewness and kurtosis. This departure from the normal distribution usually exhibits by the returns of many assets and even more accentuated in the hedge fund environment. The presence of asymmetry and fat tails violates the assumption of elliptically distributed asset returns that underlies the traditional mean-variance analysis of Markowitz's framework.

The objective of this study is to find a proper technique to deal with these biases of the real estate and alternative investments time series, in order to find an optimal asset allocation within the Markowitz's framework as an asset only. The problem definition is stated as follows:

"How should the direct real estate and the alternative investments time series be adapted, to get a reliable risk profile in order to find an optimal asset-mix within the Markowitz's framework?"

The theory has been studied on real estate and hedge fund to get an insight information of the issue and to understand how the asset classes are constructed. The literature is reviewed in order to be able to deal with the shortcomings of value-based real estate and hedge fund data. Several risk measurements and unsmoothing techniques are elaborated. The methodology is applicable to all kinds of asset classes.

In a quantitative study the methodology is applied to Dutch direct real estate index provided by ROZ/IPD and Fund of Fund Composite index provided by Hedge Fund Research Index. These two indices are the basis for analyzing the biases of the returns series. Further input for the portfolio optimization consists of listed real estate index which is provided by General Property Research Index and benchmark indices for the stock, bond and high-yield market.

The analysis consists of testing the smoothed time series of returns of stationarity, normal distribution and autocorrelation. For the portfolio analysis, a proper return series and correlation matrix are constructed. The asset allocation is executed in Excel, in which the skewness and kurtosis are also taken into account. Consideration of the skewness and kurtosis shall provide some fundamental view about the weighting of asset classes in optimal risky portfolios (i.e. maximizing the modified Sharpe ratio). The impact of the recent developments in the financial markets on the asset allocation is elaborated by mean of sensitivity analysis on the parameters return and volatility.

The conducted analysis demonstrated the following findings:

- The smoothed direct real estate and Fund of Fund time series of returns represent an auto-correlation and the return series are also not stationary. These biases are solved by unsmoothing the series with the model of Geltner et al (2007). The result of the unsmoothing the return series is given in the table below.

Asset	Return	Volatility	Sharpe*
ROZ/IPD Smoothed	9,34%	4,57%	1,10
ROZ/IPD Unsmoothed	8,72%	9,15%	0,48
FoF Smoothed	9,59%	5,47%	0,97
FoF Unsmoothed	9,59%	7,37%	0,72

* Risk-free rate is 4,29%

- Apart from direct real estate and bond, normality is rejected of 95% significance level at all asset classes. Additionally the asset allocation is executed by mean of modified Value-at-Risk, in which it produces a different allocation than the basic mean variance approach. The result of the unsmoothing and allocation with higher moments is given in the table below.

Asset	Min Variance (Smoothed)	Min Variance (Unsmoothed)	Max Sharpe (Smoothed)	Max Sharpe (Unsmoothed)	Min MVaR (Smoothed)	Min MVaR (Unsmoothed)	Max MSharpe (Smoothed)	Max MSharpe (Unsmoothed)
Stock	4,36%	6,57%	0,64%	4,59%	6,07%	7,62%	1,70%	5,66%
Bond	61,06%	75,69%	29,62%	42,87%	67,95%	76,24%	36,17%	45,50%
High-Yield	0,09%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Indirect Real Estate	0,00%	0,00%	0,85%	0,00%	0,00%	0,00%	1,55%	0,00%
FoF	15,19%	11,33%	28,30%	35,60%	10,45%	7,93%	21,17%	25,25%
Direct Real Estate	19,30%	6,42%	40,59%	16,95%	15,54%	8,20%	39,41%	23,60%

- The recent developments (e.g. rise of the oil prices and sub-prime crisis) in the financial markets have a huge impact on the asset allocation. Particularly stock, bond and high-yield are affected of the recent developments in the financial markets.

Preface

This thesis is the final work of my study "Industrial Engineering & Management" with the specialization "Financial Engineering & Management", at the faculty of "Management & Governance" at the University of Twente in Enschede. This thesis, about modelling the risk of real estate and hedge fund, is the result of a six-month research which started in February and ended in August at the bank-insurer SNS Reaal in Utrecht. During this period I conducted a literature research on unsmoothing real estate data and how to deal with the fat tail of the hedge fund data in order to find a proper asset-mix.

I would like to thank Frans Boshuizen and Maarten Heyse for their supervision, the advices, the time, the weekly meetings and providing me with useful information and criticism during the progress of my research. Besides, I would like to thank my direct colleagues Bas de Jong, Arno van Eekelen, Rob Smit, Jan Paul van der Waal and Rik van Ommen for providing me with information and advices and not to forget the relaxing golf moments at the ALM-I department. I would also like to dedicate a word of thanks to my mentor Ronald Lukassen for his advices during my first assignment as a trainee Riskmanager. Not to forget, to thank the trainees Marina Blokland, Dirk Veldhuizen, Ilya Zaanen, Thijs Roelofs and Mireille Ligtenberg who made me familiar with the organisation of the Balance Sheet & Risk Management department. Special thanks to Sander Scheerders who lent me a book on hedge fund strategies.

I would like to thank my supervisors Toon de Bakker and Emad Imreizeeq of the University of Twente. I would like to thank them both for their ideas, their valuable times and also suggestions on my research.
All the others who have helped me which I forgot to mention in this preface, thank you.

I would like to thank my family and friends for supporting me during my research period. Special thanks to my sister Semra Bağcı (for revising my report on the English language and grammar), my mother, brother, sister, brother-in-law and my nephew who disturbed me quite a lot (in a happy way) when I was writing this thesis. I would also like to thank my father- and mother in-law and both brother in-laws.

Last but not least I would like to thank my beloved wife Sule Bağcı for her support and understanding during the period in which I dedicated too little time to her.

Salih Bağcı
Utrecht, August 2008

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Chapter 1 Introduction

1.1 Organisation

In this chapter, the organisation is described shortly. The emphasis is on SNS Reaal Balance Sheets & Risk Management (hereafter called BRM), the department who instructed the project 'Modelling the Risk Profile of Real Estates & Alternative Investment Strategies'.

The organisation chart of both SNS Reaal and of the department BRM is given in appendix I.

1.1.1 SNS Reaal

SNS Reaal is an innovative retail bank-insurer with total assets of almost € 105 billion and about 7000 employees. SNS Reaal covers SNS Bank and Reaal Verzekeringen (=Insurance) these are the core brands of SNS Reaal. In addition, SNS Reaal has also a number of niche brands such as SNS Property Finance, SNS Regio Bank, ASN Bank, BLG Hypotheken, Proteq, SNS Asset Management and SNS Securities. Last year SNS Reaal acquired the Dutch insurance operations of AXA and Zwitsersleven Insurance Netherlands. After these acquisitions SNS Reaal has become one of the market leaders in insurance for the Netherlands.

SNS Reaal's mission is to become the number one of the retail financial services specialist in the Dutch market. To stay innovative and competitive SNS Reaal distinguishes itself by business principles. These business principles are: Customer focus, Professionalism, Integrity and Involvement.

1.1.2 Balance Sheet & Risk Management

The project will be fulfilled at the BRM department. BRM carries an important contribution to provide an optimum value creation by SNS Reaal, SNS Bank and Reaal Verzekeringen. The activities of BRM include policy advice and providing wheel information to the Council of Governing Board and Executive Board in the field of Balance targeting, credit risk management at portfolio level, insurance risk management, operational risk management and the pricing of the products and services. In addition, BRM develops tools which supports line managers manage their risk. The international best practice and the requirements of law-and legislation (such as Basel II, Solvency II, FiCo-directions) are the starting points.

BRM occupies among other things of:

- Asset & Liability Management
- Investment policy for SNS Bank and Reaal Verzekeringen
- Capital Management
- Funding & Liquidity Management
- Develop and Maintain the "Risk Management Policy"
- Develop and Maintain the score models for credits
- Risk analyses of all banking and insurance products that SNS Bank and Reaal Verzekeringen conducts and give recommendation rates
- Reinsurance programme of Reaal Verzekeringen and its own insurance of SNS Reaal.
- Model validation
- Risk Management Systems

The policy of BRM is oriented towards the future. It is possible that the future will bring unexpected inversions. Therefore BRM thinks ahead to utilize the possibilities which will come and protects SNS Reaal from undesired risks. The purpose for the latter, scenario analyses and simulations are carried out.

BRM consists of five (sub) departments:

- **Insurance Risk Management (IRM)**: In this department the reporting has been done concerning the products which they have also been introduced to the market. IRM also indicate and clarify the differences of the excepted versus of the actual costs. Furthermore there is also done a sufficiency test. The figures are evaluated against the market values. At valuation it is specified what the price of the product will be in the future. Before pricing a product, the sub-department pricing determines the conceivable risks for the developed (insurance) products. These risks can be an insurance risk, costs, provision, etc. IRM is also occupied with re-insurance.

- **Operations, Risk Management Systems (RMS) & Risk-Policy**: Operations has a supporting role for the several sub-departments in BRM. Risk Management System and Risk-Policy belongs to the Operations department. RMS takes care of the information services and revision. At the Risk-Policy, the Risk Management Policy is formulated and maintained.

- **Credit Risk & Pricing Management (CRPM)**: The activities of the department CRPM are: 1) Developing, modelling and monitoring of credit score models (credit score models are statistic models which are based on regression estimates of probability of default (PD) and loss given default (LGD)). 2) Developing of acceptance models (acceptance model is a specific model for customers who wants to apply for a product. The model also examine the application and the result will accept or reject the customer). 3) Monitoring the credit portfolios by means of management reports. CRPM also gives recommendation concerning (theoretical) rates for banking products.

- **Model validation**: Model validation department assesses/validates the models for implementation and validated implemented models periodically. Both technical and functional aspects are taken along.

- **Asset & Liability Management (ALM)**: the department ALM gives recommendations concerning market-, liquidity- and solvency risks. These risks are periodically monitored whether they are still within the specified sets of framework. ALM is also responsible for measuring the market risks of SNS Financial Markets and SNS Securities. ALM department is divided into three sub divisions; 1) *ALM Bank* deals with measuring and controlling the market risks (particularly interest) within the balance sheet of SNS Bank. The tender risk in the mortgage portfolio is also measured and controlled. ALM Bank develops and implements models which describe the behaviour of the customer in mortgages and saving portfolios. 2) *ALM Insurance* (hereafter ALM-I) deals with measuring and controlling the market risks within the balance sheet of SNS Reaal. Important questions are appreciating the insurance obligations (in accordance with the market), the strategic asset-mix, and hedging the risks where Reaal is not compensated sufficiently. 3) *Economic Capital* is responsible for determining and reporting Economic Capital rates. Economic Capital is the buffer that SNS Reaal has to apprehend on the basis of the risks of its activities, to counterbalance an excepted loss in a time horizon of 1 year. Economic capital becomes more and more an input for capital management of SNS Reaal. Definitely for the SNS Bank because of the regulation and legislation program BASEL II.

1.2 Objectives & Problem definition

The project will be fulfilled in the sub-department ALM-I. One of the important questions that occupies in this department is the strategic asset-mix. The strategic asset-mix is given annually, to be able to satisfy future payment obligations (e.g. pension payments and life insurance). The asset-mix consists of stocks, fixed income, real estate, derivatives and alternative investments[1] (the main alternative investment products are hedge funds and funds of hedge funds, but they also include private equity and venture capital funds). As a result ALM-I is concerned with the expected performance of the asset-mix in order to implement strategies and to create diversified asset portfolio efficiently.

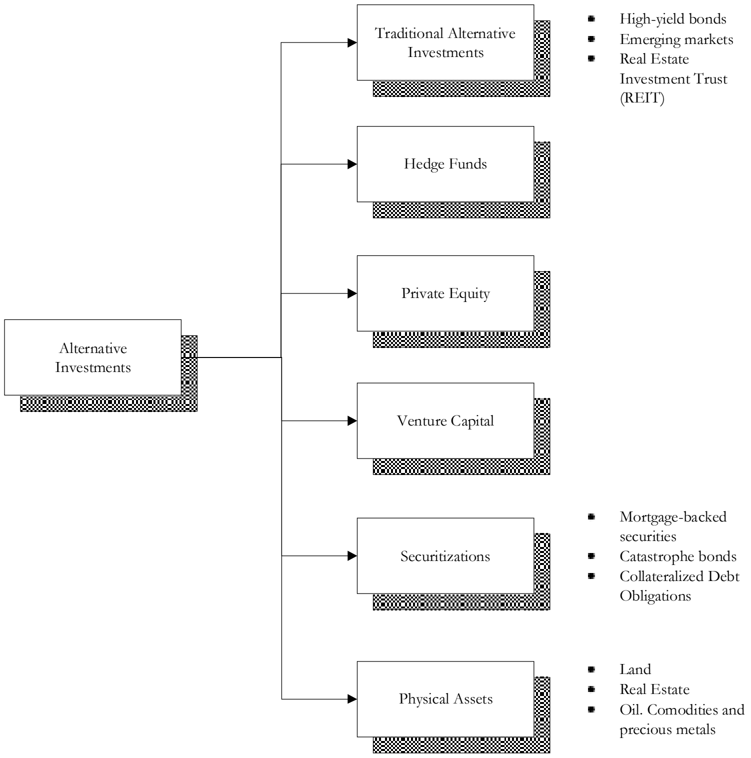

Figure 1: Alternative investments[2]

In ALM-studies, the sort and the structure of the obligations, economic expectations and the investments policy come together. In addition, there is done a simulation of the future by means of 5000 hypothetical scenarios. For the simulation, ALM-I makes use of a software programme, called ALS (Asset & Liability System). ALS is developed by Ortec who is a specialist in measuring and managing the risk/return equation[3]. The input for the ALM-studies and the underlying scenario analyses are based on historical series of returns[4]. For the assets equity and fixed income there is enough series of returns to analyse the risk. On the other hand the series of returns for the alternative investments and real estate are not always reliable and they can be misleading.

[1] In figure 1, there are many different types of alternative investments. The distinguished features of the alternative investment are: the **Lack of Liquidity** (many of the investments demand a minimum investment period), and the **Lack of Transparency** (some of the investments require specific domain knowledge which are not commonly known to outsiders).
[2] Stefanini, F., Investments Strategies of Hedge Funds, John Wiley & Sons Ltd., England 2006.
[3] www.ortec-finance.com visited on 26th of March 2008.
[4] The historical data returns of the asset classes are also provided by Ortec.

Next to the reliability, alternative investments (e.g. hedge funds) returns show low volatility and low correlation with the traditional investments. This suggests that the alternative investments increase the diversification when it is added to the asset-mix and it may decrease the overall portfolio risk. That is the reason why alternative investments are trendy asset classes within the investment world and pension funds. However the alternatives also have disadvantages. The alternative investment returns have a negative (left) skewed distribution. Figure 2 shows that the probability is higher to get a larger negative return than a larger positive return.

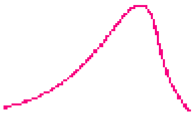

Figure 2: Negatively skewed distribution

The availability of data for direct real estate is a different issue. The series of returns which is available for direct real estate are based on appraised market value rather than actual sales transactions. The value-based real estate gives rise to return rates which is "smoothed" version of the transaction prices. On the other hand the volatility of the value-based real estate is low. It seems like that the risk is underappreciated. Therefore the volatility of the real estate is taken higher in the ALM-study by way of compensation of smoothing. Unfortunately, this is done arbitrarily. In this report, a primarily survey on the risk measurement of the direct real estate will be proposed. In addition to the risk analyses for direct real estate, there will be a risk analyses on indirect[5] real estate, to investigate whether indirect real estate may have a significance relationship with direct real estate. Since there have been a sufficient historical data concerning listed real estate returns it would not be difficult to analyse the risk of indirect real estate.

This project focuses on modelling and analysing the risk profile for real estate and alternative investments in an asset only context. From the alternative investments hedge funds will only be analysed. Risk analysis includes the risk identification and the risk measurement which the uncertain factors are quantified. The impacts on the return for investment portfolios are also considered in the risk analysis. The main objectivity of this study is to find a proper technique to deal with the biases of the real estate and alternative investments time series. In order to find an optimal asset allocation within the Markowitz's framework as an asset only.

The research model is given in figure 3.

[5] Indirect real estate is market listed real estate. In chapter 2 the distinction between the direct and the indirect will be clarified.

Activities that need to be done to accomplish the research successfully:

- Literature survey.
- Survey to un-smoothing techniques for real estates.
- Analysing the risk profile of the "smoothed" and the "unsmoothed" time series returns of the real estates.
- Survey on techniques to deal with the distribution of the alternative investments.
- Analysing the risk profile of the alternative investments.
- Analysing the asset-mix portfolio within the Markowitz's framework.

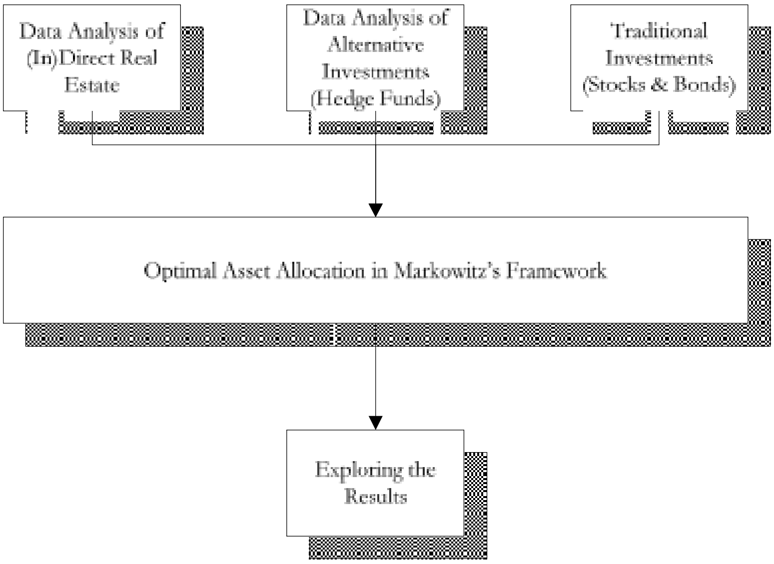

Figure 3: Research model

1.3 Problem statement

The following problem statement can be derived from the objectives:

"How should the direct real estate and the alternative investments time series be adapted, to get a reliable risk profile in order to find an optimal asset-mix within the Markowitz's framework?"

1.3.1 Research questions

To find an answer to the problem statement it is necessary to devise some research questions. The following research questions are formulated:

1. What does the real estate asset class look like?

   The study starts with understanding the real estate in the market and as an asset class. The following sub-questions outline the theoretical part with respect to real estate as an asset class.

   - What are the characteristics of real estate?
   - What is the difference between direct and indirect real estate?
   - How does real estate differ from other asset classes?

2. What is a hedge fund?

   A review will be given on the alternative investments, in particular hedge fund, and also the purpose of these alternative asset classes will be discussed.

3. Which models are used in Risk Management to measure the risk of an asset class?

   Before doing a survey on the time series of the real estate and the alternatives, a review will be given on the theory about Risk Management. Particular interest will be given to the measurement of risk.

4. What is meant by un-smoothing of data?

   The following sub-questions examine the unsmoothing techniques.

   - Which techniques are available to un-smooth real estate data?
   - Which technique is applicable for un-smoothing the real estate data?

5. What does the risk profile of the real estate data look like?

   In order to apply the unsmoothed model the historical data will be sketched out. The following sub-questions outline the historical data that is available for direct real estate and indirect real estate.

   - How is the direct real estate data constructed?
   - What are the statistical variables of the direct real estate data?
   - What are the statistical variables of the indirect real estate data?
   - Does direct real estate significantly correlate with indirect real estate?
   - How does the risk profile of the smoothed real estate data differ from the unsmoothed data?

6. What does the risk profile of the hedge fund[6] data look like?

   The historical data will be outlined in order to find a proper technique to solve the bias of the hedge fund time series.

   - What are the statistical variables of hedge fund?

[6] In this report, the alternative investment is hedge fund.

7. What is the optimal asset allocation within the Markowitz's framework?

   After discussing the historical data and the techniques which solve the biases of the two asset classes, the findings will be applied in the Markowitz's framework.

The sub-questions are formulated to make the problem more tangible and give them a direction.

1.4 Execution

1.4.1 Research Approach

The project can be split up in a number of activities and it can be divided into 4 phases.

Phase 0: Orientation phase: in this phase the organisation will be explored. It is important to study the organisation sufficiently to get insight of the activities. The organisation study is limited to the sub-department ALM-I.

Phase 1: Analysis phase: to give an answer to the problem statement and the sub-questions, the current/available data has to be analysed. Important aspect of the analysis phase is the collection of data because it is difficult to collect data it is important to start as soon as possible with this aspect.

Phase 2: Improvement phase: Parallel to the analysis phase, the literature has to be reviewed to find appropriate techniques to solve the biases of the real estate and the alternative investments time series. As a result of the findings a model will be applied in the time series of return to get a reliable risk profile, in order to find an optimum asset-mix.

Phase 3: Implementation phase: The project does not broad to implement the findings.

As a result of the meetings and feedback with the supervisors the report will be adjusted, which will serve as a guiding principle during the project.

End product: A model for transforming real estate and alternative investment time series to get a proper risk profile and a report of conclusion of the results.

1.4.2 Organisation of the report

The remainder of this report is organised as follows. In chapter 2 and 3 the fundamentals of real estate and hedge funds will be discussed respectively. Furthermore, the biases of both asset classes are indicated.

The theoretical exploration, moreover the risk measurement model to allocate the asset classes and the unsmoothing model to solve the biases of real estate and hedge fund time series are introduced in chapter 4.

In chapter 5 and 6 the historical data of real estate and hedge funds are respectively described and analysed in detail.

In chapter 7 the asset allocation is performed within the Markowitz's framework.

Finally, the conclusion and an answer to the problem statement will be given in chapter 8.

Chapter 2 Real Estate

2.1 Introduction

In the following chapter the general characteristics of the real estate market and real estate as an asset class will be described and this chapter gives an answer to the first research question:

What does the real estate asset class look like?

In the next section the different categories of real estate and the market segment are explained. In order to make a comparison with other asset classes, the characteristics of the real estate market are discussed in section 2.3.

2.2 The Market

2.2.1 Real Estate Classification

There are different ways to classify real estate investments. Firstly, there is a distinction between debts and equity investments. This report only focuses on equity investments. With respect to equity, there are two main real estate market classes: Direct real estate market and indirect real estate market. The indirect real estate market is divided into two subclasses: listed real estate funds (or public real estate funds) and non-listed real estate (or private real estate funds). The difference between listed and non-listed real estate funds are: that listed funds have underlying stocks which are publicly traded at a centralized exchange while non-listed funds are bought and sold through direct negotiations between buyers and sellers. This report will not cover the non-listed funds.

Furthermore real estate investments are divided in commercial real estate (such as offices, industrials and retail) and non-commercial real estate (such as residential, hospitals and schools).

	Direct	Indirect
Public		Listed Real Estate
Private	Direct Real Estate	Non-listed Real Estate

Table 1: Real Estate subclasses

2.2.2 Market (in)efficiency

The market efficiency is a central notion within investment analyses. When information is available for all investors and this information is used in an efficient manner, the investors valuate all the assets equally. Unfortunately, the reality deviates because of the realization of transactions whereby the investment analyses becomes complicated. Fama (1970)[7] has identified three levels of market efficiency:

- Weak form: the information set is just historical prices. Thus, no predictability is included in past returns. So the market returns follow a random walk[8]: there is no significant autocorrelation in the returns.

- Semi-strong form: the information set includes all publicly available prices.

[7] Fama, E.F., Efficient capital markets: a review of theory and empirical work, Journal of Finance, Vol. 25, pp. 383-417, 1970.
[8] The random walk is an investment theory which claims that market prices follow a random path up and down, without any influences by past price movements, making it impossible to predict with any accuracy which direction the market will move at any point.

- Strong form: all information is reflected in the price, including for instance pre-knowledge.

Obviously, the view on the degree of the efficiency of real estate diverges. Brown (1991)[9] and Geltner (1993)[10] think that real estate belongs to the weak form of market efficiency, while Hutchison & Nanthakumaran (2000)[11] argue that the real estate market is a weak efficient market. The market (in)efficiency will be discussed later for the direct real estate index in section 4.5.

2.3 Characteristics of direct real estate

This section will discuss the most important advantages and disadvantages[12] of direct real estate in relation with other asset classes (including the listed indirect real estate).

Advantages

- *Stable Income Flow*
  The extended life span of real estate and the long-term lease agreements give an investor the possibility to have the advantage of a reasonable income return (referred as direct return). Also a good location preserves its value, with a possibility of capital growth (referred as indirect return) in the long run.

- *Diversification*
  At portfolio level real estate offers good diversification possibilities. Given the unique income flow of real estate, it has shown low correlations to the traditional asset classes (bonds and equities).

- *Protection against inflation*
  The rental incomes which are paid, are indexed for inflation and the capital growth shows the real inflation correction.

- *More return by thorough management*
  With active management one can increase the income flow. The income return and the capital return can also be increased by facility management, maintenance and renovation.

- *Opportunities in the real estate market*
  As mentioned before, the real estate market is weak efficient, returns are autocorrelated. Hence, specific knowledge and excellent management can result in extra return.

[9] Brown, G. Property investments and the capital markets, E.&F.N. Spon, Lodon, 1991.
[10] Geltner, D., Estimating market values from appraised values without assuming an efficient market, Journal of real estate research, Vol. 8, Iss. 3, 325-345, 1993.
[11] Hutchison N. & Nanthakumaran N., The calculation of investment worth-Issues of market efficiency, variable estimation and risk analysis, Vol. 18, Iss. 1, 33-52
[12] Van Gool, Brounen, Jager and Weisz, Onroerend goed als belegging, Wolters-Noordhoff Groningen fourth edition, 2007

Disadvantages

- *Appraisal value based*
  Real estate has a long holding period where no trading takes place. Nevertheless, real estate is periodically appraisal valued in order to measure the performance of the real estate. An appraisal is an estimate of an object's value. Appraisal value differs from transaction value and therefore it gives an uncertainty on the risk measurement.

- *Shorter times series of returns*
  The historical series of returns for direct real estate are not so extended like stocks and bonds. The returns for direct real estate are given yearly or at the most quarterly, rather than daily transaction prices.

- *Management intensive*
  With respect to management real estate, it needs more knowledge and it is management intensive.

- *Transaction costs*
  The transaction costs in the real estate market are relatively high.

- *Illiquid market*
  The real estate market is a "passive" market. The number of transactions that takes place is relatively low; the real estate market is marked by infrequent price-making processes. Furthermore, the supply of real estate is not flexible enough.

Chapter 3 Hedge Fund

3.1 Introduction

In this chapter the characteristics of hedge fund will be described and this chapter gives an answer to the second research question:

What is a hedge fund?

In the next section the history/origin of hedge fund is described. Subsequently the investment strategies of the hedge funds are described in section 3.3. The chapter ends with discussing the different biases of the hedge funds time series of returns.

3.2 History of Hedge Funds

Hedge Funds exist for nearly 60 years. Alfred Winslow Jones, a former reporter for the Fortune Magazine, is recognized to be the first hedge fund manager. He combined two speculative techniques (short sales and leverage) to reduce the total portfolio risk. This way he constructed a conservative portfolio, featuring a low exposure to the general market performance.

From the end of the 80s the hedge fund industry established itself in the financial world. As a result of the rapid growth in the number of hedge funds, the US Securities and Exchange Commission (SEC) had started to keep an eye watch over the blossoming hedge fund industry. At the beginning of the 90s there was the real boom. The asset managed by hedge funds had been growing at a rate of 23% per year from 1990 and 14% from 1999[13]. Private wealthy investors are historically the main resource for hedge funds. The bull markets in the 90s generated an unprecedented wealth creation which significantly expanded the base of sophisticated investors seeking for new interesting opportunities.

Since the year 2000, institutions worldwide have been rapidly increasing their allocations to hedge funds. In 2005, Absolute Return magazine published that there were 196 hedge funds with more than $1 billion assets, with a combined $743 billion under management (the vast majority of the hedge fund industry was estimated on $1 trillion in assets)[14]. In 2006 the total hedge fund industry assets increased to $1.444 trillion[15]. As large institutional investors have entered the hedge fund industry the total asset levels continue to rise. The 2008 Hedge Fund Asset Flows & Trends Report published by HegdeFund.net and Institutional Investor News estimates that the total industry asset is reached to $2.68 trillion in quarter three of 2007. This shows that the Hedge Funds industry is gigantic nowadays. It gives the drive for each investor to understand the industry in a broad way and be aware of the expansion in the hedge fund industry.

3.3 Definition & Investment Strategies of Hedge Funds

The term 'hedge fund' has no legal definitions. Stefanini (2006) defines hedge fund as follows: "A hedge fund is an investment instrument that provides different risk/return profiles compared to traditional stock and bond investments". Whereas Investopedia[16] defines hedge fund as: "An aggressively managed portfolio of investments that uses advanced investments strategies in both domestic and international markets with the goal of generating high returns (either in an absolute or over a specified market benchmark)". Moreover, hedge funds are set up by managers who have their own management styles and investment strategies, and they do not have to fulfil special regulatory limitations to pursue their mission: capital protection and to maximize return on investment by generating a positive return with low volatility and low

[13] Donato de Feo, An analysis of hedge funds, an asset allocation perspective, paper/thesis published by www.msfinance.com, 2005
[14] Absolute return magazine, America's biggest hedge funds control $743 billion, 8 September 2005
[15] Hennessee trade news, Performance plus new money takes fund industry to $1.44 trillion in AUM.
[16] www.investopedia.com/terms/h/hedgefund.asp. Accessed on 25th of May 2008.

market correlation. An investment strategy stems from the managers experience and creativity, endowing it with nuances that makes it almost unique. There is no accepted norm to classify the different hedge fund strategies. Hedge fund strategies are no static universe, rather they are subject to constant change and expansion. Nevertheless, hedge funds investments are classified into five main strategies[17]:

1. Relative value
2. Event driven
3. Directional/Trading
4. Long/short equity
5. Other Strategies

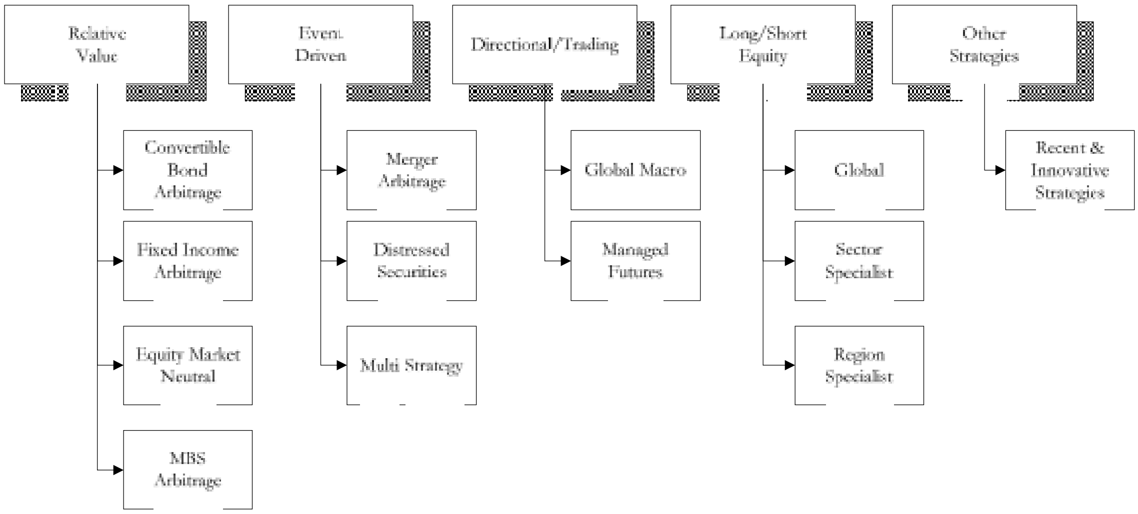

Figure 4: Investment strategies

Relative value strategies are arbitrage transactions that seek the profit of the spread between two securities rather than from the general market direction. Arbitrage is a two-sided strategy involving the simultaneous purchase and sale of related securities that are mis-priced compared to each other. Relative value strategies include convertible bond arbitrage, fixed income arbitrage, mortgage-backed arbitrage and equity market neutral.

- *Convertible Bond Arbitrage*: Convertible bond are bonds that give their holders the rights to periodic coupon payments and, as of a fixed date, the right to convert the bonds into a fixed number of shares if the bond-holder decides to exercise its conversion right, instead of being paid back the par value of the bonds, it receives a fixed number of shares in exchange. Convertibles are ideal securities for arbitrage because the convertible itself is traded along predictable ratios and any discrepancy or mis-price would give rise to arbitrage opportunities for hedge fund managers.
- *Fixed Income Arbitrage*: it is a generic description which includes a wide range of strategies that seek to exploit pricing anomalies within and across fixed markets. These pricing anomalies are typically due to factors such as investor's preferences, exogenous shocks to supply or demand, or structural features of the fixed income market. Fixed Income arbitrageurs take long and short positions, seeking to take advantage of temporary mismatches between related securities. Portfolios are constructed in such way to have no correlation with interest change rate changes, by trying to minimize the portfolios total duration.

[17] Stefanini (2006)
Francois-See Lhabitant, Hedge Funds: Quantitative Insights, Jonh Wiley & Sons Ltd., England 2004
Donato de Feo, An analysis of hedge funds, an asset allocation perspective, paper/thesis published by www.msfinance.com, 2005

- *Equity market neutral*: is also referred to as statistical arbitrage. It is a quantitative portfolio construction technique that seeks to exploit pricing inefficiencies between related equity securities while at the same time exactly neutralizing exposure to market risk. The neutrality is achieved by offsetting long positions in undervalued equities and short positions in overvalued equities. The strategy's objective is to exploit mis-pricings in a risk free manner.
- *Mortgage-Backed Securities Arbitrage*: is a special type of fixed income arbitrage. Mortgage-backed securities arbitrage is the securitization of a set of mortgages collateralized by real estate. Hedge funds managers look to capitalize on security-specific mis-pricing.

Event driven seeks to capitalize on opportunities arising during a company's life cycle, triggered by extraordinary corporate events such as spin-offs, mergers and acquisitions, bankruptcy, business combinations and reorganizations. The strategy is divided in distressed securities strategy, merger arbitrage and event driven multi-strategy.

- *Merger Arbitrage Strategy*: involves event-driven situations such as leverage buy-outs and mergers. The strategy generate returns by purchasing stock of the company being acquired, and selling the short stock of the acquiring company.
- *Distressed Securities Strategy*: Managers invest in the securities of a company where the securities price has been affected by a distressed situation. Depending on the managers style, investments may be made in bank dept, corporate dept, trade claims, common stocks, preferred stock and warrants.
- *Event driven multi-strategy*: funds draw upon multiple themes. Managers often shift strategies in response to market opportunities.

Directional/Trading strategies seek to take advantage of major market trends rather than focusing their analysis on single stocks. Global macro investing and managed futures are the dominant styles in this category.

- *Global Macro Managers*: tend to make leveraged bets on anticipated price movements of the stock markets, interest rates, foreign exchange and physical commodities. Macro managers employ a top-down approach and may invest in any markets using any instruments to participate in expected movements. These movements may result from forecasted shifts in the world economies, political fortunes or global supply and demand for resources, physical as well as financial.
- *Managed Futures*: primarily trade listed commodities and financial futures contracts on the behalf of their clients.

Long/short equity strategies are where the manager takes a long position on the stock if he thinks the market is under-pricing and short sells stock if he perceives his being over-priced. A regional or industry focused managers specialise in a region, a country or a specific sector, while global managers invest worldwide.

Other strategy is a residual category of the recent innovative strategies.

3.4 Biases in Hedge Funds Time Series of Returns

In order to cover the general performance of a hedge fund in the asset allocation, it is necessary to display the biases of the hedge funds historical data. Lhabitant (2004) recognizes four distortions carried by the hedge fund data:

- Selection bias
- Survivorship bias
- Back-fill bias
- Infrequent pricing and illiquidity bias

The **selection bias** follows from the fact that the contribution of historical data to databases is voluntary, therefore only best performed funds tend to report data.

The **survivorship bias** is the statistical bias in performance aggregates due to the inclusion of only live funds and the exclusion of liquidated-, no longer operating-, or non-reporting funds.

Back-fill bias occurs when a hedge fund is attached to the database and when a part of the entire historical performance, which is usually quite positive, is added to the database.

Infrequent pricing and illiquidity bias is caused by the unsavoury practice of reporting only part of the gains in months when a fund has positive returns, so to partially offset potential future losses. This behaviour has specific consequences on variance and correlation and this is also identified with performance smoothing. This bias is comparable with the smoothing bias of the direct real estate which is discussed in chapter 2.

Unfortunately, the first three biases subsist, only the smoothing bias can be solved. The model, to solve the smoothing bias, is discussed in the following chapter in which the literature is also going to be reviewed.

Chapter 4 Theoretical Framework

4.1 Introduction

In the following chapter a theoretical discussion is held regarding risk management and unsmoothing techniques of the real estate time series of returns. This chapter gives an answer to the research questions 3 and 4:

Which models are used in Risk Management to measure the risk of an asset class?

What is meant by un-smoothing of data?

First, some background information of the importance of Risk Management will be given in section 4.2. Section 4.3 discusses the theoretical aspects of Time Series Analyses. This chapter ends with the frequently used unsmoothing techniques. Some basic statistical definitions can be found in appendix II.

4.2 The Importance of Risk Management

4.2.1 Risk Exposures

There are several sorts of risks that an investor can be exposed to. In figure 5 the risks exposures are sketched in which financial institutions are faced with,

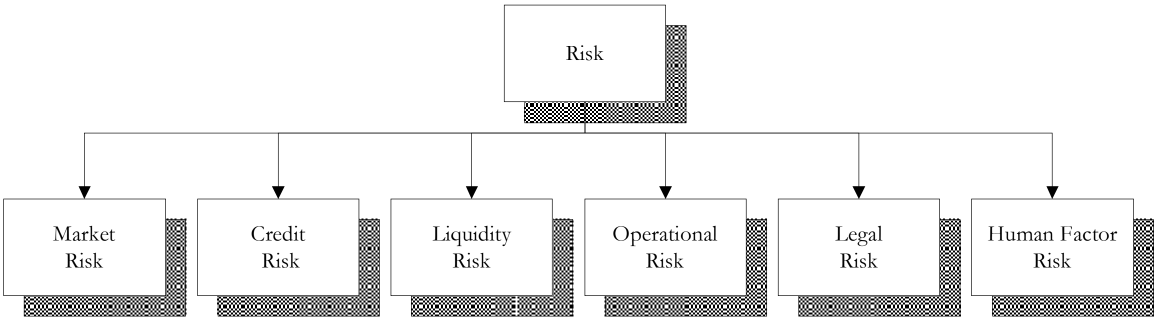

Figure 5: Typology of Risks Faced by a Financial Institution[18]

Market Risk: Is the risk that changes in financial market prices. The market risk can be divided into basis risk, convexity risk, interest rate risk, exchange rate risks and commodity[19] price risks.

Credit Risk: Is the risk of loss arising whereby a counterpart is unwilling to fulfil its contractual obligations.

Liquidity Risk: Is the risk of loss due to the inability to sell the asset at a representative price.

Operational Risk: Refers to losses resulting from the failure of internal systems, failure of management and fraud.

Legal Risk: Arises from the idea that the contracts will not be enforced.

Human Factor Risk: Is a special form of operational risk. It relates to human errors that controls the internal systems.

[18] Crouhy M., Galai D. and Mark R., Risk Management, McGraw-Hill, 2001.
[19] Like oil and gold prices.

The study only focuses on market risk for real estate and hedge fund investments. The reason is that the market risk is caused by market movements and an investor is not able to control the market. Consequently, it is important to measure and monitor the market risk.

4.2.2 Risk & Return

According to Corgel and de Roos (1999)[20] appraisal value based real estate and hedge fund returns have abnormally low coefficient of variation relative to other risky assets. That is why investing in real estate and hedge funds are preferred by institutional investors to diversify their portfolio. Investment choices are made as a consequence of assumptions, expectations and predictions of the future. As a result, there is large uncertainty about future returns (so there is risk involved). Risk is usually measured by determining the standard deviation (also called the volatility) of the historical returns of a specific investment. If several investment opportunities have the same return but different volatilities, a rational investor will select the investment that has the smallest volatility. In general, the higher the risk of an investment, the higher the expected return demanded by an investor. It is therefore important to be able to determine the risk of an investment as correct as possible. The expected return can be calculated with several methods, mainly with arithmetic and geometric method.

Arithmetic Return

Arithmetic return represents the value of a series of returns, computed as the sum of all returns in the series divided by the count of all returns in the series.

The arithmetic return (mean) of an asset, denoted[21] as $\overline{R}_A$:

$$\overline{R}_A = \frac{1}{n}\sum_{i=1}^{n} R_i \tag{4.1}$$

Geometric Return

The geometric return of a collection of return data is defined as the *n*th root of the product of consecutive returns in the data set, where n is the number of members. The geometric return (mean) of the return data set $[R_1, R_2, \ldots, R_n]$ is[22]:

$$\overline{R}_G = \left(\prod_{i=1}^{n}(1+R_i)\right)^{1/n} - 1 \tag{4.2}$$

R_i is the return during period *i* and *n* is the number of observations.

Arithmetic versus Geometric Return

Each of the two methods of computing the average has some advantages and disadvantages which it makes more appropriate than the other certain purposes. The arithmetic mean is characterized by the following properties[23]:

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[20] Corgel B. John & de Roos A. Jan, Recovery of Real Estate Returns for Portfolio Allocation, journal of real estate finance and economics, Vol. 18, Iss. 3, 279-296, 1999.
[21] Larsen J. Richard & Marx L. Moris, An Introduction to Mathematical Statistics and its Applications, Prentice Hall Third Edition, 2001.
[22] Luenberger G. David, Investment Science, Oxford University Press, 1998.
[23] Geltner D., Miller N., Clayton J. and Eichholtz P., Commercial Real Estate Analysis & Investments, Thompson, Second Edition, 2007

- The arithmetic mean is always greater than the geometric mean.
- The arithmetic mean has superior statistical properties in the sense that it provides the best estimator of the true underlying return tendency for each period. Therefore, it provides the best forecast of the return for any future period.

These properties of the arithmetic mean can be compared with the following properties of the geometric mean:

- Because the geometric mean reflects compounding of returns, it better represents the average growth rate per period during the overall time span. So, to reflect the relation between the amount of value the investor ends up with and the amount he started with.
- The geometric mean is unaffected by the volatility of the periodic returns.

Because of these attributes, the arithmetic mean/return is most widely used in forecasts of future expectations and in portfolio analysis. On the other hand the geometric mean is most widely used in historical performance measurement and in the evaluation of investment managers. According to Geltner et al (2007) the arithmetic mean is the most often used by academics. They avoid the whole issue of geometric versus arithmetic mean by working with log differences. For any stock, bond and real estate indices, the return at time *i* is defined as

$$R_i = \ln(S_i) - \ln(S_{i-1}) \tag{4.3}$$

where S_i is the index level at time *i*. This definition approximates the relative change in the index (return), hence

$$\ln(S_i) - \ln(S_{i-1}) - \ln\left(\frac{S_i}{S_{i-1}}\right) - \ln\left(1 - \frac{S_i - S_{i-1}}{S_{i-1}}\right) \approx \frac{S_i - S_{i-1}}{S_{i-1}}.$$

The issue of geometric versus arithmetic mean is also discussed by Abrams (1996)[24]. In his article[25] he emphasizes that the arithmetic method is the best method to use.

For the continuation of the research the arithmetic method will be used to calculate the returns of the time series.

Volatility

The volatility of an individual asset can be calculated as follows[26]:

The variance of an asset, denoted as $\mathrm{var}[R]$:

$$\mathrm{var}[R] = \frac{1}{n-1} E(R - ER)^2 \tag{4.4}$$

The standard deviation/ volatility of an asset, denoted as σ :

$$\sigma = \sqrt{\mathrm{var}[R]} \tag{4.5}$$

R_i is the return during period *i* and *n* is the number of observations.

[24] Abrams B. Jay, Arithmetic vs. Geometric Means: Empirical Evidence and Theoretical Issues, Uniquely Applying Original Valuation Theory, Abrams Valuation Group, 1996.
[25] Abrams (1996) discusses this issue by mean of theoretical and empirical evidence, where he illustrates by mean of regression analysis the arithmetic mean is the best method to use.
[26] Larsen & Marx (2001).

Annualizing Returns and Standard deviation

Annualizing (arithmetic) returns and standard deviations from sets of periodic data one can use the following set of equations:

$$\bar{R}_{annual} \quad m*\left(\bar{R}_{periodic}\right) \qquad (4.6)$$
$$\sigma_{annual} \quad \sigma_{periodic}\sqrt{m}$$

where,

$\bar{R}_{annual}$ – Annualized return

m Number of periods per year

$\bar{R}_{periodic}$ – Periodic return

σ_{annual} Annualized standard deviation

4.2.3 Skewness & Kurtosis

The variables mean and variance are described in the previous subsection which are actually special cases of what are referred to more generally of the moments of a random variable. Moreover, the mean is the first moment about the origin and the variance is the second moment about the mean. This subsection will discuss[27] the third and the fourth moment of the return series.

Skewness is a parameter that describes asymmetry in a random variables probability distribution. Moreover, a distribution is skewed if one of its tails is longer than the other. Skewness can be positive; this means that it has a long tail in the positive direction. It can also have a negative value which is called a negative skewness. The skewness can be measured in terms of its third moment about the mean, by the coefficient S, where

$$S \quad \frac{E\left[(R-\mu)^3\right]}{\sigma^3}. \qquad (4.7)$$

A second shape parameter in common use is the coefficient of kurtosis, K, which involves the fourth moment about the mean:

$$K \quad \frac{E\left[(R \quad \mu)^4\right]}{\sigma^4}-3. \qquad (4.8)$$

Kurtosis is the measure of the peak of the probability distribution of a real valued random variable. The minus 3 at the end of the formula is often explained as a correction to make the kurtosis of the normal distribution equal to zero, which is called *mesokurtic*. The normal distribution is a family of a mesokurtic distribution. A high/positive kurtosis distribution is called *leptokurtic*. It has a sharper and fatter tails which means that it has a higher probability than a normal distributed variable of extreme values. A low/negative kurtosis distribution is called *playkurtic* and has a more rounded peak with wider shoulders with thin tails, so a lower probability than a normal distributed variable of extreme values. Figure 6 shows the three different sort of kurtosis's.

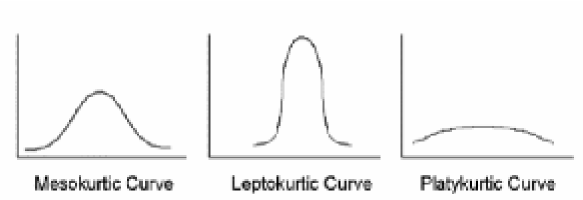

Figure 6: Different kurtosis's

[27] Larsen and Marx (2001)

4.2.4 Value at Risk

Another risk indicator is Value at Risk (VaR). VaR measures the worst expected loss over a given time horizon under normal market conditions and with a given confidence interval. It offers a probability statement about the potential change in the value of a portfolio resulting from a change in market factors over a specified period of time. VaR gives an answer to the following question[28]: "What is the maximum loss over a given time period such that there is a low probability that the actual loss over the period will be larger?".

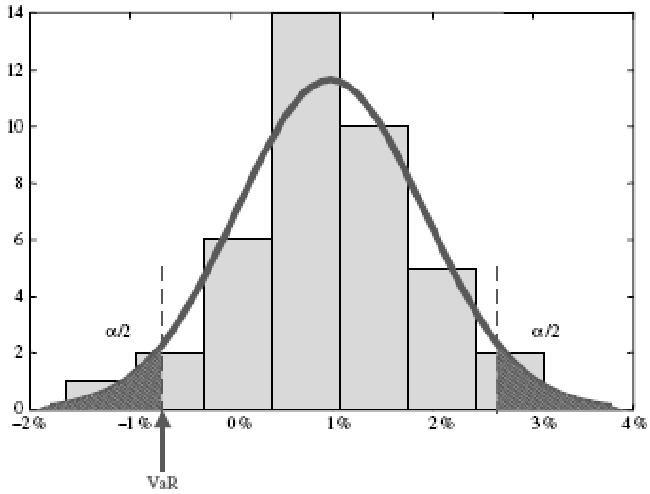

Figure 7: VaR of the returns empirical distribution[29]

VaR can be calculated through various practical methods. Each of them starts with estimating the statistical distribution of returns. There are three approaches to derive this distribution:

- **The analytic variance-covariance approach**: it assumes that the risk factors are log-normally distributed or equivalently that the log-returns are normally distributed.
- **The Monte Carlo approach**: this methodology can be implemented by choosing any analytic multivariate distribution. It estimates VaR by simulating the random behaviour of risk factors. Monte Carlo is computational intensive and is generally the slowest form of VaR to calculate.
- **The historical simulation approach**: VaR is derived from the empirical distribution generated by the historical realizations of the risk factors over a specified period of time. The results depend greatly on the historical period considered of the analysis. Assuming that the past is fair representative to the future, it requires long time series, which are crucially lacking for the direct real estate and the hedge fund industry.

The choice of a methodology for modelling changes is hard to make. All the approaches have a shortcoming. In common to the most applied approach is the analytic variance-covariance approach which assumes that the distribution of the changes in the portfolio value is normal and is therefore characterized by the first and the second moments. The VaR of any asset *i* with normally distributed returns is estimated as:

$$VaR_i - E(R_i) + z_c\sigma_i \qquad (4.9)$$

where z_c depends on the level of confidence[30], and $E(R_i)$ and σ_i are respectively asset *i*'s expected return and volatility. The VaR of a portfolio of N assets is obtained from the individual VaRs of the assets[31]:

[28] Grouhy et al (2001)
[29] Stefanini (2006)

$$VaR_P \quad \sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N}\rho_{i,j}w_iVaR_iw_jVaR_j} \tag{4.10}$$

where w_i is the weight of the i th asset and $\rho_{i,j}$ is the correlation between the ith and the jth asset.

However, as mentioned in the introduction, hedge funds show a fat tailed distribution. This accounts for the fact that the VaR is not a workable method. Therefore, one needs a model that can be used for fat tailed and/or skewed distributions. Favre and Galeano (2002)[32] identify a model that takes the skewness and kurtosis into account. The adjustment of the variance-covariance approach by Favre and Galeano (2002) is referred as the modified VaR (MVaR)[33], which is calculated as:

$$MVaR_i - E(R_i) - \left(z_c + \frac{z_c^2-1}{6}S_i + \frac{z_c^3-3z_c}{24}K_i - \frac{2z_c^3-5z_c}{36}S_i^2 \right) \sigma_i \tag{4.11}$$

where S_i and K_i are the skewness and kurtosis, respectively, of asset i. Remark, when S and K are equal to zero the formula changes back to equation 4.9.

The MVaR is a useful model to enable the quantiles of the standard normal distribution to calculate the risk by not only matching the mean and volatility but also considering the skewness and kurtosis of the empirical distribution to the theoretical one.

Equation 4.10 can also be used to obtain the portfolio of MVaR. The individual VaRs are than replaced by the individual MVaRs.

[30] z_c is a constant in the standard normal tables. For α is 0.05, 0.025 and 0.01 the z value is -1.645, -1.96 and -2.33 respectively. In this report only the 99% confidence level will be considered.

[31] Lhabitant (2004)

[32] Favre L. and Galeano J-A., Mean-Modified Value-at-Risk optimization With Hedge Funds, journal of Alternative Investment, Vol. 5, Fall 2002.

[33] When using MVaR, we assume that the asset classes are normally distributed (multivariate normally distributed). Therefore the dependency between the assets can be modelled by Gaussian Copula. A copula is used as a general way of formulating a multivariate distribution. When the normality assumption is left out, one can use non-Gaussian copulas to model the dependency of different distributions. Because of the lack of time and the complexity, non-Gaussian Copulas are left out from the scope.

4.2.5 Markowitz's Framework

In the previous sections the risk and return of an individual asset is described. These techniques can also be used to determine the corresponding risk and return of a portfolio. Most common portfolio theory is derived by Harry Markowitz, referred as the Modern Portfolio Theory (MPT). The MPT deals with strategic decision of how to allocate asset classes to find a (minimum) variance portfolio. By adding multiple assets in a portfolio, the investor can realize a risk reduction. This is also called risk diversification. In terms of diversification, risk is divided into *systematic* and *unsystematic* risk. *Systematic*, market or undiversified risk is the risk of holding the market portfolio. When the market moves, each individual asset is more or less affected. *Unsystematic*, unique of specific risk is risk that is unique to an individual asset and can be diversified away in a large portfolio. The returns of a portfolio in that case are only influenced by the market. However, once the portfolio has 20 or more asset classes[34], it is impossible to reduce the risk below the level of the undiversified risk that exists in the market.

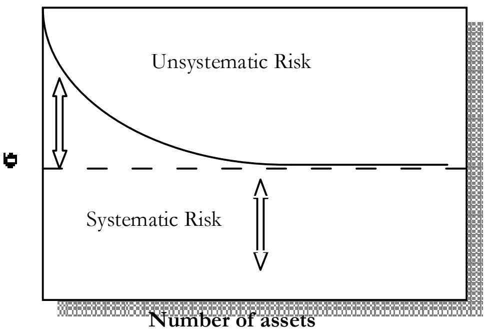

Figure 8: Systematic and Unsystematic Risk

Return & Risk

The mean return and the variance of a portfolio are determined from the following formulas[35]:
The expected return of a portfolio, denoted as R_p:

$$E[R_p] = \sum_{i=1}^{n} w_i E[R_i] \tag{4.12}$$

$$\sum_{i=1}^{n} w_i = 1$$

where n is the total number of assets with expected returns $E[R_i]$ (for $i = 1 \ldots n$) and w_i is the weight[36] for each asset within the portfolio.
The variance of a portfolio, denoted as $\text{var}[R_p] = \sigma_p^2$:

$$\sigma_p^2 = \sum_{i,j=1}^{n} w_i w_j \sigma_{ij} \tag{4.13}$$

where σ_{ij} is the covariance[37] of asset *i* with asset *j*.

By composing all possible combinations of the risky assets the so-called efficient frontier can be established as presented in figure 9. That is, the collection of all feasible set of portfolios. Portfolios below the

[34] Luenberger, (1998)
[35] Luenberger, (1998)
[36] In this study short-selling is not allowed. Hence, $w_i \geq 0$. Short-selling involves selling assets that are borrowed in expectation of a fall in the assets's price. When and if the price declines, the investor buys an equivalent number of assets at the new lower price and returns to the lender, the assets that were borrowed.
[37] $\sigma_{ii} = \sigma_i^2$ is the variance of asset i.

efficient frontier are not efficient because for the same risk one could achieve a greater return, while a portfolio above the frontier is not possible. An efficient portfolio can be described as the portfolio that offers the lowest risk for its expected return and the highest expected return for its level of risk.[38]

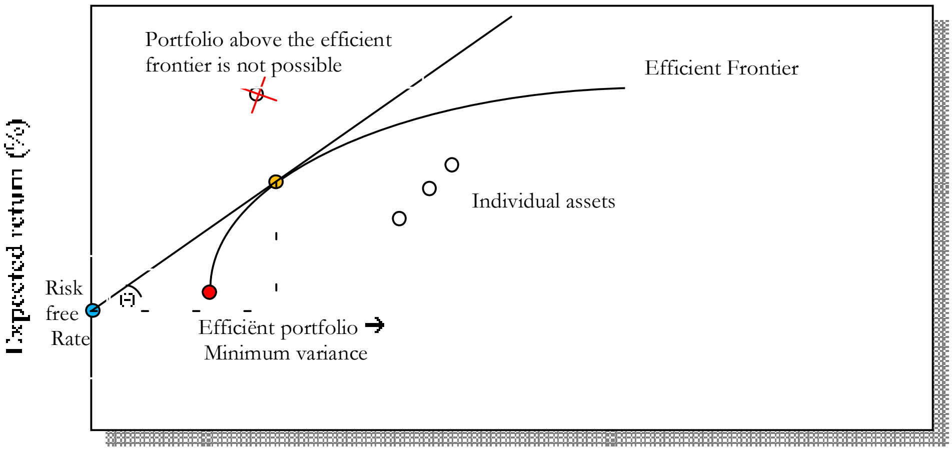

Figure 9: Efficient frontier

The performance of the trade-off risk and return can be measured by the Sharpe Ratio (SR)[39]:

$$SR \quad (R - R_f)/\sigma \tag{4.14}$$

where R is the expected return and σ the standard deviation of the asset or the portfolio. A higher Sharpe ratio is preferred to a lower one. Moreover, higher return at a given level of volatility is preferred and a lower volatility at a given return.

R_f is the risk-free rate. In figure 9 the risk-free rate is represented as the straight-line, which is interpreted as the Capital Allocation Line (CAL). Note that any feasible portfolio the CAL-slope is

$$\tan\Theta = (R_P - R_f)/\sigma_P \tag{4.15}$$

where Θ is denoted as the angle between the tangent on the efficient frontier and the horizontal axis.

In this report the Dutch Treasury Bills, also known as Dutch Treasury Certificates (DTC) will be used as a risk-free rate[40]. Treasury Bills are a government obligation, issued for periods of three till 12 months, and are traded on a discount basis. They are among the most liquid form of short-term investment[41].

[38] Brealey A. Richard & Myers C. Stewart, Principles of Corporate Finance, McGraw-Hill Irwin, international 7th edition, 2003
[39] Alexander C., Market Models, A guide to financial data analysis, John Wiley & Sons Ltd, February 2005.
[40] As can be said the risk-free pays a return to the investor with a standard deviation equal to zero. But then it is assumed that the Government does not default. In reality all financial instruments carry some degree of risk, and therefore there is not such thing as risk-free asset.
[41] www.dutchstate.nl visited on 20th of June 2008. The 1 year DCT at the end of 2007 was 4.29%. For this report 4.29% is used as the risk-free rate.

The implicit assumption underlying the Sharpe ratio is that returns follow a normal distribution, since the first two moments have assumed to be sufficient to describe the distribution itself. However, the hedge fund return series are not in particular normally distributed. According to that the modified Sharpe ratio can be used as measuring the performances of an asset or a portfolio. The modified Shape ratio is an adjustment on the original Sharpe ratio where the standard deviation or risk factor of the model is replaced by modified Value at Risk (MVaR). MVaR is a measure which takes place in the higher statistical moments, discussed earlier in section 4.3.4. The modified Sharpe ratio can be estimated as:

$$MSR = \frac{(R - R_f)}{MVaR}. \tag{4.16}$$

The benefit of involving the higher moments is to avoid underestimating risk.

4.3 Time Series Analyses

A time series is a collection of observation which is sequentially made through time. There are numerous reasons to record and to analyse the data of a time series. Among these the wish is to gain a better understanding of the data generating mechanism, the prediction of future values or the optimal control of a system. This research aims at understanding the data and to find the most appropriate statistical model for the historical data and to use this model for unsmoothing of the time series of real estate and hedge funds.

First the lag operators will be introduced that is specific to time series. The lag operator L, when placed in front of any variable with a time subscript, gives the previous value of the series. The lag operator is defined by[42]

$$\begin{aligned} L(r_t) &= r_{t-1} \\ L^2(r_t) &= L[L(r_t)] = L(r_{t-1}) = r_{t-2} \\ L^s r_t &= r_{t-s} \\ (1-L)r_t &= r_t - r_{t-1} = \Delta r_t \\ L(1-L)r_t &= r_{t-1} - r_{t-2} = \Delta r_{t-1} \end{aligned} \tag{4.17}$$

where Δ is the first difference operator and *t* is the time.

4.3.1 AR an Univariate model

The first step in the time series analyses is to plot the observation by time. The time plot can give an important insight on the trend. For modelling time series it is important that the series is a stationary process and therefore it shows no trends or seasonal patterns. A time series is stationary if $E(r_t) = \mu t$, $Var(r_t) = \sigma^2$ are the same at every date *t*, that is $E(r_t)$ and $Var(r_t)$ are finite constants and the $\text{cov}(r_t, r_{t-s})$ depends only on the lag *s*. This indicates that the expectation and the variance are independent of time. A simple example of a stationary time series is an autoregressive model of order 1, the AR(1)[43] model.

[42] Spierdijk L., Time Series Analysis, PowerPoint presentation of the course Financial Econometrics, University of Twente, Enschede, 2007.

[43] This report only discuss the AR(1) model, because the gross of the literature on unsmoothing techniques is based on the AR(1) model.

The AR(1) model is a representation by functions of his own lag, as a consequence the AR(1) model can be described as a univariate time model.

Consider now a AR(1) model without a constant term

$$r_t = \alpha r_{t-1} + \varepsilon_t \tag{4.18}$$

where ε_t is independent and identically distributed (i.i.d.) N $(0, \sigma^2)$. When the disturbance is white noise, then equation (4.18) is a pure AR(1) process. Usually the mean value of white noise is assumed to be 0 and the standard deviation σ taken to be 1. The AR(1) model is only a stationary process if $|\alpha| < 1$. This can be verified as follows[44]:

$$\begin{aligned} E(r_t) &= \alpha E(r_t) \\ E(r_t)(1-\alpha) &= 0 \\ E(r_t) &= 0 \end{aligned} \quad \text{and} \quad \begin{aligned} Var(r_t) &= \alpha^2 Var(r_t) + \sigma^2 \\ Var(r_t)(1-\alpha^2) &= \sigma^2 \\ Var(r_t) &= \sigma^2/(1-\alpha^2) \end{aligned} . \tag{4.19}$$

The autocovariance of the AR(1) model is given by:

$$E(r_t r_{t-s}) = \alpha^s \sigma^2/(1-\alpha^2), \tag{4.20}$$

which depends only on lag *s*. So the AR(1) model is a stationary process when $|\alpha| < 1$.
The properties of the AR(1) model are summarized in the table below:

Properties	*AR(1) model*
Mean	$E(r_t) = 0$
Variance	$Var(r_t) = \sigma^2/(1-\alpha^2)$
AutoCovariance	$E(r_t r_{t-s}) = \alpha^s \sigma^2/(1-\alpha^2)$
Stationarity	Stationary if $\lvert\alpha\rvert < 1$

Table 2: Properties of AR(1) model.

The AR(1) model can also be tested for stationarity. There are several test discussed in the literature to test the AR(1) model for stationarity. A well known test is the Dickey-Fuller (DF) unit root test, a statistical test of the null hypothesis that a time series is non-stationary against the alternative that it is stationary:

$H_0 : \alpha = 1$ (Non stationary), when $\alpha = 1$ the AR(1) model becomes a random walk model.
$H_0 : |\alpha| < 1$ (stationary).

Another property of the AR(1) model is the mean-reversion. The variance of a stationary time series is finite. Hence, a stationary time series can never drift too far away from its mean. The mean-reversion in the AR(1) model depends on the size of α in equation (4.18). When $\alpha = 1$ then the series is a random walk, which is non-stationary, and there is no mean-reversion.

The most return data on financial markets are generated by stationary processes. The statistical concepts and methods that apply to return data do not apply to price data. The historical data that is presented in this report is based on quarterly and yearly returns of real estate and monthly return for hedge funds. The stationarity for direct real estate and hedge fund will be discussed in chapter 5 and 6, respectively.

[44] Alexander (2005)

4.3.2 Autocorrelation

An essential element of analysing time series concerns the mutual dependence of the successive observations in a series, which is the autocorrelation. The *s*th-order autocorrelation coefficient for a stationary time series r_t is

$$\rho_s = \mathrm{cov}(r_t, r_{t-s}) / \mathrm{var}(r_t) \qquad (4.21)$$

where $\mathrm{cov}(r_t, r_{t-s}) = E(r_t r_{t-s})$.

To identify an appropriate model for a stationary series it is convenient to represent the autocorrelations at different lags in a chart, which is called the correlogram. Figure 10 shows the correlogram of a simple AR(1) model. The significance of the correlogram is that it can help in rapidly recognizing what kind of underlying structure the time series have. Column 1 visualizes the autocorrelation. Column 2 gives the correlation for the specified lag.

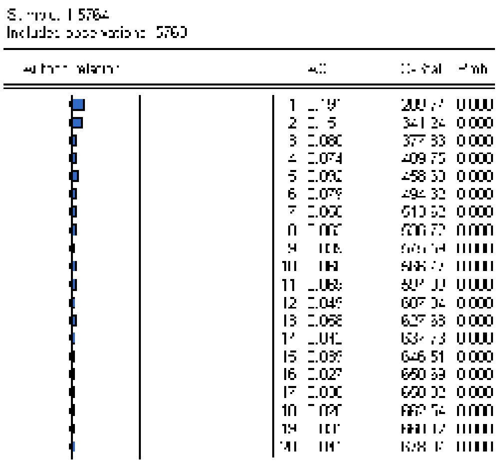

Figure 10: Example of a correlogram[45]

The autocorrelation can also be tested on the significance of autocorrelation; one of the common tests is the Box-Pierce test. The last two columns in figure 10 are the Box-Pierce Q statistics and their probability value. The Q statistic at lag p is a test statistic for the null hypothesis that there is no autocorrelation to order p and is computed as

$$Q = T \sum_{n=1}^{p} \varphi(n)^2 \quad (\text{With } Q \sim \chi_p^2) \qquad (4.22)$$

where T is the sample size and $\varphi(n)$ is the *n*th-order sample autocorrelation. Q is asymptotically distributed as χ_p^2 with degrees of freedom equal to the number of autocorrelations.

$$\varphi(n) = \sum_{t=n+1}^{T} r_t r_{t-n} \Big/ \sum_{t=1}^{T} r_t^2 . \qquad (4.23)$$

In chapter 5 and 6 the series of returns of real estate and the hedge funds will be tested for autocorrelation.

[45] This is the correlogram of the returns of exchange rate of the US dollar to Euro.

4.4 Unsmoothing Techniques

The real estate appraisers or appraisal firms usually perform the valuation of a property at the end of each year (fourth quarter). Appraisers are therefore aware of the previous appraised values. This often leads to autocorrelation and create a lower volatility than transaction-based return. This effect is referred to smoothing. The smoothing bias also appears in the returns series of the hedge funds because real estate is considered as an asset class and it is involved in the ALM-study. It is necessary to solve these biases. This can be done by unsmoothing the appraisal valued real estate data. Figure 11 shows the smoothed and unsmoothed real estate data which you can see that the unsmoothed real estate is much more volatile. In chapter 5, it is also shown that the unsmoothed real estate returns do not show any autocorrelation (both in the first and second order).

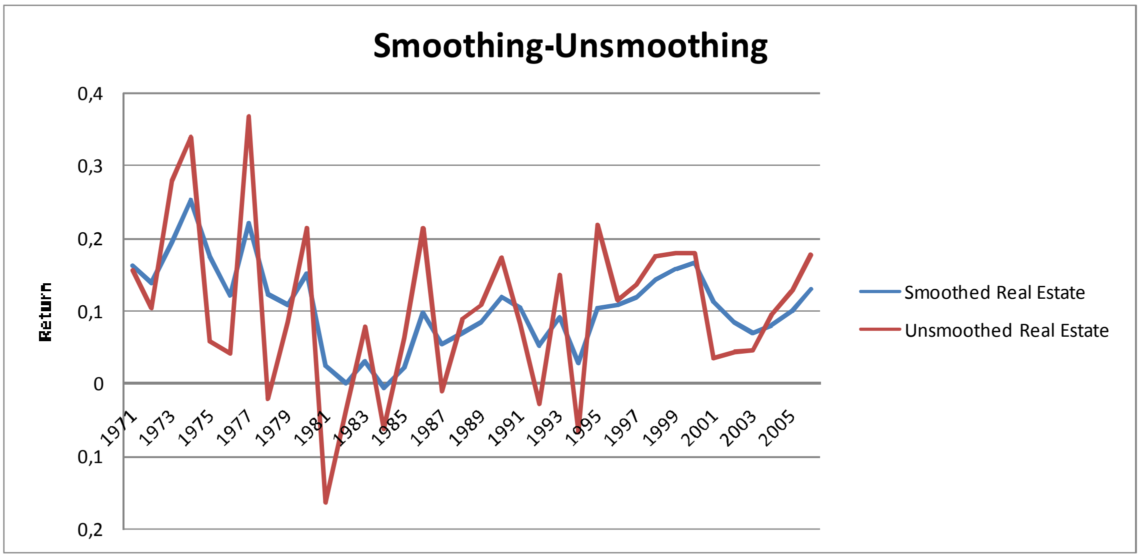

Figure 11: Smoothing and Unsmoothing effect of yearly real estate data[46]

The problems arise from using the appraisal based real estate return in measuring real estate performances, in particular the risk, have been widely discussed in several papers. Most papers on the topic unsmoothing techniques for real estate indices are based on Fisher et al (1994)[47] and on Geltner (1991, 1993)[48]. In the following subsection both techniques will be examined with extension to other unsmoothing techniques.

4.4.1 Unsmoothing in an efficient market

The most important assumptions made by Fisher et al (1994) is that real estate indices behave stochastically as if the properties were traded in an informational efficient market (the underlying true returns are uncorrelated across time). Another essential assumption is the consideration of stationarity of the real estate index. The authors examine in their paper indices that attempt to reconstruct property market values by unsmoothing the appraisal-based Russell- NCREIF Index. The Russell- NCREIF Index is the most widely cited index of institutional-grade commercial property returns in the United States. Fisher et al

[46] The model of Geltner (1993) is used to unsmooth the real estate data (the data is originated by Ortec). The smoothing factor in this figure is 0.4. This model is described in section 4.5.2.

[47] Fisher D. Jeffrey, Geltner M. David & Webb Brian R., Value Indices of Commercial Real Estate: A Comparison of Index Construction Methods, journal of real estate finance and economics, Vol. 9, 137-164, 1994.

[48] Geltner (1993)
Geltner D., Smoothing in Appraisal based returns, journal of real estate finance & economics, Vol. 4, Iss. 3, 327-345, 1991.

(1994) also discusses that the quarterly Russell- NCREIF Index exhibits much less volatility than market value indices.
The smoothing model presented by Fisher et al (1994) can be expressed as

$$r_t^* - \sum_{L=1}^{N} \phi(L) r_{t\ L}^* + e_t \qquad (4.24)$$

where r_t^* is the observed/smoothed return during period t, $r_{t\ L}^*$ are prior observations from the return series, $\phi(L)$ is a vector of lag coefficients, and e_t is a residual. The term $\sum_{L\ 1}^{N} \phi(L) r_{t\ L}^*$ captures the mean effect of prior returns on the current return. The residual term contains r_t, the recovered/unsmoothed return, and the effect of appraisal based smoothing. Thus, $e_t \quad r_t w$, where w represents the weighting factor, which is between 0 and 1.

Equation (4.24) can be rewritten in such way that the unsmoothed return is defined as:

$$r_t \quad \frac{(r_t^* \quad \sum_{L\ 1}^{N} \phi(L) r_{t\ L}^*)}{w} \qquad (4.25)$$

Hence, for the AR(1) model (L=1) the unsmoothed return is defined as:

$$r_t \quad \frac{(r_t^* - \phi_1 r_{t\ 1}^*)}{w}$$

Because of the efficient market assumption and therefore the assumptions of unpredictable true returns, e_t is white noise (i.e. e_t has a normal distribution with mean 0 and a constant variance σ^2)[49], so that the autoregressive ϕ(L) parameter can be estimated empirically in equation (4.25) from the observable data on the r_t^* series. To evaluate the weight w, Fisher et al (1994) considers a last assumption. That is, the true volatility of property values is approximately half the volatility of the S&P500 Index of stock market values. By means of the true volatility the weight can be characterized as

$$w \quad \frac{2\sigma_{e_t}}{\sigma_{SP}}. \qquad (4.26)$$

where σ_{e_t} is the standard deviation of the residuals for the autoregressive model, which is a proxy for the unsmoothed real estate standard deviation . In addition to the AR(1) model (equation 4.25), the real estate index returns shows a strong evidence of a fourth order lag. The fourth order lag is caused by the fact that the properties are only reappraised annually in the fourth quarter of that year[50]. Fisher et al (1994) deals with this issue by adding in their model (equation 4.25) a fourth order AR coefficient: $\phi_1 + \phi_4 L^3$. This will transform the unsmoothed model to:

[49] See section 4.4.1 for the explanation of white noise for a AR(1) model.
[50] Ross A. Stephen and Zisler C. Randall, Risk and Return in Real Estate, journal of real estate finance and economics, Vol. 4 Iss. 2, 175-190, 1991

$$r_t \quad \frac{(r_t^* - (\phi_1 + \phi_4 L^3) r_{t\ 1}^*}{w} \qquad (4.27)$$

The model of Fisher et al (1994) is used in many papers and in different forms. Stevenson (2000, 2004)[51] identifies the model of Fisher et al (1994) as the Full Information Model[52].

Extension 1

Unfortunately, the model represented by Fisher et al (1994) has a disadvantage that the error term e_t does not necessarily have an expectation zero, another disadvantage is that the series of returns show a strong positive autocorrelation. In order to solve these biases Cho et al (2003)[53] proposed a simple extension of the model of Fisher et al (1994). *The solution involves the use of generalized differences to alter the model into one in which the errors are independent. A constant term is then added to the model to control for omitted effects moving uniformly over time as well as potential spurious correlation of the expected return with time*[54].

Cho et al (2003) elaborates the generalized model as follows:

Equation 4.25 is subtracted from $r_{t-2}^* - \phi(L) r_{t-3}^* + e_{t-2}$, this results to:

$$\Delta r_t^* \quad \phi(L) r_{t\ 1}^* + \Delta e_t \qquad (4.28)$$

where $\Delta r_t^* = r_t^* - r_{t\ 2}^*$ and $\Delta e_t = e_t - e_{t-2} = w_0 (r_t - r_{t-2})$. Cho et al (2003) assumes that $r_t \approx \mu + r_{t\ 2} + \varepsilon_t$ or $r_t - r_{t\ 2} - \mu - \varepsilon_t$, where ε_t has a zero mean and variance σ_ε^2 and where ε_t is serially uncorrelated, therefore equation 4.28 becomes:

$$\Delta r_t^* - \mu' + \phi(L) r_{t\ 1}^* + \varepsilon_t' \qquad (4.29)$$

where $\mu' \quad w_0 \mu$ and $\varepsilon_t' \quad w_0 \varepsilon_t$ *a.*

By using generalized difference equation, instead of first difference equation, the issue of having $r_{t\ 1}$ on both side of equation 4.29 is avoided.

In the next subsection one more model will be discussed.

4.4.2 Unsmoothing in an inefficient market

As discussed earlier in chapter 2, real estate market also belongs to a weak or a full form of inefficient market. For that, Geltner (1991, 1993) developed an approach to unsmooth real estate series of returns, which avoids to make the assumptions of an efficient market. Stevenson (2000) refers to the model as the partial information model, on the other hand Fisher et al (1994) identifies the model as the market value. The model of Geltner (1993) is also used for unsmoothing other alternative asset classes. Conner (2003)[55] uses the model to unsmooth stale pricing[56]. Kat and Lu (2002)[57] and Kat and Palaro (2006)[58] use the

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[51] Stevenson S., International Real Estate Diversifivication: Empirical Tests using Hedged Indices, journal of real estate research, Vol. 19, Iss. 1, 105-131, 2000
Stevenson S., Testing the statistical significance of real estate in an international mixed asset portfolio, journal of property investment & finance, Vol. 22 Iss. 1, 11-24, 2004

[52] Because of the assumption of perfect market efficiency the model of Fisher et al (1994) is referred as a full information model.

[53] Cho H., Kawaguchi Y. and Shilling D. James, Unsmoothing Commercial Property Returns: A Rivision to Fisher-Geltner-Webb's Unsmoothing Methodology, journal of real estate finance and economics, Vol. 27, Iss. 3, 393-405, 2003

[54] Cho (2003)

[55] Conner A., The Asset Allocation Effects of Adjusting Alternative Assets for Stale Pricing, Research from SEI Investments, January 2003.

[56] According to Conner (2003) stale pricing shows a positive autocorrelation. This is also true for other alternative asset classes, such as private equity and hedge funds.

model for unsmoothing the observed returns of hedge funds. The model is also used by Campbell Koedijk and de Roon (2008)[59] to unsmooth emotional assets[60] in order to analyse the risk-return profile of the emotional assets.
So the model of Geltner (1993) is frequently used to analyse the risk and return profile of other asset classes. The unsmoothing technique of Geltner (1993) is identified as follows:

$$r_t = \frac{r_t^* - \alpha r_{t-1}^*}{1 - \alpha} \qquad (4.30)$$

.

where r_t^* is the smoothed return during period t, r_t is the corresponding unsmoothed return during period t, and α is the smoothed parameter between 0 and 1. Equation 4.30 is also referred as the "simplest reverse-engineering model" by Geltner et al (2007). In Geltner et al (2007) the smoothed factor α is related to the average lag in the appraisal series: with

$$\alpha = 1/(Lg - 1) \qquad (4.31)$$

where, Lg is the average number of periods of lag[61]. Thus in quarterly index, if the average lag is one year, then Lg = 4 and $\alpha = 0.2$. In an annual index, Lg = 1 and $\alpha = 0.5$. In addition to this model, Geltner et al (2007) mention another approach where they discuss the value of α. They cited the model as "the simple one step model". The simple one-step reverse-engineering model goes in a single step from an appraisal index of return to a transaction based index of return. The transaction based index return is an index return which reflects the expected sales prices within each period of time. The model is just like equation 4.30, but with $\alpha = 0.4$. However, this model can only be applied at yearly appreciation returns[62].

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[57] Kat M. Harry and Lu S., An Excursion Into The Statistical Properties of Hedge Fund Returns, , Alternative Investments Research Centre Working Paper Series, Working paper #0016, 2002
[58] Kat M. Harry and Palaro P. Helder, Replication and Evaluation of Fund of Hedge Funds Returns, Alternative Invetsment Research Centre Working Paper Series, Working paper #0028, 2006
[59] Campbell R.A.J., Koedijk C.G. and de Roon F.A., Emotional Assets, Social Science Research Network, Working Paper Series, 2008.
[60] Emotional assets are art, wine, stamps and watches which give the high net worth individual's investment into the luxury goods.
[61] Geltner et al (2007)
[62] Unfortunately, Geltner et al (2007) does not discuss on what reason the value of α is based on, therefore I had contact with Mr Geltner by e-mail to find out how the value of α is calibrated. He explained to me that the α value depends on several factors. However, the formula described at the end of section 4.5.2 (equation 4.31) gives a reasonable value for α. One can also use the autocorrelation at lag 1 for the value of α. In the case of the ROZ/IPD yearly series the autocorrelation at lag 1 is near to 0.5 (see figure 17). This gives the same result as equation 4.31. However it is well-advised to use α is 0.4. Section 5.5 discusses which α to use for the remainder of the research.

4.4.3 Which model to use

In the previous subsections the two major unsmoothing techniques are described so far. In table 3 the assumptions and the characteristics to both techniques, Full Informational Model and Simple Reverse Engineering Model, are described. The most important weakness of the Full Informational Model which is presented by Fisher et al. (1994) is the assumption of an efficient market. Recall from chapter 2, that the real estate market is indicated as a weakly efficient or moreover an inefficient market. The market inefficiency is also emphasised by Geltner et al. (2007), where the authors identify it as the informational inefficiency. They implicate that the direct real estate market is not as informational efficient as the public exchanges such as listed real estate and stocks. Informational inefficiency implies that the direct real estate moves slowly in response to the arrival of news (e.g. news with regard to real estate). This indicates that the value of direct real estate is more predictable in a weak or inefficient market. Through the predictability, investors in direct real estate have an opportunity for timing the market, in order to buy low and sell high.
But the predictability of the direct real estate market is not always valuable. It is difficult to buy or sell direct real estate in a short time horizon because the transaction costs in buying and selling direct real estate are very high. It is much greater than those in the securities market. A regular transaction costs in direct real estate are on the order of 5% to 10% of the asset value[63]. The transaction costs can be decreased by holding the direct real estate investment for a long period of time, this spreads out the transaction costs over many periods of return.

	Full Information Model	Simple Reverse Engineering Model
Assumptions	• Efficient Market • Unpredictable Returns • True volatility is half the volatility of the S&P500 Index	• Inefficient Market • Predictable true Returns
Characteristics	• Complex • After unsmoothing the data, it still consists biases (these biases are nevertheless solved by extending the model)	• Simple • After unsmoothing, the series of returns become zero-auto-correlated. • The choice of the smoothing factor α is not validated sufficiently

Table 3: Full Information Model versus Simple Reverse Engineering Model

Since the direct real estate has been considered as an inefficient market, the simplest reverse-engineering model will be used in the following chapters to unsmooth the Dutch direct real estate series of returns. Another reason is that the model is easy to use and it is also applied in other asset classes. Considering that the available historical real estate data is quarterly[64] as well as yearly, several values for the smoothed factor α will be used. The following table shows the values for the smoothed factor α that will be used in the coming chapters.

Smoothed factor α	Time Series
0.4	Yearly
0.5	Yearly

Table 4: Values for the smoothed factor

[63] Geltner et al. (2007)
[64] The quarterly series of returns covers only the period 2000-2007. Figure 15 in chapter 5 shows that there is not much movement in the time series which makes the time series impracticable to use in an asset-allocation. Because of this, the quarterly data will not be taken into account in the unsmoothing process. But then again the "smoothed" quarterly series will be analysed in the next chapter.

Chapter 5 Data Analysis for Real Estate

5.1 Introduction

In the following chapter the historical data of direct and indirect real estate will be analyzed. This chapter gives an answer to research question 5:

What does the risk profile of the real estate data look like?

In the next section the Dutch direct real estate index ROZ/IPD is discussed. After that the risk-return profile of ROZ/IPD index and the distribution of the series will be examined and the series of returns are tested for stationarity. In section 5.3 the ROZ/IPD return series is unsmoothed by using the model "Simplest Reverse Engineering Model". The market listed real estate funds are analyzed in section 5.4. This chapter ends with summarizing the findings.

5.2 ROZ/IPD Real Estate Index

In the late 70's the National Council of Real Estate Investment Fiduciaries (NCREIF) started recording the real estate information of the United States. In imitation of mentioned and the enthusiasm of the possibility to benchmark a Dutch real estate, 23 Dutch funds established to create together a databank with information on Dutch real estate. According to that, the foundation Raad voor Onroerende Zaken (ROZ) real estate index has been found. In 1995 ROZ collaborated with Investment Property Databank (IPD) and since then ROZ/IPD index has been distributed the Dutch real estate market index. The goal of the ROZ/IPD real estate index is to publish an independent index for direct real estate with an institutional character and it makes possible to:

- Give an objective evaluation of the performances of a real estate fund.
- Make a comparison of the performances between real estate and other asset classes.
- Create a transparency of the real estate market.
- Setup time series.
- Do an academic research on real estate as an asset class.

As discussed in chapter 2 the real estate market is divided in commercial and non-commercial real estate. ROZ/IPD distinguishes real estate in: office, residential, retail and industrial. Initially the direct real estate returns were reported yearly, as of 2000 the reports are published quarterly. Hordijk, de Kroon and Theebe (2004)[65] established to back-track the series of returns, with statistical techniques, to the year 1978 (yearly returns). This way the real estate series of returns are long enough to perform a reliable performance study on the real estate market. By way of comparison: internationally there are only two more real estate markets which have long series of returns. One of them is the Russell- NCREIF Index which reports since 1975 real estate returns in the United States. Furthermore, the performance of the British real estate market has been reported since 1985 by the IPD Index. The studies on unsmoothing techniques are mostly based on the United States and the British real estate returns. However the same techniques can be used for the Dutch real estate market. Section 5.3 will continue into the unsmoothing techniques for the ROZ/IPD Index. For now the smoothed series will be discussed. First the quarterly ROZ/IPD index data will be analyzed subsequently the extended data of Hordijk et al (2004) combined with the data provided from Ortec, named as Ortec series.

[65] Hordijk C. Aart, de Kroon M. Harry and Theebe A.J. Marcel, Long-run Return Series for the European Continent: 25 Years of Dutch Commercial Real Estate, journal of real estate portfolio management, Vol. 10, Iss. 3, 217-230, 2004

5.2.1 Construction of the ROZ/IPD Index

The benchmark of ROZ/IPD real estate index includes capital return (indirect return) and income return (direct return). To determine the capital growth in a transparent way, ROZ/IPD formulates[66] specific appraisal guidelines for the participating parties. The value of a property will be registered at regular basis by an independent appraiser. The capital return is determined with the following formula:

$$CVG_t = \frac{CV_t - CV_{t-1} - Cex_t - Crec_t}{CV_{t-1} + Cex_t} \quad (5.1)$$

where

CVG_t = Capital Growth (indirect return) at time *t*.
CV = Capital Value
Cex = Capital Expenditure
$Crec$ = Capital Receipts

The income return of ROZ/IPD real estate index consists of rental income during a specific period and it is determined as follows:

$$IR_t = \frac{NI_t}{CV_{t-1} + Cex_t} \quad (5.2)$$

where

IR Income returns (direct return)
NI Net Income
CV Capital Value
Cex = Capital Expenditure

5.2.2 Risk & Return of the ROZ/IPD Index

In the following figures the quarterly indirect and direct returns of the ROZ/IPD index are presented[67].

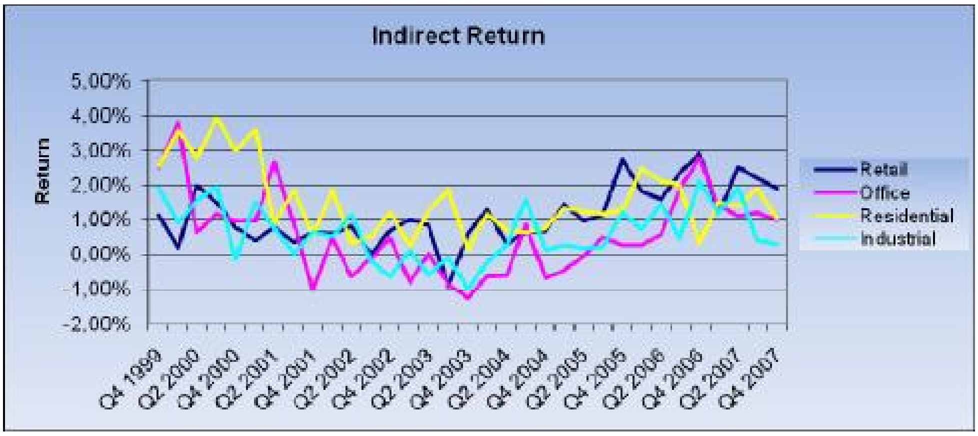


Figure 12: ROZ/IPD Index Indirect Return (Retail, Office, Residential and Industrial) 2000-2008

[66] www.rozindex.nl/documentatie visited at 3 April 2008.
[67] The returns are obtainable from www.rozindex.nl/indices_kwartaalindex.htm visited on 27th of February 2008.

Figure 13: ROZ/IPD Index Direct Return (Retail, Office, Residential and Industrial) 2000-2008

The figures illustrates a clear volatility in the indirect returns for all the sectors. For the direct return, one can see the income return is stable, as a consequence of the long-term lease agreement which is associated with the development of inflation. The direct return of the category industrial jumps between the rest of the sectors. The year 2006 shows a bell-shape for the industrial whereas in the 1st half of 2006 an increase appear and the 2nd half a decrease. However the increasing and the decreasing factors are very small.

In the figure below the total return is demonstrated. The total return contains the direct return and indirect return. Because of the stable direct return, figure 13 has almost no influence on the volatility of the sectors.

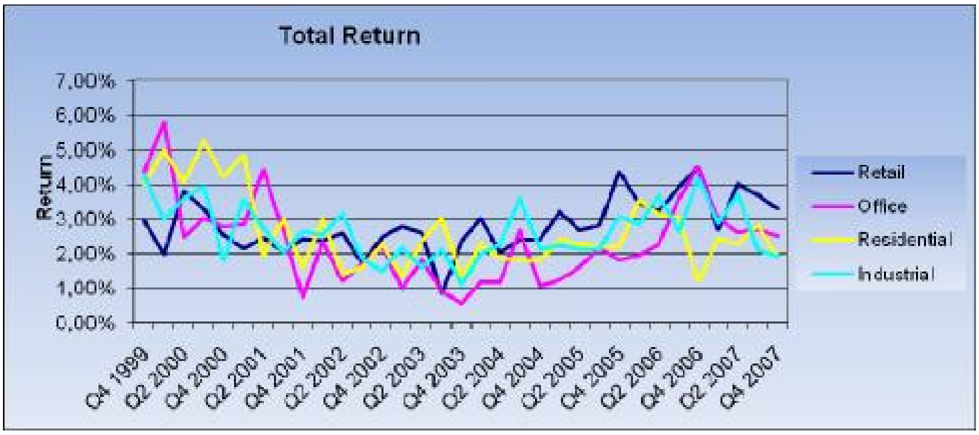


Figure 14: ROZ/IPD Index Total Return (Retail, Office, Residential and Industrial) 2000-2008

Next to the quaterly index, figure 15 shows the yearly extended index return that is provided from Ortec and from ROZ/IPD. One can see that the returns slightly differ from each other.

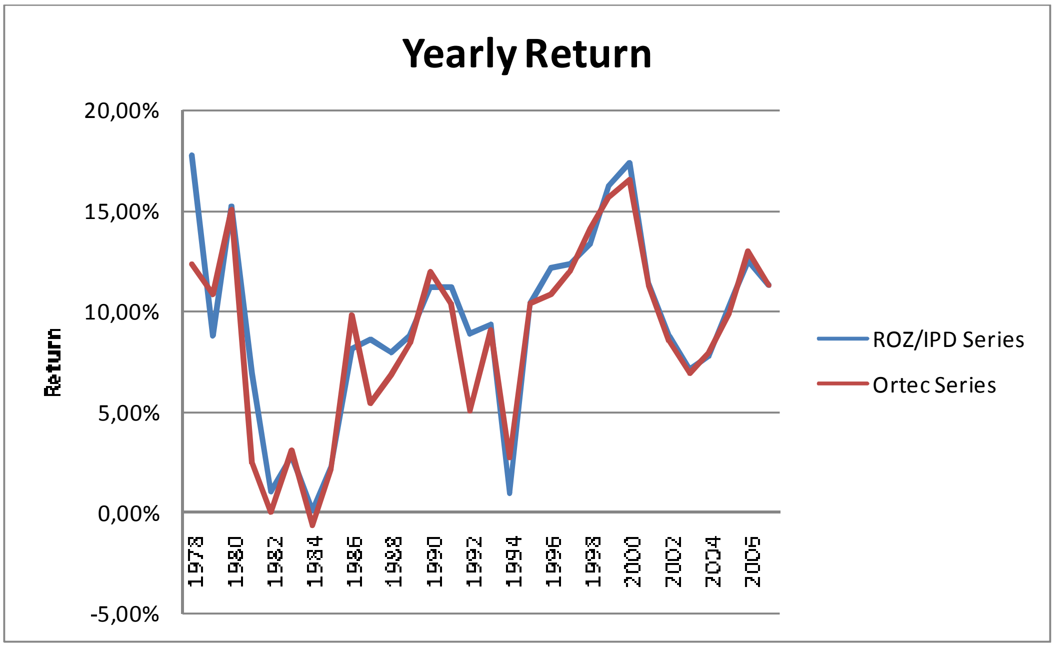


Figure 15: Annual return of direct real estate 1978-2007

The figure shows that the returns of the Ortec series are more volatile in the period 1987 till 1995. In the period 1978 till 1987 and the period 1999 till 2007 the returns of the Ortec and ROZ/IPD series have the same trend. The difference can be clarified that Ortec used a different kind of statistical technique to extend the historical data. The return and the volatility of the yearly and the quarterly (annualized) index return are given in table 5.

Time Series of Returns	Total Return	Total Volatility	Sharpe Ratio++
Retail*	11,27%	1,58%	4,42
Office*	9,29%	2,41%	2,07
Residential*	10,54%	2,20%	2,84
Industrial*	10,53%	1,66%	3,76
All Property*+	10,75%	1,26%	5,13
Ortec Series**	8,75%	4,59%	0,97
ROZ/IPD series**	9,34%	4,57%	1,10

*Annualized Return & Volatility period 1999-2007
**Extended Return & Volatility period 1978-2007
+All property is an aggregate of retail, office residential and industrial.
++Risk-free rate is 4,29%

Table 5: Return & Volatility ROZ/IPD index

It is remarkable to see in table 5 that retail has the highest total return with the lowest volatility comparison to other sectors. One of the reasons of the high return of retail is the rise of the rental fees in the period 1999-2007. The increasing interest to invest in retail also has an impact on the risk-return relation. Many institutional investors (e.g. pensionfunds and insurers) has been expanding their investments in retail. The main reason for this, is they expect an increase in the retail segment. On the other hand investors invest less in Office because of the strongly increased vacancies in office. This negative view can also be seen in table 5 in which Office has the lowest total returns with the highest total volatility comperison to other sectors.

As discussed in the introduction of this paper, table 5 shows that the volatility of the sectors are extremly low in relation to what you will expect with the corresponding return. This indeed indicates that the series are smoothed, as a result the Sharpe Ratio with a risk-free rate of 4.29% gives a misrepresented view of the performance of the sectors. Regardless of the smoothing, the lack of data of direct real estate also has an influence on the inaccurate result of the performances. Fortunately, the issue of lack of historical data is partialy solved by Hordijk et al (2004), by extending the historical data of direct real estate to the year 1978. Table 5 also shows the return and volatility of the extended yearly series. It can be seen that extended yearly series are much volatile than the quaterly (annualized) series in the period between 1999-2007. The reason for this is that the extended returns partialy represents real estate trancation prices[68]. Furthermore, the return and volatility of the extended ROZ/IPD series differ from the extended Ortec series but the difference is not signifigant high which is therefore neglegible. The series contructed by ROZ/IPD have in some degree higher return with a lower volatility.

5.2.3 Optimal Property Allocation

The following table shows the correlation matrix between the sectors. As expected the commercial real estate, that is retail, office and industrial, are positively correlated with each other. Retail has a correlation of 0.4297 with industrial and 0.238 with office . Whereas the noncommercial real estate, residential, has a negative correlation of -0.012 with retail. But residential has unexpectedly positive correlation of 0.485 and 0.364 with respectively office and industrial.

Correlation Matrix	Retail	Office	Residential	Industrial
Retail	1			
Office	0,238	1		
Residential	-0,012	0,485	1	
Industrial	0,429	0,517	0,364	1

Table 6: Correlation matrix total return ROZ/IPD index

The correlations introduced in table 6 are used to find an optimal property allocation. This is done by means of Markowitz's portfolio theory[69]. Table below shows the perfomances of the optimum portfolio and the equal weighted portfolio. The performances of the two portfolios slightly differ from each other. As expected retail has the highest weight when allocating by optimum portfolio and office only 8% of the allocation. A marginal comment on the use of the Markowitz's framework is the assumption of normality of the different sectors[70]. Hence, the distrubution of the sectors and the distribution of the extended yearly series will be analysed in the coming sections.

	Optimum Portfolio	Equally Weighted
Retail	43%	25%
Office	8%	25%
Residential	20%	25%
Industrial	29%	25%
Exp Return	10,74%	10,41%
Volatility	1,12%	1,22%
SR*	5,76	5,02

*Riskfree rate is 4,29%

Table 7: Optimum property allocation

[68] Hordijk et al. (2004)
[69] Excel (solver) is used for the determination of the optimum asset allocation
[70] Section 5.4.2 concludes that the real estate series (for all sectors) are 95% significant normally distributed

5.2.4 Distribution Analysis of Direct Real Estate

For examining the distribution of the return series for real estate, the Shapiro-Wilk (SW) and the Jarque-Bera (JB) test statistic are used. The SW test is more often used for small (<30) sample sizes, but the test is also representative for large sample sizes. Shapiro and Wilk (1965)[71] show in their article that the test statistic is an effective measure of normality, even for samples smaller than 20. On the other hand the JB test statistics is more often used for large[72] sample sizes. The following table shows the test statistics SW of testing[73] for normality in return distribution of the real estate series.

	Tests for Normality (Shapiro-Wilk)				Confidence level is 95%			
	Statistic		p Value		Skewness	Kurtosis	Normal Distr.	Sample size
Retail*	**W**	0,96912	**Pr < W**	0,4563	0,1617	0,3861	yes	33
Office*	**W**	0,93271	**Pr < W**	0,0418	0,9191	0,9401	no	33
Residential*	**W**	0,91031	**Pr < W**	0,0100	0,9093	0,0635	no	33
Industrial*	**W**	0,95252	**Pr < W**	0,1575	0,3833	-0,7629	yes	33
All Property*	**W**	0,958081	**Pr < W**	0,228	0,2312	-0,8871	yes	33
Ortec Series**	**W**	0,961741	**Pr < W**	0,3429	-0,4331	-0,5143	yes	30
ROZ/IPD series**	**W**	0,951009	**Pr < W**	0,1799	-0,3202	-0,0566	yes	30

* Quaterly period 1999-2007
** Extended Yearly period 1978-2007

Table 8: Tests[74] for Normality in Real Estate Return Distribution

The null hypothesis of the SW test is that the return series are normally distributed. The Pr < W value listed in table 8 is the p-value. The null hypothesis is rejected for Pr < 0.05. According to the SW, the null hypothesis of normal distribution cannot be rejected for retail, industrial, all property and both the extended yearly series. In appendix III the Q-Q plot[75] and the histogram of both the quarterly and the yearly return series of the real estate can be viewed. One can see in Appendix III that the Q-Q plot for all the series has a non-normal distribution. However, for a normal distribution, the excess kurtosis and the skewness both should be zero. Which can be seen in table 8, none of the series has that feature. Retail, office and Residential show a positive excess kurtosis which indicates more weight in both tails of the distribution than in the normal distribution. Distributions with positive kurtosis are also called leptokurtic or fat-tailed distributions. Next to it, office and residential have a high positive skewness. This can also be seen from the histogram in appendix III, where the distribution is right skewed. On the other hand the extended yearly return series show a negative (left) skewness.

In addition to SW test a JB test is carried out. JB is a test statistic for testing whether the series is normally distributed. The test statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution. The JB statistic is computed as:

$$JB = \frac{N}{6}\left(S^2 + \frac{(K)^2}{4} \right) \qquad (5.3)$$

with N the number of observations, S the skewness and K the Kurtosis.

[71] Shapiro S.S. and Wilk M.B., An Analysis of Variance Test for Normality (Complete Samples), Biometrika, Vol. 52, No. ¾, pp. 591-611, December 1965.
[72] It is not clear what the minimum sample size has to be, of the JB test statistics. EViews illustrates an example of JB test statistics were the sample size is 25. It is also discussed that the Central Limit Theorem (CLT) holds for large sample sizes. The CLT states that the sum of large number of independent and identically distributed random variables will be approximately normally distributed if the random variables have a finite variance. http://en.wikipedia.org/wiki/central_limi_theorem.
[73] The significance level alpha is chosen to be 0.05.
[74] The tests for SW are done in the software programme "Statistical Analysis System" (SAS).
[75] Q-Q plot is a graphical technique to check the distribution of a given variable to the normal distribution (represented by a straight line).

The table below shows the test statistics (JB) for testing of the non-normality in return distribution of each sector.

Tests for Non-Normality (Jarque-Bera)# Test	Statistic	p Value	Normal Distr.	Sample Size
Retail*	0,163251	0,921617	yes	33
Office*	4,768859	0,092142	yes	33
Residential*	4,158549	0,125021	yes	33
Industrial*	1,679271	0,431868	yes	33
All Property*	1,469004	0,479744	yes	33
Ortec Series**	1,335052	0,512976	yes	30
ROZ/IPD series**	0,534998	0,765291	yes	30

* Quaterly period 1999-2007
** Extended Yearly period 1978-2007
#Critical value is 5,99 for a confidence level of 95%.
The normality test is rejected when the statistic is hihger than the critical value

Table 9: Tests[76] for non-normality in Quarterly Return Distribution

Under the null hypothesis of a normal distribution the JB statistics is distributed as χ^2 with 2 degrees of freedom, which gives a critical value of 5.99 for a confidence level of 95%. According to the JB test, the null-hypothesis will be rejected, while the probability that a JB statistic exceeds (in absolute value) the observed value under the null-hypothesis, is (very close to) zero. A small probability value leads to the rejection of the null hypothesis of a normal distribution. Moreover, null hypothesis that the series is normally distributed will be rejected when the statistic is larger than the critical value. From the JB test, it is deduced that the hypothesis of normal distribution for all quarterly and both extended yearly series cannot be rejected.

5.2.5 Stationarity & Autocorrelation of Direct Real Estate

The Dickey-Fuller unit root test[77], which is mentioned in section 4.4.1, is used to test the stationarity of the direct real estate series of returns. On the whole sample, only one rejections of the $H_0 : \alpha \quad 1$ (Non stationary) hypothesis at the 10% significance level have been detected; that is the quarterly return series of the sector Office (table 10). This means, that none of the direct real estate data sets are stationary (with the exception of office).

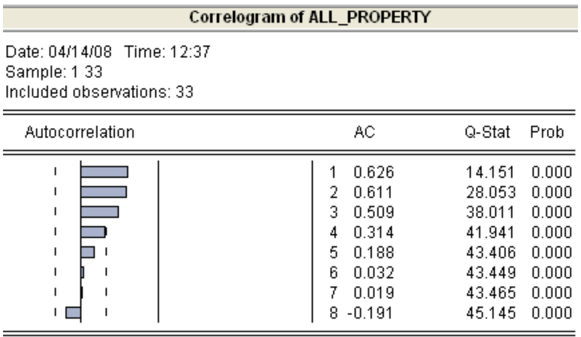
Null Hypothesis: TIME SERIES has a unit root**			Test Critical Values*		
Dickey-Fuller test statistic	**t-Statistic**	**Prob.**	**1%**	**5%**	**10%**
Retail	0,268	0,757	Acc.	Acc.	Acc.
Office	-1,659	0,091	Acc.	Acc.	Rej.
Residential	-1,524	0,118	Acc.	Acc.	Acc.
Industrial	-1,030	0,266	Acc.	Acc.	Acc.
All Property	-0,706	0,403	Acc.	Acc.	Acc.
ROZ/IPD Series	-1,524	0,118	Acc.	Acc.	Acc.
Ortec Series	-1,232	0,195	Acc.	Acc.	Acc.

* The critical values for 1%, 5% and 10% are respectively -2,64712; -1,95291 and -1,61001
** The Null Hypothesis is rejected when the t-statistics is smaller than the critical value.

Table 10: Stationarity test for the direct real estate return series

[76] The tests for JB are done in the software programme "EViews".
[77] The DF unit root tests are done in "EViews".

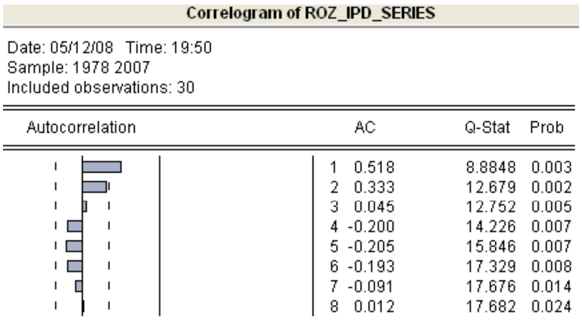
The autocorrelation of the real estate data set is detected by using the Box-Pierce test statistics in order to determine which lag autocorrelation is presented in the direct real estate series of returns. The correlogram of the real estate sectors (retail, office, residential and industrial) are given in appendix IV. It shows that almost all the sectors (with the exception of industrial) have at least an autocorrelation at lag 1. Furthermore residential also has a lag 2 correlation. The correlogram of 'all property', extended ROZ/IPD and the extended Ortec series are given in the figures below. The series of all property show an autocorrelation at lags one, two and three. Next to it, the correlogram of the ROZ/IPD and Ortec series, both represent an autocorrelation at lag 1. The solution of these biases is discussed in the next section.


Correlogram of ALL_PROPERTY

Date: 04/14/08 Time: 12:37
Sample: 1 33
Included observations: 33

Lag	AC	Q-Stat	Prob
1	0.626	14.151	0.000
2	0.611	28.053	0.000
3	0.509	38.011	0.000
4	0.314	41.941	0.000
5	0.188	43.406	0.000
6	0.032	43.449	0.000
7	0.019	43.465	0.000
8	-0.191	45.145	0.000

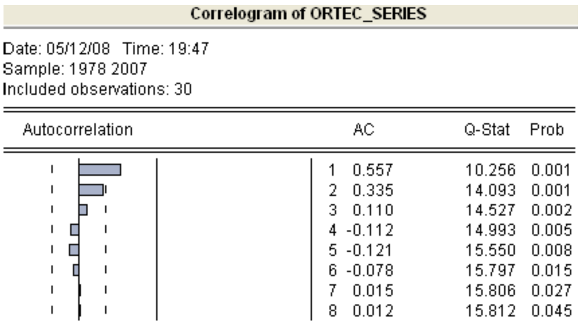
Figure 16: Correlogram of All Property


Correlogram of ROZ_IPD_SERIES

Date: 05/12/08 Time: 19:50
Sample: 1978 2007
Included observations: 30

Lag	AC	Q-Stat	Prob
1	0.518	8.8848	0.003
2	0.333	12.679	0.002
3	0.045	12.752	0.005
4	-0.200	14.226	0.007
5	-0.205	15.846	0.007
6	-0.193	17.329	0.008
7	-0.091	17.676	0.014
8	0.012	17.682	0.024

Figure 17: Correlogram ROZ/IPD Series


Correlogram of ORTEC_SERIES

Date: 05/12/08 Time: 19:47
Sample: 1978 2007
Included observations: 30

Lag	AC	Q-Stat	Prob
1	0.557	10.256	0.001
2	0.335	14.093	0.001
3	0.110	14.527	0.002
4	-0.112	14.993	0.005
5	-0.121	15.550	0.008
6	-0.078	15.797	0.015
7	0.015	15.806	0.027
8	0.012	15.812	0.045

Figure 18: Correlogram Ortec Series

5.3 Unsmoothed Real Estate Series

In this subsection the unsmoothed series will be analysed. The unsmoothed series only consist of the yearly time series: ROZ/IPD and Ortec series. This is done because the quarterly data is not representative[78] to be used in the asset-allocation in the following chapters.

5.3.1 Risk & Return of the Unsmoothed Series

The simple reverse engineering model[79] is used to unsmooth the direct real estate return series. The model is expressed as $r_t = \frac{r_t^* - \alpha r_{t-1}^*}{1-\alpha}$. The unsmoothed series for the ROZ/IPD and the Ortec series are given in the figures below. Both figures show that the unsmoothed series are more volatile than the "smoothed" series.

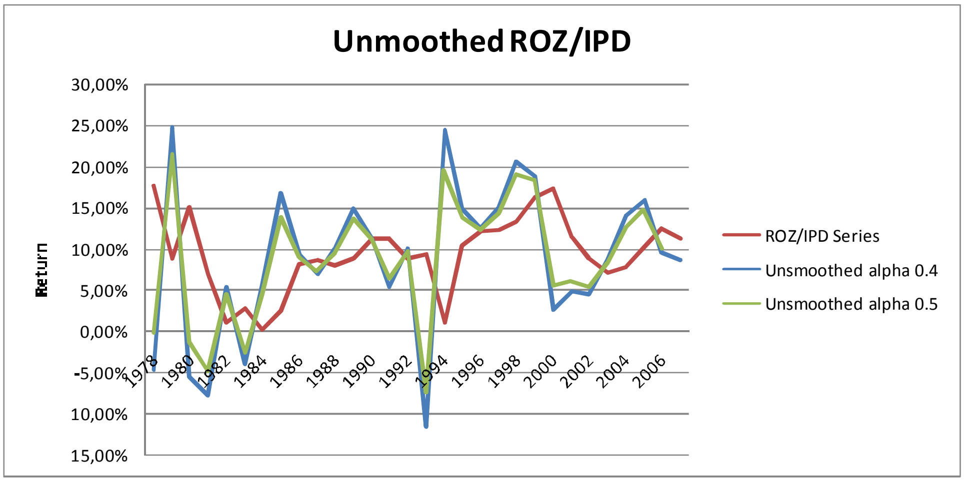


Figure 19: Unsmoothed ROZ/IPD yearly returns series

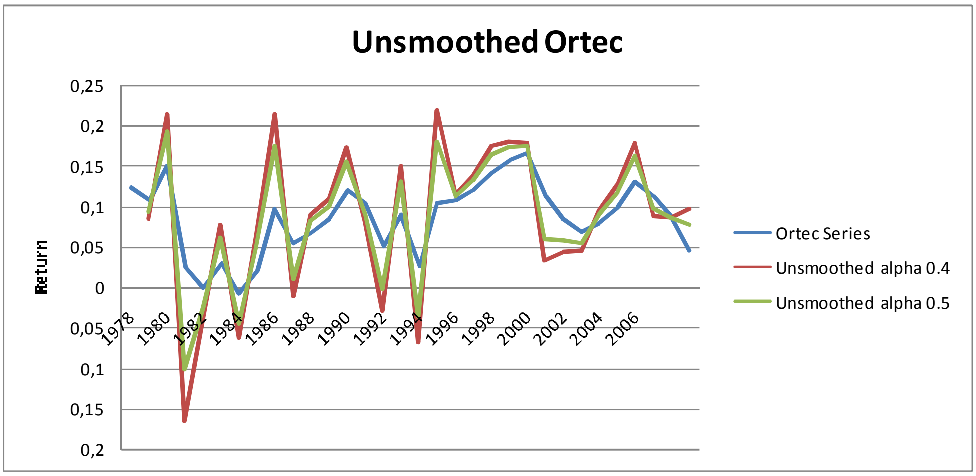


Figure 20: Unsmoothed Ortec yearly returns

[78] The quarterly series of returns only cover the period 2000-2007. Figure 15 shows that there is not much movement in the time series which makes the time series impracticable to use in an asset-allocation.
[79] The model is discussed in chapter 4.

The return and the volatility of the unsmoothed series are given in the table below.

Series 1978-2007	Return	Volatility	Sharpe Ratio*
Ortec	8,75%	4,59%	0,97
ROZ/IPD	9,34%	4,57%	1,10
Unsm Ortec 0.4	8,57%	9,71%	0,44
Unsm Ortec 0.5	8,56%	7,78%	0,55
Unsm ROZ/IPD 0.4	8,72%	9,15%	0,48
Unsm ROZ/IPD 0.5	8,83%	7,29%	0,62

* Risk-free rate is 4,29%

Table 11: Return & Volatility of the unsmoothed direct real estate series

The returns of the unsmoothed series are slightly smaller than the "smoothed" series; on the other hand the volatility is doubled in comparison with the "smoothed" series, as a result the Sharpe Ratio is reduced by factor 0.5. The volatility of the unsmoothed series which are unsmoothed with α is 0.4, are higher in comparison with α is 0.5, this was already observed in the figures 19 and 20.

5.3.2 Distribution analyses of the Unsmoothed Series

The same as section 5.2.4, the normality tests for the unsmoothed series are tested with the SW and JB test statistics. Reminding the null hypothesis for both the SW and JB test is that the unsmoothed return series are normally distributed.

	Tests for Normality (Shapiro-Wilk)				Confidence level is 95%			
	Statistic		p Value		Skewness	Kurtosis	Normal Distr.	Sample size
ROZ/IPD series 0.4	W	0,967822	Pr < W	0,5022	-0,4049	-0,1513	yes	29
ROZ/IPD series 0.5	W	0,971613	Pr < W	0,6042	-0,4156	-0,1883	yes	29
Ortec Series 0.4	W	0,946044	Pr < W	0,1444	-0,7356	0,2481	yes	29
Ortec Series 0.5	W	0,943743	Pr < W	0,1257	-0,6720	-0,1116	yes	29

Table 12: Tests for normality in unsmoothed real estate return distribution

Tests for Non-Normality (Jarque-Bera) Test	Statistic	p Value	Normal Distr.	Sample Size
ROZ/IPD series 0.4	0,840318	0,656942	yes	29
ROZ/IPD series 0.5	0,9037	0,63645	yes	29
Ortec Series 0.4	2,347798	0,309159	yes	29
Ortec Series 0.5	2,063345	0,35641	yes	29

Table 13: Tests[80] for non-normality in unsmoothed real estate return distribution

According to SW and JB the hypothesis of normality cannot be rejected for all the series with a confidence level of 95%. In appendix V the Q-Q plot and the histogram for the unsmoothed series are given. It shows that none of the unsmoothed series are normally distributed. This can also be viewed from table 12 in which the unsmoothed series show a negative skewness.

[80] The confidence level of the test is 95%, the critical value of this confidence is 5.99. The hypothesis is rejected when the test statistic is higher than the critical value.

5.3.3 Stationarity & Autocorrelation of the Unsmoothed Series

The result of the stationarity test for both unsmoothed series is given in table 14. The hypothesis of having a unit root at 10% significance level is rejected for the unsmoothed ROZ/IPD series with the smoothed factor α is 0.4 and for both unsmoothed Ortec series. At 5% significance level only the unsmoothed Ortec series with the smoothed factor α is 0.4 is rejected. This means that the unsmoothed Ortec series is significantly more stationary than the unsmoothed ROZ/IPD series. But one have to observe that the t-statistic of ROZ/IPD series with α is 0.4 is close to the critical value of 5% significance level. The critical value for 5% significance level is -1.95291 whereas the t-statistic of the ROZ/IPD series is -1.793. This minor difference can be vital to make a choice of the unsmoothed series to use it in the asset allocation. This will be discussed in section 5.6.

Null Hypothesis: TIME SERIES has a unit root**			**Test Critical Values***		
Dickey-Fuller test statistic	**t-Statistic**	**Prob.**	**1%**	**5%**	**10%**
ROZ/IPD Series 0.4	-1,793	0,070	Acc.	Acc.	Rej.
ROZ/IPD Series 0.5	-1,514	0,120	Acc.	Acc.	Acc.
Orte Series 0.4	-2,035	0,042	Acc.	Rej.	Rej.
Ortec Series 0.5	-1,698	0,084	Acc.	Acc.	Rej.

* The critical values for 1%, 5% and 10% are respectively -2,64712; -1,95291 and -1,61001

** The Null Hypothesis is rejected when the t-statistics is smaller than the critical value.

Table 14: Stationarity test for the unsmoothed direct real estate return series

The results for testing the time dependency of the unsmoothed series are given in the figures below. As expected none of the unsmoothed series shows any autocorrelation.

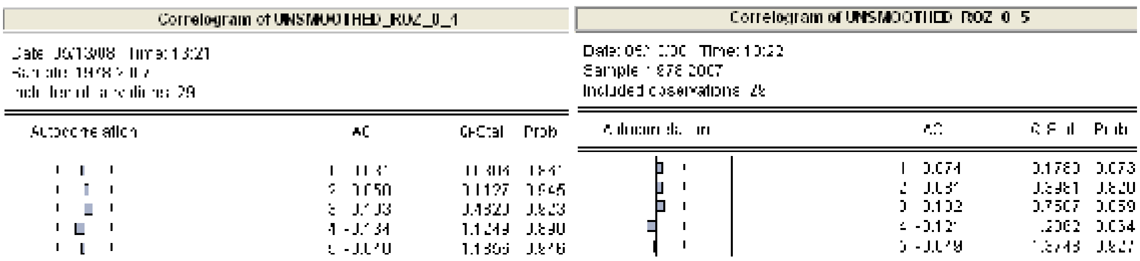


Figure 21: Correlogram of the unsmoothed yearly ROZ/IPD series

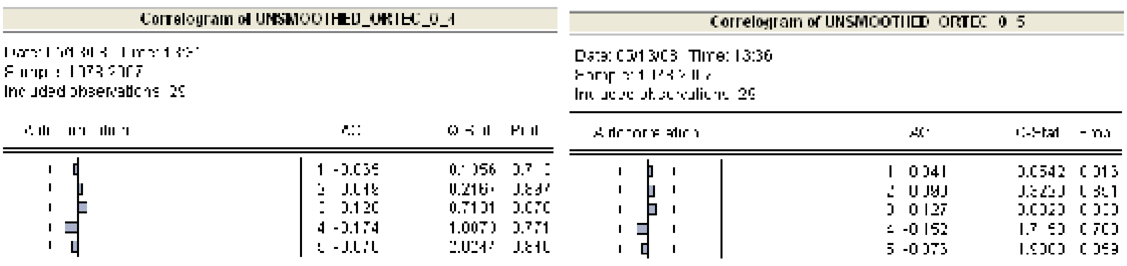


Figure 22: Correlogram of the unsmoothed yearly Ortec series

5.4 Market Listed Real Estate

5.4.1 Which listed return series to use in the asset allocation process

Until further notice, for listed real estate data analysis, the General Property Research (GPR) 250 Index and GPR Index Netherlands[81] will be used. Wereldhaven, Corio, Vastned Retail and Office/Industrial equities also proceed further in the analysis[82]. These indices and equities reflect the performances of among others the Dutch real estate markets. The following figure shows how the equities represent the several sectors. The proportion in the Dutch real estate market of the equities is given in table 15.

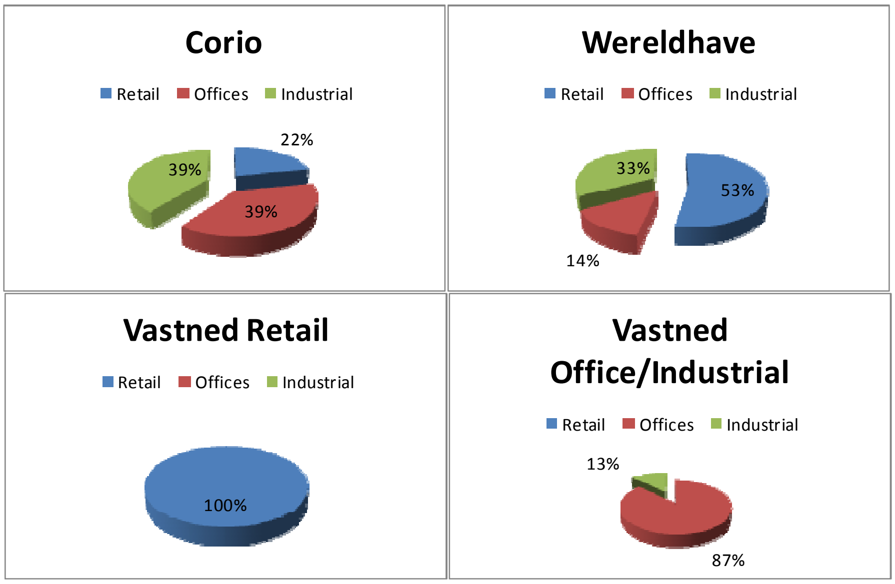


Figure 23: Segmentation to retail, office and industrial of the equities

Equity	% in Netherlands
Wereldhave	16%
Corio	58%
Vastned Office/Industrial	50%
Vastned Retail	36%

Table 15: Proportion of Dutch Assets by Fund

For both indices and equities, the observation rang from 31-01-1990 till 31-12-2007 and data[83] consists of end-of-the-month quotes. The value indices and equities are based on total return calculations. The components of total return are price return and dividend return. Dividends are included in the index at the ex-dividend date. The historical chart of the indices and equities is given in figure 24. The indices GPR 250 Index and GPR Index Netherlands have the same trend movements which GPR Index Netherlands outperforms GPR 250 Index. From the four equities, Corio has the best performance in the period of 1990

[81] The GPR 250 Index consists of the 250 most liquid property companies worldwide and only uses the tradable market capitalization of these companies as index weights. The index reflects on the performance of property companies with a free float market capitalization of more than 50 million US dollars. The index is calculated on a daily basis and the constituents are revised each quarter. The GPR Index Netherlands is a sub-index of the GPR General Index. The GPR General Index reflects on the performance of the full global universe of property companies. Both indices are constructed on a total return basis. Used source: www.propertyshares.com and Bloomberg.

[82] The return of the indices and equities represents the total return which the dividend payments are incorporated.

[83] The historical data (last traded prices) was downloaded from Bloomberg.

till 2008. Figure 24 also gives a clear picture of the beginning of the sub-prime crises. The figure drops at the end of March 2007, the indices drops further than the equities.

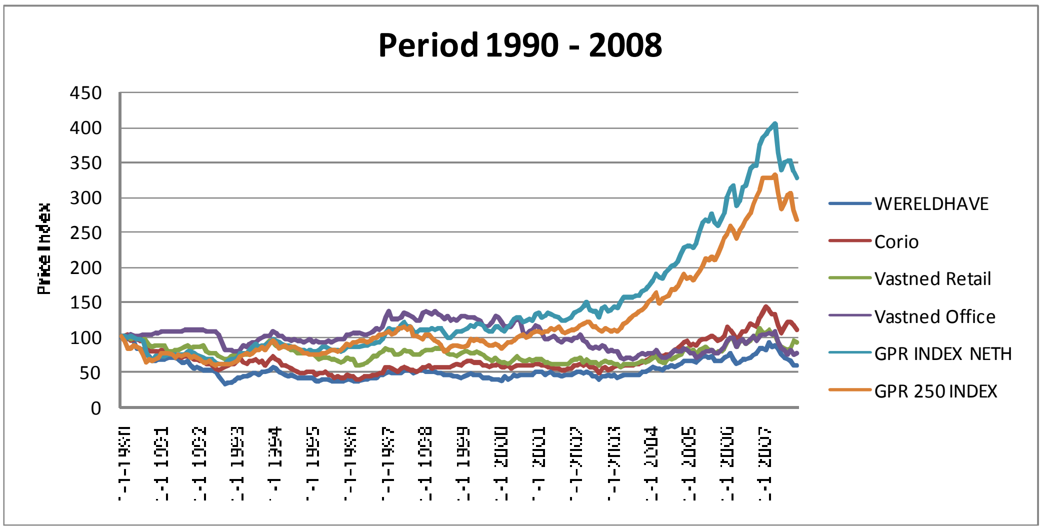


Figure 24: Historical chart of the indices and equities

The historical performances, the correlation matrix of the indices and equities are given in the tables below. The equities Wereldhave and Vastned Office/Industrial have a negative annualized return, for Corio and Vastned Retail a positive annualized return. Table 16 also shows that GPR Index Netherlands outperforms GPR 250 Index which was already observed in figure 24.

Equity Indices	Return*	Volatility	Sharpe Ratio**
Wereldhave	-1,16%	18,22%	-0,30
Corio	1,97%	16,89%	-0,14
VastNed Ret	0,70%	14,78%	-0,24
VastNed Off/Ind	-0,25%	16,02%	-0,28
GPR Index Neth	7,51%	13,10%	0,25
GPR 250 Index	6,59%	14,30%	0,16

* Annualized Return & Volatility
** Rsik-free rate is 4,29%

Table 16: Annualized Return & Volatility of the Listed Real Estate Indices and Equity

From the correlation matrix below it can be seen that GPR Index Netherlands is to a great extend positively correlated with the equities. As expected GPR Index Netherlands is also correlated positively with GPR 250 Index with a correlation of 0.515.

Because of the significantly high correlation between GPR Index Netherlands and the listed real estate equities, also the belief that GPR Index Netherlands covers the property performances of the Dutch region properly. The GPR Index Netherlands will only be used for further analysis and for the asset allocation in the coming sections and chapters.

Correlation matrix	Corio	Vastned Retail	Vastned Off/Ind	Wereldhave	GPR Index Neth.	GPR 250 Index
Corio	1	0,479	0,321	0,391	0,657	0,354
Vastned Retail		1	0,496	0,449	0,509	0,222
Vastned Off/Ind			1	0,459	0,409	0,271
Wereldhave				1	0,569	0,387
GPR Index Neth.					1	0,515
GPR 250 Index						1

Table 17: Correlation matrix of the listed real estate indices and equity

5.4.2 GPR Index Netherlands versus Stock Index

Chapter 2 stated that the listed real estate has the same characteristics as the stock market. To find out if this statement is correct, this sub-section analyse the GPR Index Netherlands, the Euronext-AEX index and the MCSI Europe. The AEX index is made up of the 25 most active[84] securities in the Netherlands. This index provides a fair representation of the Dutch Economy under which the property market. Corio and Unibail-Rodamco are the two equities which represents the real estate sector in the AEX index.
The MSCI Europe index stands for, Morgan Stanley Capital International Europe index and is a free float-adjusted market capitalization index that is designed to measure developed market equity performances in Europe[85]. The MSCI Europe index consists of among others the Dutch market indices. The return observation for the AEX and the MSCI Europe index rang from 31-01-1990 till 31-12-2007 and the data[86] consists of end-of-the-month quotes. The historical prices for the GPR Index Netherlands, AEX and MSCI Europe index are given in the figure below. The AEX and the MSCI Europe index have in a great extend the same movements. In the period of the year 1993-2003 the AEX and the MSCI Europe have a more variation in the prices in comparison with GPR Index Netherlands. It can be seen that the dropping point for both indices were at the end of the year 2000 but from September 2001 it dropped with a huge amount. This was the consequence of the 9/11 attacks. It is remarkable to see that GPR Index Netherlands is not touched by the 9/11 attacks, a reason for this could be the rentals for the buildings has to be paid in any matter[87].

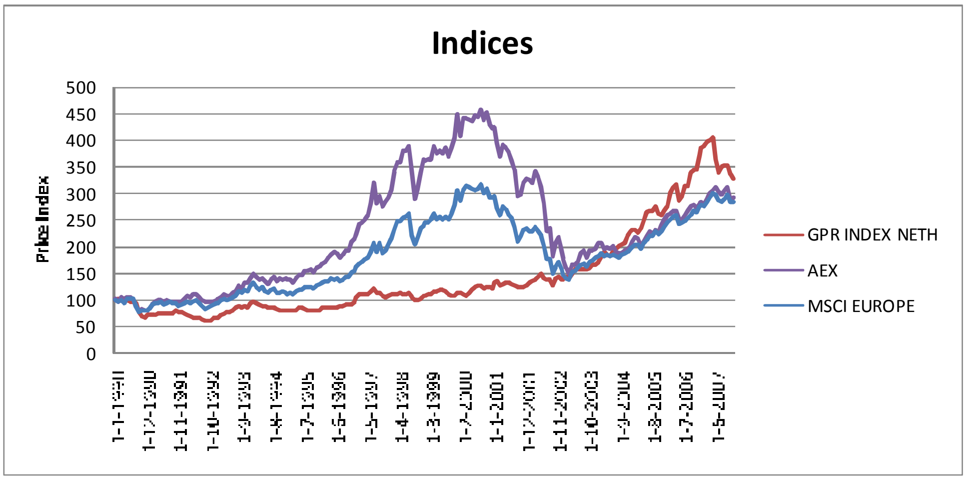


Figure 25: Historical chart listed real estate index versus market index.

[84] At the date of visiting the website the AEX index were composed of 23 stocks. www.euronext.com is visited on 19th of May 2008.
[85] See www.yourdictionary.com for the finance definition of MSCI Europe Index. The website is accessed on 19th of May 2008.
[86] The historical data (prices) for the AEX and the MSCI Europe index were downloaded from Bloomberg.
[87] Section 5.3 discussed that the return of a real estate consists of direct and indirect return whereas the direct returns is the rental fees.

The risk and the return of the indices and the correlation matrix are given in table 18 and table 19. In table 19 it is observed that the AEX index has a strong correlation with MSCI Europe.

Indices	Return*	Volatility	Sharpe Ratio**
AEX	7,84%	18,93%	0,19
MSCI Europe	7,05%	15,38%	0,18
GPR Index Neth	7,51%	13,10%	0,25

* Annualized Return & Volatility

** Risk-free rate is 4,29% Annualized Return & Volatility

Table 18: Annualized Return & Volatility of GPR Index, AEX and MSCI Europe

Correlation matrix	AEX	MSCI Europe	GPR Index Neth
AEX	1	0,916	0,430
MSCI Europe		1	0,470
GPR Index Neth			1

Table 19: Correlation matrix of GPR Index, AEX and MSCI Europe

5.4.3 Distribution, Stationarity & Autocorrelation

In this section the standard hypothesis are tested for the indirect real estate time series. For all the series, normality distribution is rejected at 95% significance level. Also the hypothesis that the series are non-stationary is rejected at 99% significance level. From the correlogram (appendix VI), it is observed that the GPR Index Netherlands shows a lag 1 autocorrelation. The other indirect real estate series show a zero autocorrelation. It can be concluded that the indirect real estate series is accurate to use it in an asset allocation process.

Indices	Skewness	Kurtosis	JB test	Normally Distr.	Sample Size
AEX	-0.843	2.133	65.913	No	215
MSCI Europe	-0.845	1.425	43.597	No	215
GPR Index Neth.	-0.641	2.430	67.320	No	215

Table 20: Distribution analysis of indirect real estate

Null Hypothesis: TIME SERIES has a unit root**			Test Critical Values*		
Dickey-Fuller test statistic	t-Statistic	Prob.	1%	5%	10%
GPR Index Neth	-9,544	0,000	Rej.	Rej.	Rej.
AEX	-8,784	0,000	Rej.	Rej.	Rej.
MSCI Europe	-12,877	0,000	Rej.	Rej.	Rej.

* The critical values for 1%, 5% and 10% are respectively -2,64712; -1,95291 and -1,61001

** The Null Hypothesis is rejected when the t-statistics is smaller than the critical value.

Table 21: Stationarity test for the indirect real estate

5.5 Data summary

In this chapter the direct and indirect real estate time series are analysed. Different time series are used for analysing the direct real estate. The series are quarterly and yearly. The quarterly series are not representative enough to work with. Therefore, yearly direct real estate historical data is only considered for further research. For the yearly data two time series are provided, the Ortec series and the ROZ/IPD series. Both series are extended by statistical techniques to the year 1978. These time series represents some biases which are solved by revising the data with the "simplest reverse engineering model". The direct real estate series is revised with alpha is 0.4 and 0.5 because it was not clear which value to use for the smoothed alpha. It is viewed that for both values the yearly direct real estate series were stationary and showed a zero autocorrelation after the unsmoothing. Only the ROZ/IPD series which is unsmoothed with alpha is 0.4 will be used in the forthcoming chapters. The selection of ROZ/IPD series follows from the fact that it is originated from ROZ/IPD itself which the series represents the 'true' index. The Ortec series is constructed[88] by mean of statistical techniques which gives a distorted view of the series. The choice for the alpha is done arbitrarily[89].

There is enough historical data for the indirect real estate series. For analysing the indirect real estate, several real estate equities, the GPR 250 Index and GPR Netherlands Index are considered. The time series of the indices are tested for normality, stationarity and for autocorrelation. For both indices the normality is rejected and both are 99% significant stationary.

The asset class GPR Netherlands Index will be used for asset allocation. The preference for the GPR Netherlands Index arises from the fact that it represents the Dutch real estate market sufficiently. The table below gives a review of the variables which will be used in the following chapters.

Asset Class	Return	Volatility	Skewness	Kurtosis
Direct Real Estate	8.72%	9.15%	-0.4049	-0.1513
Indirect Reaal Estate	7.51%	13.10%	-0.641	2.430

Table 22: Real Estate input variables

[88] It is not clear how the Ortec series is constructed. The construction of the ROZ/IPD Index is given in section 5.2.1.

[89] For 0.4 the unsmoothed series provides a higher volatility as of alpha is 0.5. Intuitively, when a return is high return you will expect a high volatility. It is rational to use 0.4 for the unsmoothing because this will represent the direct real estate time series in a proper way. See also footnote 62 for more explanation of the value of alpha.

Chapter 6 Data Analysis for Hedge Fund

6.1 Introduction

In this chapter the historical data of hedge funds will be analyzed. This chapter gives an answer to research question 6:

What does the risk profile of the hedge fund data look like?

In the next section the risk-return profile of hedge funds is described. The distribution of the series is examined and the series of returns of the hedge fund is tested for autocorrelation and stationarity.

6.2 Fund of Fund Index

The Hedge Fund Research Index (HFRI)[90] Fund of Fund Composite index for hedge funds will be used to study the risk of the hedge fund. The reason to choose a Fund of Funds index (FoF) is from Bacmann and Gawron (2004)[91]. They think that the FoF index is representative for the hedge fund universe because a FoF index is less subjective to the different biases[92] in the hedge fund databases. Secondly, they think that Funds of Funds invest in funds which are not necessarily listed in any database and therefore provide a better and larger coverage of the hedge fund industry. Finally, they believe that Fund of Funds is used by many institutional investors to invest in the hedge fund industry.

The HFRI FoF composite index is compound from following four categories[93]:

- HFRI FoF Conservative: seeks consistent returns by primarily investing in funds that generally engage in more conservative strategies, such as the relative value strategies.
- HFRI FoF Diversified: invests in a variety of strategies among multiple managers.
- HFRI FoF market Defensive: invests in funds that generally engage in short-biased strategies, such as managed futures.
- HFRI FoF Strategic: seeks superior returns by primarily investing in funds that generally engage in more opportunistic strategies.

6.2.1 Risk & Return and Distribution

The return series of the HFRI FoF Composite index rang from 31-01-1990 till 31-12-2007 and the data consists of end-of-the-month quotes. The historical chart of the FoF index including the MSCI Europe and the GPR index are given in the figure below. The figure shows that the FoF index outperforms both, stock and indirect real estate. The same as the indirect real estate, the FoF index does not show any impact of the 9/11 attacks and the dot.com bubble that started at the beginning of the year 2000. In table 23 the risk and return of the asset classes are given. The FoF index outperforms the stock, direct and the indirect real estate index. The volatility of the FoF index is also relatively low. This is the consequence of the smoothing effect which is discussed in chapter three. The smoothing bias can be solved by applying the model of Geltner et al (2007). The smoothing process will be discussed in the next section together with staionarity and autocorrelation. Table 23 also shows the modified value-at-risk (MVaR), along with the

[90] The data is provided by Hedge Fund Research Inc. (HFR). HFR is a research firm specialised in the aggregation, dissemination and analyzing of alternative investment information. They also produce and distribute indices of hedge fund performances. www.hedgefundresearch.com. Visited on 28th of May 2008.
[91] Bacmann J.F and Gawron G., Fat tail risk in portfolios of hedge funds and traditional investments, RMF Investment Management, A member of the Man Group, January 2004
[92] In section 3.4 the different biases are explained.
[93] www.hedgefundreserearch.com
Bacmann and Gawron (2004)

modified Sharp ratio[94] (MSR). The differences of the MSR's of the assets classes are in comparison with the SR's much lower. The FoF index has the highest MSR with a ratio of 0.185. Furthermore, stock has the highest MVaR, with a ratio of 0.535. Moreover, there is a change of 1% that a portfolio which only exists with stock, will loose more than 53.5% of its value in a one year interval. Note that MVaR is higher than the traditional VaR, this is a result of the skewness and kurtosis which are taken into account.

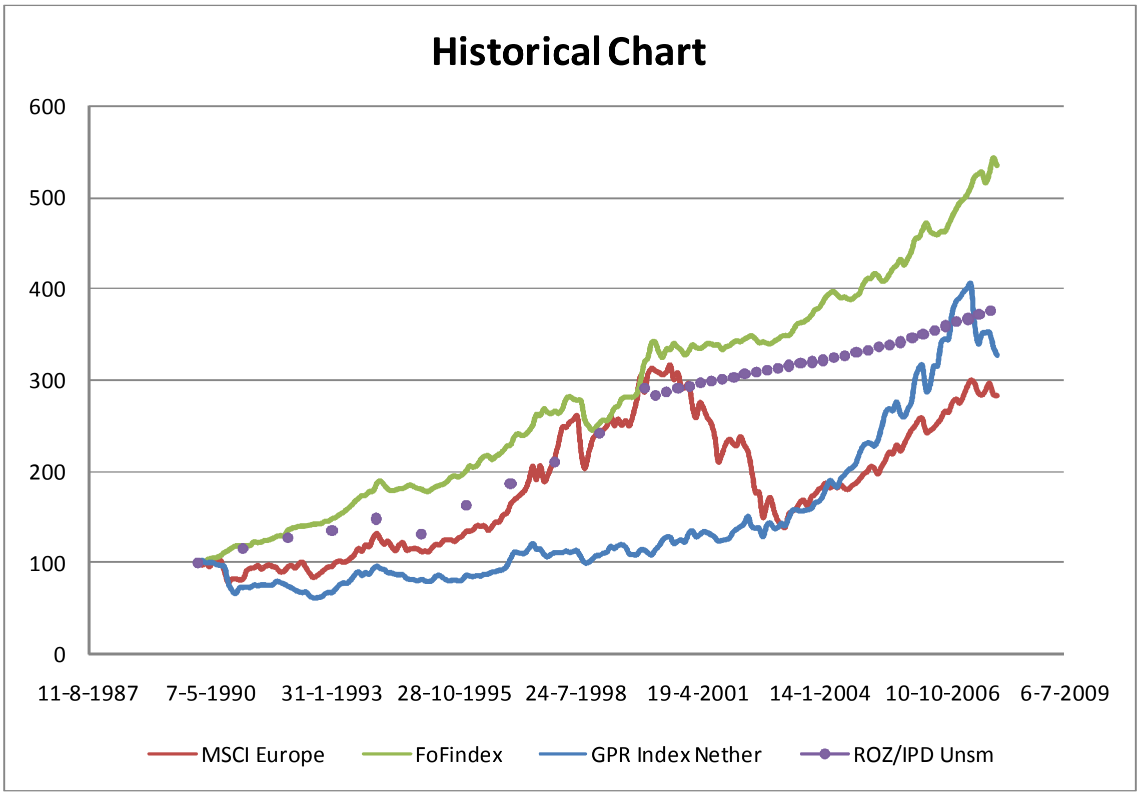


Figure 26: Historical Chart FoF Index

Indices	Return*	Volatility	Skewness	Kurtosis	Sharpe Ratio**	VaR 99%	MVaR 99%	MSR
HFRI Composite FoF Index	9,59%	5,47%	-0,279	4,052	0,969	0,223	0,285	0,186
MSCI Europe	7,05%	15,38%	-0,846	1,425	0,179	0,429	0,535	0,052
ROZ/IPD Unsm	8,72%	9,15%	-0,405	-0,151	0,484	0,300	0,319	0,139
GPR Index Neth	7,51%	13,10%	-0,641	2,430	0,246	0,380	0,497	0,065

* Annualized Return & Volatility
** Risk-free rate is 4,29%

Table 23: Statistical descriptive[95] of the asset classes

[94] See section chapter 4 for the explanation of these parameters.
[95] As a result of the fat tail of the hedge fund, the descriptive for the hedge fund analysis are in this chapter extended with VaR, MVaR and MSR.

In order to check the influences of the 3rd and the 4th moments, the FoF return index is tested for non-normality. The Jarque-Bera test statistic is only used for examining the distribution. The table below gives the result of the test which the normal distribution for HFRI FoF Composite index is rejected. In addition, Crystal Ball fits the return series as a Students't distribution for all the criterion methods[96].

	JB Statistics	Prob.	Normally Distr.	Fitted Ditsr.	Sample Size
FoF Comp. Index	149.179	0.000	No	Students t	213

Table 24: Distribution analysis of FoF index

6.2.2 Autocorrelation, Unsmoothing & Stationarity

The correlogram of the FoF index is given in figure 27. It shows that the returns index has an autocorrelation at lag 1 which is a result of smoothed return series. Fortunately, this can be solved with the same model of Geltner et al (2007):

$$r_t = \frac{r_t^* - \alpha r_{t-1}^*}{1-\alpha}.$$

Correlogram of FOF_INDEX

Date: 06/01/08 Time: 13:06
Sample: 1 214
Included observations: 214

Autocorrelation		AC	Q-Stat	Prob
	1	0.289	18.166	0.000
	2	0.090	19.919	0.000
	3	-0.001	19.919	0.000
	4	-0.057	20.629	0.000
	5	-0.061	21.462	0.001

Figure 27: Correlogram of FoF index return series

In the case of hedge funds, Kat and Lu (2002) suggest to set the value of α equal to the autocorrelation coefficient at lag 1 to ensure that the newly constructed series r_t has the same mean as r_t^* and no first order autocorrelation (see figure 28). As a result, more accurate picture of the 'true' return series can be inferred. It can be seen in figure 27, the value of the autocorrelation at lag 1 is 0.289. Figure 29 illustrates the effect of unsmoothing the FoF index return series. The unsmoothed series show more peaks as a result of the volatility and one can observe from table 25, that MVaR is also much higher than the smoothed FoF index return series.
d

Correlogram of UNSM_FOF_INDEX

Date: 06/01/08 Time: 14:00
Sample: 1 213
Included observations: 213

Autocorrelation		AC	Q-Stat	Prob
	1	0.004	0.0028	0.958
	2	0.014	0.0459	0.977
	3	-0.015	0.0918	0.993
	4	-0.044	0.5222	0.971
	5	-0.056	1.2099	0.944

Figure 28: Correlogram of unsmoothed FoF index return series

[96] The criterion methods are Anderson-Darling, Chi-square and Kolmogorov-Sminov.

Indices	Return*	Volatility	Skewness	Kurtosis	Sharpe Ratio**	VaR 99%	MVaR 99%	MSR
FoF Index	9,59%	5,47%	-0,279	4,052	0,969	0,223	0,285	0,186
FoF Unsm	9,59%	7,37%	-0,338	3,781	0,719	0,268	0,349	0,152

* Annualized Return & Volatility
** Risk-free rate is 4,29%

Table 25: Descriptive of unsmoothed FoF index

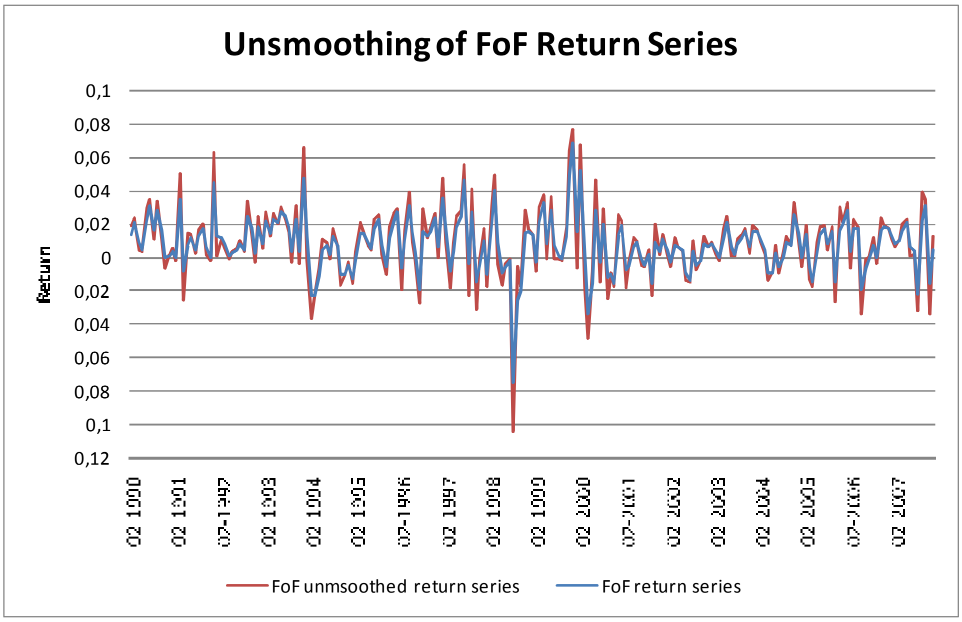


Figure 29: Unsmoothing of FoF Index return series

The JB and the SW test statistics are performed to check whether the unsmoothed FoF Index is normally distributed. From the table 26 and 27, one can observe that the hypothesis of normality is rejected for both test statistics. Recall that for the SW test statistic the hypothesis is rejected when Pr < 0,05 and the hypothesis for the JB test is rejected when the statistics is > 5,99 for a confidence interval of 95%. One can conclude that the unsmoothed FoF return series are not normally distributed. This can also be viewed from the histogram and Q-Q plot of the unsmoothed FoF return series which are given in appendix VII.

	Tests for Normality (Shapiro-Wilk)				Confidence level is 95%	
	Statistic		p Value		Normal Distr.	Sample size
FoF Unsmoothed	**W**	0,957856	**Pr < W**	<0,0001	no	212

Table 26: Shapiro-Wilk Normality test for the Unsmoothed FoF return series

	JB Statistics Crit. Val. 5,99	Prob.	Normally Distr.	Sample Size
FoF Unsmoothed	130,92	0.000	no	212

Table 27: Jarque-Bera Normality test for the Unsmoothed FoF return series

The null hypothesis of a unit root of the FoF index return series is rejected at all significance levels. This means that the return series of FoF index is stationary and it is accurate to use it in an asset allocation which will be discussed in the next chapter.

Null Hypothesis: TIME SERIES has a unit root**			**Test Critical Values***		
Dickey-Fuller test statistic	t-Statistic	Prob.	1%	5%	10%
HFRI FoF Composite Index	-9,073	0,000	Rej.	Rej.	Rej.
HFRI FoF Comp. Unsm Index	-8,489	0,000	Rej.	Rej.	Rej.

* The critical values for 1%, 5% and 10% are respectively -2,64712; -1,95291 and -1,61001

** The Null Hypothesis is rejected when the t-statistics is smaller than the critical value.

Table 28: Stationarity test for the FoF index return series

Chapter 7 Asset Allocation with Markowitz

7.1 Introduction

In this chapter the asset mix is determined within the Markowitz's framework. This chapter gives an answer to research question 7:

What is the optimal asset allocation within the Markowitz's framework?

In the next section the descriptive of the asset classes will be reviewed. In the same section the estimation of the correlation between the asset classes is also discussed. Section 7.3 determines the asset allocation with the assumption of normal distribution. The higher moments (i.e. skewness and kurtosis) are considered in section 7.4. The chapter ends with comparing the results of section 7.3 with the results of section 7.4. In addition, the sensitivity analyses on the asset classes are elaborated. The construction of the Markowitz's framework in Excel is described in appendix VIII.

7.2 Review of the Asset Classes

7.2.1 Descriptive of the Asset classes

Chapter 1 introduced the following three major asset classes:

Traditional asset class:
Along with the MSCI Europe, the Lehman Brothers Pan- European Aggregate Bond Index[97] and Pan-European High-Yield Index[98] are the benchmarks for the traditional asset class[99]. A bond is a debt investment in which an investor loans money to an entity (corporate or governmental) that borrows the funds for a defined period of time at a fixed or floating interest rate. Bonds are commonly referred to fixed-income securities[100]. High-Yield is a high paying bond with a lower credit rating than investment-grade corporate bonds and treasury bonds. The higher yield is a consequence of the higher risk of default of these bonds[101].

Alternative asset class:
The HFRI FoF Composite Unsmoothed Index is the benchmark for the alternative asset class.

Real Estate asset class:
The real estate will be distinguished in direct and indirect real estate. The ROZ/IPD Unsmoothed return series with alpha value of 0.4 and the GPR Index Netherlands are the benchmarks for direct real estate and indirect real estate, respectively.

Assuming that all return distributions are normal (section 7.3), the volatility will be used as a risk measure. The performances will be evaluated by the Sharpe ratio. For higher moments (section 7.4) the MVaR will be used as the risk measurement and evaluated by MSharpe.

[97] The index contains Treasuries, Government-Related, Corporate and Securities and asset-backed securities. The securities that are included in the Aggregate Bond index must have a rate of Baa3/BBB-/BBB or above.
[98] The High-Yield Index contains fixed-rate, non-investment grade corporate securities. The securities that are included have a rate of Ba1/BB+/BB+ or below.
[99] The historical data is provided by Lehman Brothers Inc. The data for the bond index rang from June 1998 to December 2007 and for the high-yield January 1999 to December 2007. Both data consists of end-of-the month returns.
Lehman Brothers Inc. serves the financial needs of corporations, governments, institutional clients and high net worth individuals worldwide. It provides among others of equity and fixed income sales, investment banking and asset management.
[100] www.investopedia.com/bond
[101] www.investopdeia.com/high-yield

In table 29 the descriptive of the asset classes are given. The construction of the correlation matrix is discussed in the next subsection.

Asset Classes	Return	Volatility	Skewness	Kurtosis	Sharpe ratio	VaR 99%	MVaR 99%	MSR
Stock*	7.05%	15.38%	-0.846	1.425	0.179	0.429	0.535	0.186
Bond*	4.73%	3.01%	-0.229	-0.583	0.140	0.117	0.118	0.036
High-Yield*	4.51%	11.14%	-0.636	3.439	-0.004	0.305	0.430	-0.001
FoF*+	9.59%	7.37%	-0.338	3.781	0.969	0.268	0.349	0.186
Direct real est+	8.72%	9.15%	-0.405	-0.151	0.484	0.301	0.319	0.139
Indirect real est*	7.51%	13.10%	-0.641	2.430	0.246	0.380	0.497	0.065

* Annualized Return and Volatility
+ Unsmoothed return series

Table 29: Description of Descriptive Statistic of the asset classes

7.2.2 Estimating the Dependency of the Asset Classes

The linear correlation or Pearson's correlation coefficient between asset class R_i and R_j is defined by

$$\rho\left(R_i, R_j\right) \quad \frac{E\left(R_i R_j\right) \quad E\left(R_i\right)E\left(R_j\right)}{\sqrt{Var\left(R_i\right)}\sqrt{Var\left(R_j\right)}} \tag{7.1}$$

where $E\left(R_i R_j\right) - E\left(R_i\right)E\left(R_j\right)$ expresses the covariance between asset class R_i and R_j. Note that the definition implicitly assumes strict stationarity[102].

Because of the different observation ranges of the asset classes, it is not possible to measure the dependence directly between the asset classes. When the annual observation is used, the statistics show a distorted view. The tables bellow illustrates the descriptive of the asset classes for the annual returns (which are derived from the monthly data), where one can see the differences of both monthly (annualized) and annual statistics.

[102] Alexander (2001)

Statistics	MSCI Europe Index	Lehman Brother European Aggr Bond Index	Lehman Brother European High-Yield Index	GPR Index Netherlands	HFRI Composite FoF Index Unsmoothed	ROZ/IPD Unsmooted
Return	7,60%	4,64%	4,84%	8,35%	9,82%	8,72%
Volatility	18,42%	3,64%	14,34%	18,70%	7,18%	9,15%
Skewness	-0,72	-0,63	0,12	0,06	-0,05	-0,40
Kurtosis	-0,01	-0,68	-0,21	-0,30	0,11	-0,15
Return*	7,05%	4,73%	4,51%	7,51%	9,59%	
Volatility*	15,38%	3,01%	11,14%	13,10%	7,37%	
Skewness*	-0,85	-0,23	-0,64	-0,64	-0,34	
Kurtosis*	1,42	-0,58	3,44	2,43	3,78	

* Annualized Return & Volatility

Table 30: Descriptive of the Asset Classes: Monthly-Annualized (below the line) & Annual Returns

The dissimilarities of correlation matrix of both monthly (ROZ/IPD index excluded) and annual data can be observed in table 31 and 32. It can be seen that monthly data of HFRI Composite FoF Index follows its own path, i.e. the FOF Index shows no significant dependency with the other asset classes. Conversely, the yearly correlation coefficients of HFRI Composite FoF Index are in an absolute term much higher in comparison with the monthly correlation coefficients. For instance for monthly data the asset class MSCI Europe has no significant dependency with the asset class HFRI Composite FOF Index (0,017) whereas the annual data asset classes are positively correlated (0,466).

The dependency of the Lehman Brother Euro Bond Index with the High-Yield Index has also a huge difference. From the monthly data the asset class Bond has no significant dependency with High-Yield (0,006) whereas the annual data asset class Bond is negatively correlated (-0,327). The other asset classes illustrates in the annual data slightly more (in absolute term) correlation coefficient in comparison with the monthly data. Because of these distorted views, the missing values have to be estimated in such way that it represents a credible correlation matrix of the asset classes.

Correlation Matrix (Monthly Data)	MSCI Europe Index	Lehman Brother European Aggr Bond Index	Lehman Brother European High-Yield Index	GPR Index Netherlands	HFRI Composite FoF Index Unsmoothed
MSCI Europe Index	1	-0,365	0,476	0,476	0,017
Lehman Brother European Aggr Bond Index		1	0,006	-0,080	-0,114
Lehman Brother European High-Yield Index			1	0,345	0,084
GPR Index Netherlands				1	0,066
HFRI Composite FoF Index Unsmoothed					1

Table 31: Correlation Matrix for Monthly Data

Correlation Matrix (Yearly Data*)	MSCI Europe Index	Lehman Brother European Aggr Bond Index	Lehman Brother European High-Yield Index	GPR Index Netherlands	HFRI Composite FoF Index Unsmoothed	ROZ/IPD Unsmooted
MSCI Europe Index	1	-0,594	0,621	0,508	0,466	0,414
Lehman Brother European Aggr Bond Index		1	-0,327	-0,045	-0,821	-0,473
Lehman Brother European High-Yield Index			1	0,532	0,491	-0,053
GPR Index Netherlands				1	0,203	0,172
HFRI Composite FoF Index Unsmoothed					1	0,3532
ROZ/IPD Unsmooted						1

* The yearly data is derived from the monthly data

Table 32: Correlation Matrix for Annual Data

The missing values can be estimated by means of fitting the series through interpolation. The main interpolation method is the global interpolation. This model produces one equation. This equation is usually a higher degree polynomial, fitting all known data points. Unfortunately, this method gives distorted view of the series, the figure below illustrates the fitted direct real estate series of returns with a polynomial degree of 15. The model results in a smoothed curve but tend to overshoot at the beginning and at the end points.

However, the missing observation can be estimated by the “Missing Value Analysis” which is available in SPSS. Note that we are only interested in the correlation matrix. The mean, the standard deviation and the higher moments are estimated through historical data which will be maintained and used for the asset allocation.

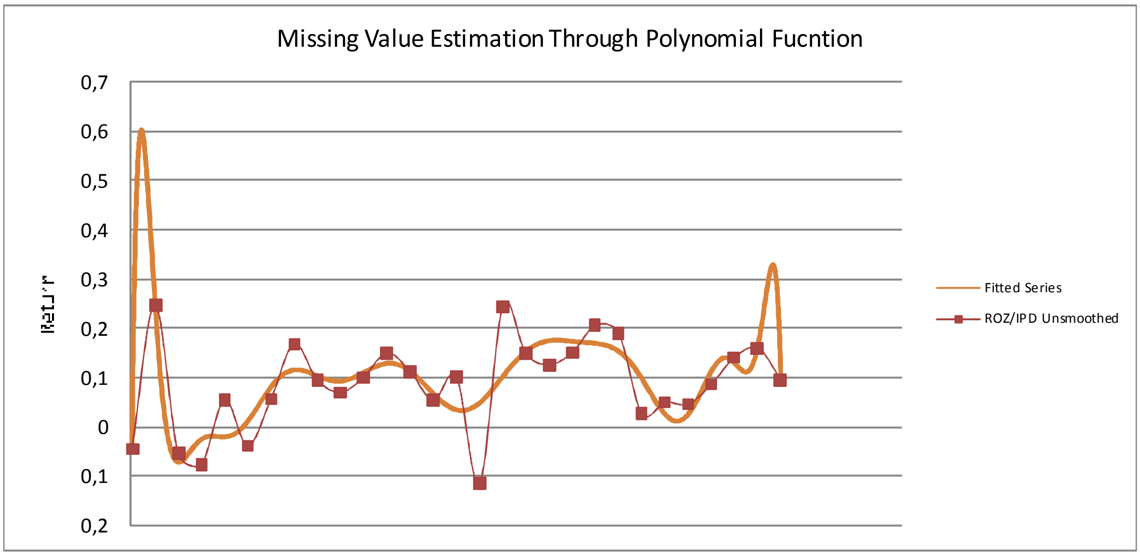


Figure 30: Fitted Series with Polynomial Function

The Missing Value procedure performs three primary functions[103]: First, it describes the missing value observation from that, it estimates the correlations using an expectation-maximization (EM) algorithm. Finally, it fills in the missing observations with estimated values using the EM algorithm. The EM algorithm is an efficient iterative procedure to compute the Maximum Likelihood estimate in the presence of missing or hidden data. Each iteration of the EM algorithm consists of two processes: The E-step, and the M-step. In the expectation, or E-step, the missing data are estimated given the observed data and current estimate of the model parameters. This is achieved using the conditional expectation, explaining the choice of terminology. In the M-step, the likelihood function is maximized under the assumption that the missing data are known. The estimates of the missing data from the E-step are used instead of the real missing data[104].

A simple application for filling missing values in a column of a database:
Assume, 50% of the values in a column are known and the remaining values are missing. When the data is normally distributed with a unit variance then the only variable to compute is the mean value. Subsequently the expected value of each missing value is the mean (E-step) but the E-step changes the overall mean of the data; therefore the estimate can be proved. An example is elaborated in the table below[105], the iteration goes from left to right:

Data	New Data	New Data	New Data	New Data	New Data	New Data
4	4	4	4	4	4	4
10	10	10	10	10	10	10
?	0	3.5	5.25	6.125	6.5625	6.7825
?	0	3.5	5.25	6.125	6.5625	6.7825
Initial Mean: 0	New Mean: 0	New Mean: 5.25	New Mean: 6.125	New Mean: 6.5625	New Mean: 6.7825	New Mean: 6.890625

Table 33: Example of EM Algorithm

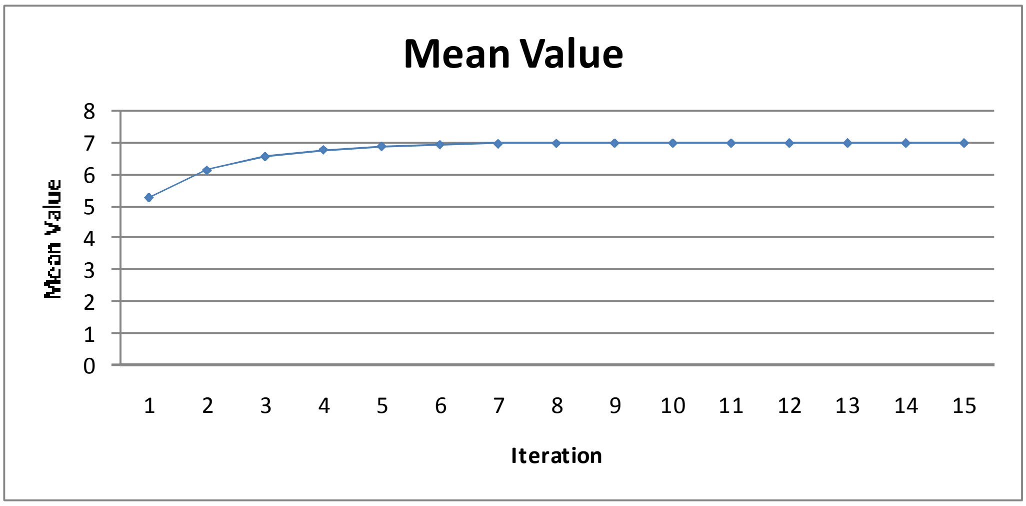


Figure 31: Iteration of EM Algoritm

Table 33 and figure 33 demonstrate that the mean value converges to 7. Corollary, when assuming normal distribution with unit variance the best estimator is the average of the known values. For our problem there is not such an easy way to find the best answer. SPSS can be used for complex models for estimating the missing value with the EM algorithm. The estimated correlation matrix of EM method is given below. The correlation matrix shows that hedge fund is indeed low correlated with other assets.

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103 SPSS Help version 13.0
104 Borman S., The Expectation Maximization Algorithm: A Short Tutorial, Sean Borman publications, 2006.
105 http://en.wikipedia.org/wiki/expectation_maximization

Correlation Matrix (Estimated with missing value anlaysis)	MSCI Europe Index	Lehman Brother European Aggr Bond Index	Lehman Brother European High-Yield Index	GPR Index Netherlands	HFRI Composite FoF Index Unsmoothed	ROZ/IPD Unsmooted
MSCI Europe Index	1	-0,366	0,474	0,476	0,018	0,251
Lehman Brother European Aggr Bond Index		1	0,001	-0,076	-0,092	-0,159
Lehman Brother European High-Yield Index			1	0,338	0,089	0,028
GPR Index Netherlands				1	0,065	0,336
HFRI Composite FoF Index Unsmoothed					1	0,1090
ROZ/IPD Unsmooted						1

Table 34: Estimated Correlation Matrix (Month) with EM algorithm

7.3 Optimal Asset Allocation with Assumption of Normality

The Markowitz's portfolio theory states that all investors should hold portfolios on the efficient frontier. Figure 31 illustrates the efficient frontier of the unsmoothed asset classes. It can be seen that the efficient frontier is sloped from the southwest to the northeast. Each point on the efficient frontier represents a different (efficient) portfolio. To invest in an efficient portfolio, the investor achieves the highest possible return given a predetermined risk.

Given, the set of assets there is only one optimal risky portfolio. No other combination can provide an investor with a higher risk adjusted return. The optimal risky portfolio is the tangency point of the Capital Allocation Line and the efficient frontier, presented in figure 32. The tangency point represents the portfolio with the maximum Sharpe ratio, i.e. the optimal risky portfolio. The risk (volatility) and return of the minimum variance and the maximum Sharpe are given in table[106] 35.

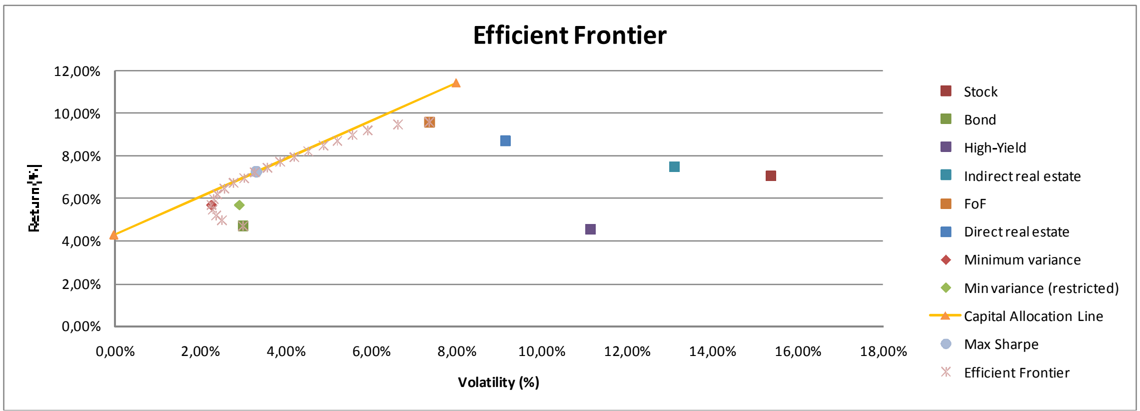

Figure 32: Efficient Frontier with the assumption of normality (Unsmoothed FoF & Real Estate)

[106] The risk & return for all optimization portfolios including the asset allocation are given in appendix VIII.

Optimization Portfolios	Minimum variance	Maximum Sharpe
Return	5,69%	7,24%
Volatility	2,29%	3,32%
Sharpe Ratio*	0,6113	0,8889

* Risk-free rate is 4,29%

Table 35: Risk & Return of Optimization Portfolios

Figure 33 illustrates the efficient frontier of the smoothed and unsmoothed asset classes. As expected, the smoothed efficient frontier has a lower risk profile with a higher expected return corresponding with the unsmoothed asset classes. The performances of the min variance (i.e. risk) and max Sharpe (i.e. optimal risky portfolio) for the smoothed and unsmoothed asset classes are given in the table 36.

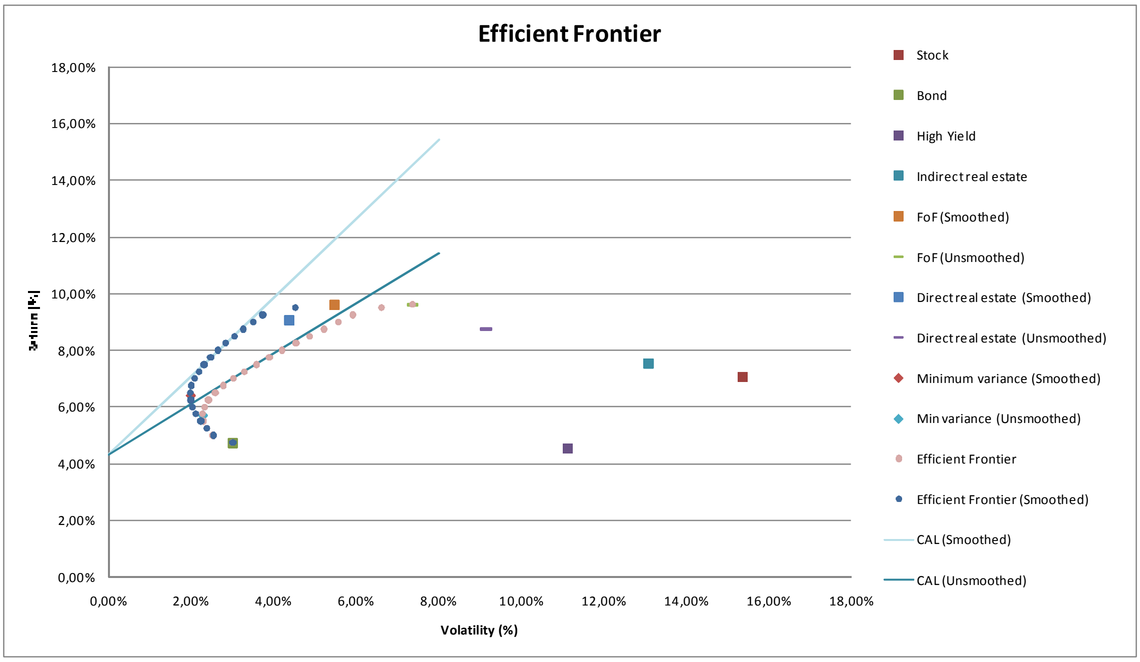

Figure 33: Efficient Frontier with the assumption of normality ((Un)smoothed FoF & Real Estate)

	Min variance (Unsmoothed)	Min variance (Smoothed)	Max Sharpe (Unsmoothed)	Max Sharpe (Smoothed)
Return	5,69%	6,40%	7,24%	7,90%
Volatility	2,29%	1,98%	3,32%	2,59%
Sharpe Ratio*	0,6113	1,0677	0,8889	1,3944

* Risk-free rate is 4,29%

Table 36: Risk & Return of the smoothed asset classes

Figure 34 illustrates the asset allocation for the smoothed and unsmoothed asset classes. It can be seen that both direct real estate and FoF asset classes are well allocated in the smoothed and unsmoothed asset allocation. Note that the asset classes High-Yield and indirect real estate are not allocated in the unsmoothed asset allocation. On the other hand, the smoothed min risk portfolio has a weight of 0.09% for High-Yield which is negligible and indirect real estate is only allocated (0.85%) in the smoothed optimal risky portfolio. This is the consequence of almost zero correlation of bond and high correlation with stock. Remind that table 34 in section 7.2.2, estimated that bond is negatively correlated with stock (-0.366) whereas the indirect real estate (-0.076) and High-Yield (0.001) show a correlation near to zero. High-yield (0.474) and indirect real estate (0.476) are positively correlated with stock.

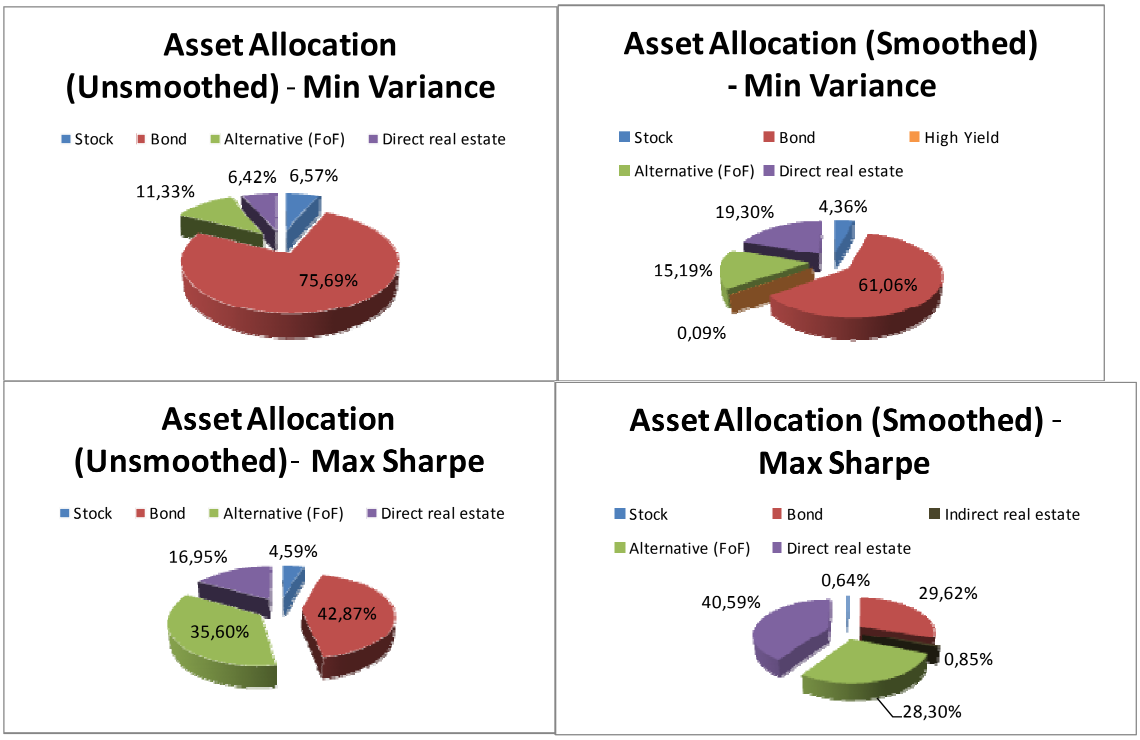

Figure 34: Allocation with assumption of normality (Unsmoothed & Smoothed asset classes)

7.4 Optimal Asset Allocation with higher moments

It is also necessary to insert the 3rd and the 4th moment in the asset allocation because of the fact that most asset classes are not normally distributed. The figure below presents the result of the asset allocation with higher moments. When the risk is assessed more precisely (i.e. unsmoothing the return series and taken along the skewness and kurtosis), the efficient frontier goes further to the right. Moreover, the higher the accuracy of the risk measurement, the higher the risk and lower the return of the portfolio.

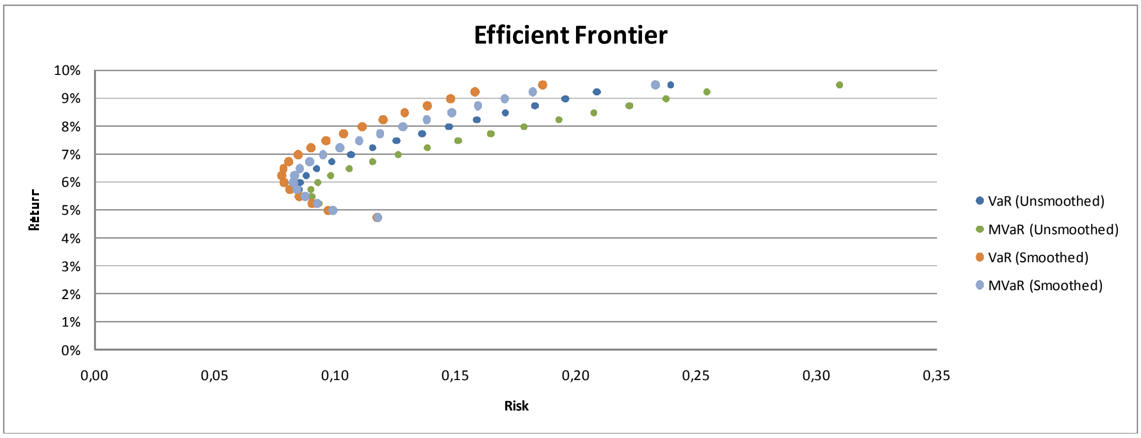

Figure 35: Efficient frontier with higher moments (Unsmoothed & Smoothed)

The optimal portfolio with a minimum risk (i.e. minimum MVaR) and optimal risky porfolio (i.e. max MSharpe) of the unsmoothed and smoothed asset classes are given in figure 36. Again the asset classes' High-Yield and indirect real estate are not allocated in the portfolio. As expected the unsmoothed series are allocated somewhat smaller in comparison with the smoothed series. The performances of the unsmoothed and smoothed portfolios are given in table 37. The unsmoothed max MSharpe portfolio has a slightly lower return and a higher volatility compared with the smoothed max MSharpe portfolio.

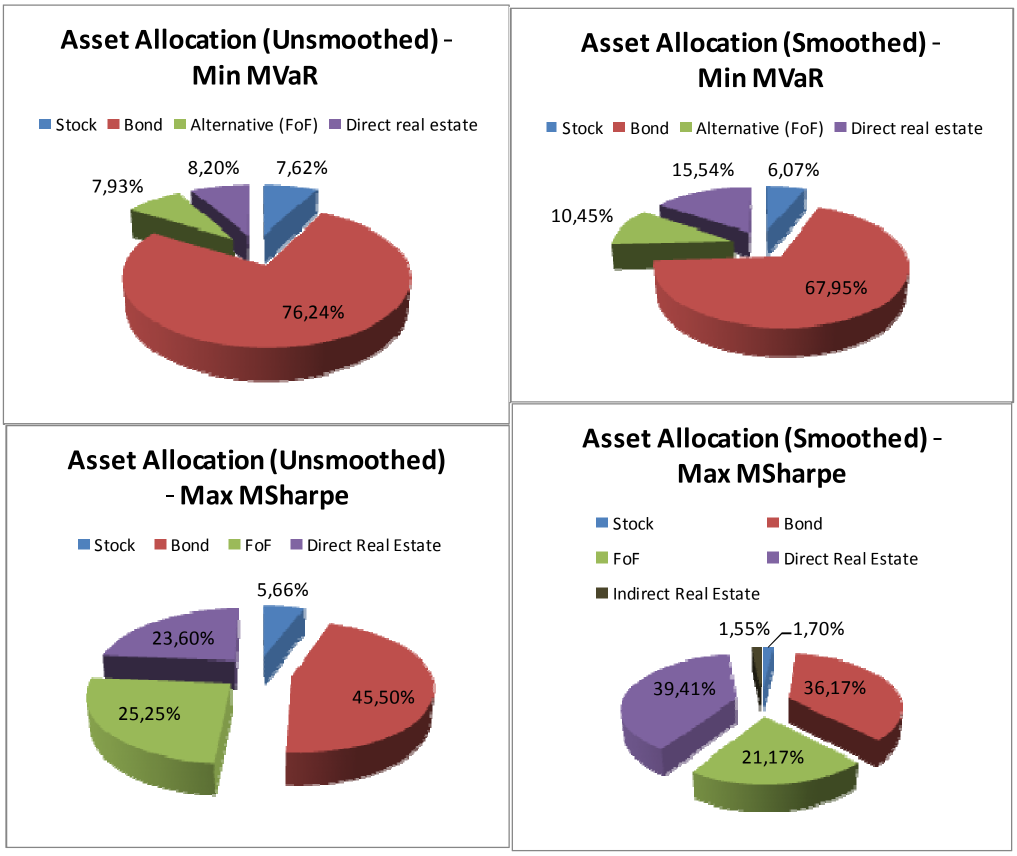

Figure 36: Allocation with higher moments (Smoothed & Unsmoothed)

Optimization Portfolios	Min MVaR (Unsmoothed)	Min MVaR (Smoothed)	Max MSharpe (Unsmoothed)	Max MSharpe (Smoothed)
Return	5,62%	6,05%	7,03%	7,55%
Volatility	2,31%	2,03%	3,22%	2,37%
MVaR	0,0865	0,0823	0,1286	0,1122
MSharpe Ratio*	0,1483	0,2137	0,2130	0,2903

* Risk-free rate is 4,29%

Table 37: Risk & Return of the portfolios with higher moments (Unsmoothed & Smoothed)

7.5 Max Sharpe versus Max MSharpe

7.5.1 Optimal Risky Portfolios

Table 38 and 39 give the results of the smoothed and unsmoothed asset allocation and the performances of the optimal risky portfolios. Table 38 shows that the unsmoothed direct real estate is less allocated than the smoothed direct real estate for both max Sharpe and max MSharpe. On the other hand, the allocation of the unsmoothed FoF is increased in comparison with the smoothed FoF. This is the result of the different influences of unsmoothing the direct real estate and FoF return series. Remind from chapter 5 and 6 that the volatility of direct real estate is increased by 458 bps[107] and the return is decreased by 62 bps as a result of unsmoothing. The volatility of FoF series is increased by 190 bps with a steady expected return. The performances are reviewed in table 40.

One can also observe from table 38 that when the risk is measured by mean of MVaR, the unsmoothed FoF is less allocated, while the allocation is increased for stock, bond and direct real estate. Note from table 39 that the return of the max Sharpe portfolio which has a slightly lower risk, outperforms the max MSharpe portfolio.

Asset	Max Sharpe (Smoothed)	Max MSharpe (Smoothed)	Max Sharpe (Unsmoothed)	Max MSharpe (Unsmoothed)
Stock	0,64%	1,70%	4,59%	5,66%
Bond	29,62%	36,17%	42,87%	45,50%
High-Yield	0,00%	0,00%	0,00%	0,00%
Indirect Real Estate	0,85%	1,55%	0,00%	0,00%
FoF	28,30%	21,17%	35,60%	25,25%
Direct Real Estate	40,59%	39,41%	16,95%	23,60%

Table 38: Optimal Risky Portfolios (Smoothed & Unsmoothed)

Performances	Max Sharpe (Smoothed)	Max MSharpe (Smoothed)	Max Sharpe (Unsmoothed)	Max MSharpe (Unsmoothed)
Return	7,90%	7,55%	7,24%	7,03%
Volatility	2,59%	2,37%	3,32%	3,22%
MVaR	0,1262	0,1122	0,1442	0,1286
Sharpe*	1,3944	1,3718	0,8889	0,8512
MSharpe*	0,2864	0,2903	0,2048	0,2130

*Risk-free rate 4,29%

Table 39: Performances of the Optimal Risky Portfolios (Smoothed & Unsmoothed)

Asset	Return	Volatility	Sharpe*
ROZ/IPD Smoothed	9,34%	4,57%	1,10
ROZ/IPD Unsmoothed	8,72%	9,15%	0,48
FoF Smoothed	9,59%	5,47%	0,97
FoF Unsmoothed	9,59%	7,37%	0,72

* Risk-free rate is 4,29%

Table 40: Risk & Return of direct real estate and FoF (Smoothed & Unsmoothed)

[107] 1 bps or basis point is equal to 0,01%.

7.5.2 Parameter Modification: As a Result of Recent Market Developments

In the preceding sections the allocation was based on historical data which ranges from the year 1990 upto and including the year 2007. The last half year there has been an increasing movement in the financial markets, therefore it is worthwhile to study the impact of the developments on the asset allocation. The sensitivity analysis is based on the max MSharpe portfolio and only the input parameters return and volatility are modified. The parameters skewness & kurtosis and the correlation matrix are maintained.

Table 41 illustrates the modified input parameters. In view of the recent market developments, the historical volatility of stock is relatively low. Because of that, the volatility is increased from 15,38% to 20%. As a consequence of similar characteristics with stock, the volatility of indirect real estate is increased from 13,10% to 17%. The return on High-Yield is increased from 4,51% to 8,65% which is the current observed return. Various market observers reduced their expectations of future returns on property as an effect of an expected downturn in economic growth therefore the real estate and hedge fund returns are decreased to 6,5%.

Asset	Return		Volatility	
	Original	Modified	Original	Modified
Stock	7,05%	7,05%	7,05%	20,00%
Bond	4,73%	4,73%	3,01%	3,01%
High-Yield	4,51%	8,65%	11,14%	11,14%
Indirect Real Estate	7,51%	7,51%	13,10%	17,00%
FoF	9,59%	6,50%	7,37%	7,37%
Direct Real Estate	8,72%	6,50%	9,15%	9,15%

Table 41: Modified input parameters of the asset classes

The result of the allocation of the modified parameters and the performances are given in table 42 and 43. The allocation of stock and FoF are negatively influenced by the market movement. The allocation of stock is decreased by 5,50% and FoF is decreased by 7,96%. As expected the weight of high-yield is increased to 16,62%. Note that the market movements do not influence the allocation of indirect real estate and again indirect real estate is not allocated in the optimal risky portfolio. Table 43 shows that the portfolio return is decreased by 93 bps and the volatility is increased by 16 bps as a result of the market movement. In practice the optimal asset allocation also depends on market view of the investor.

Asset	Original Max MSharpe (Unsmoothed)	Modified Max MSharpe (Unsmoothed)
Stock	5,66%	0,16%
Bond	45,50%	42,67%
High-Yield	0,00%	16,62%
Indirect Real Estate	0,00%	0,00%
FoF	25,25%	17,29%
Direct Real Estate	23,60%	23,25%

Table 42: Allocation of the modified parameters

Performances	Original Max MSharpe (Unsmoothed)	Modified Max MSharpe (Unsmoothed)
Return	7,03%	6,10%
Volatility	3,22%	3,38%
MSharpe*	0,21	0,14

Table 43: Performances of the modified allocation

Chapter 8 Conclusion

8.1 Introduction

In the previous chapters the research questions are elaborated. In this last chapter the conclusions and recommendations are presented. The handled research questions and the results of this research are given in this chapter.

8.2 Conclusion

This report gives an answer, by mean of several research questions, to the following problem statement:

"How should the direct real estate and the alternative investments time series be adapted, to get a reliable risk profile in order to find an optimal asset-mix within the Markowitz's framework?"

In the previous chapters we investigated that both direct real estate and hedge fund showed some biases on the time series of returns. In this thesis we distinguished the real estate in direct and indirect real estate. With regard to risk and return the indirect real estate showed much resemblance with the stock market. Nevertheless the indirect real estate is taken as a separate asset class.

Furthermore, we saw that both direct real estate and FoF series represented an autocorrelation (direct real estate has even an autocorrelation at lag 3) and the return series were also not stationary. The autocorrelation stems due the fact that appraisers and hedge fund managers based themselves on previous valuations and therefore the time series of returns were smoothed. We also investigated whether the time series were normally distributed. This is done by means of two statistical tests. Both tests gave the same result in which the normal distribution for direct real estate could not be rejected with a confidence level of 95% whereas the hypothesis of normal distribution for hedge fund was rejected.

Chapter 5 and 6 concluded that the direct real estate and hedge fund return series have been far from consistent. Therefore it is necessary to solve the biases of the return series in a sufficient way. We illustrated that the biases of the return series could be solved by unsmoothing the return series by mean of the reverse engineering model of Geltner et al (2007):

$$r_t = \frac{r_t^* - \alpha r_{t-1}^*}{1-\alpha}.$$

We concluded that reverse engineering model has been the best model to use for unsmoothing the autocorrelated series because of the inefficient market of real estate. The only issue of this model is the indistinctness on which value to use for the alpha. After e-mailing Mr. Geltner the originator of the model, it became clear that it is well-advised to use 0.4 for the smoothing factor. The alpha value for the unsmoothing of the hedge fund series of returns is chosen as the autocorrelation coefficient which is suggested by Kat and Lu (2002), who did an extensive study on hedge fund series.

As a consequence of unsmoothing, the direct real estate and the FoF series of returns are adapted in a stationary series and therefore the unsmoothed series are now more reliable to use, to model the risk of direct real estate and FoF. As a result of unsmoothing the volatility of direct real estate is doubled with a slightly lower expected return and the volatility of FoF series is increased by 190 bps with a steady expected return. This can also be observed from the table below.

Asset	Return	Volatility	Sharpe*
ROZ/IPD Smoothed	9,34%	4,57%	1,10
ROZ/IPD Unsmoothed	8,72%	9,15%	0,48
FoF Smoothed	9,59%	5,47%	0,97
FoF Unsmoothed	9,59%	7,37%	0,72

* Risk-free rate is 4,29%

In the second part of the research we analyzed the higher moments for asset allocation. The optimal asset allocation is based on the Markowitz's framework which assumes that the assets are normally distributed and therefore only the mean and variance are considered. From chapter 5 and 6 we came to the conclusion that beside the bond and direct real estate, the asset classes are not normally distributed. They have a negative skewness and particularly FoF has a high positive kurtosis. Due to this, it is not reasonable to take only the mean and variance into consideration when determining the asset allocation. Therefore, it is also important to take the skewness and kurtosis into account.

Our result confirms that introducing skewness and kurtosis by means of MVaR, the asset allocation task will produce a different allocation. The MVaR model is the adjustment of the variance-covariance approach introduced by Favre and Galeano (2002). The asset allocation is executed in Excel where we constructed a simple tool to estimate the optimum weights. Unsmoothing the direct real estate and FoF, and taking the higher moments results in the following asset allocation along with the performances.

Asset	Min Variance (Smoothed)	Min Variance (Unsmoothed)	Max Sharpe (Smoothed)	Max Sharpe (Unsmoothed)	Min MVaR (Smoothed)	Min MVaR (Unsmoothed)	Max MSharpe (Smoothed)	Max MSharpe (Unsmoothed)
Stock	4,36%	6,57%	0,64%	4,59%	6,07%	7,62%	1,70%	5,66%
Bond	61,06%	75,69%	29,62%	42,87%	67,95%	76,24%	36,17%	45,50%
High-Yield	0,09%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Indirect Real Estate	0,00%	0,00%	0,85%	0,00%	0,00%	0,00%	1,55%	0,00%
FoF	15,19%	11,33%	28,30%	35,60%	10,45%	7,93%	21,17%	25,25%
Direct Real Estate	19,30%	6,42%	40,59%	16,95%	15,54%	8,20%	39,41%	23,60%

Performances	Min Variance (Smoothed)	Min Variance (Unsmoothed)	Max Sharpe (Smoothed)	Max Sharpe (Unsmoothed)	Min MVaR (Smoothed)	Min MVaR (Unsmoothed)	Max MSharpe (Smoothed)	Max MSharpe (Unsmoothed)
Return	6,40%	5,69%	7,90%	7,24%	6,05%	5,62%	7,55%	7,03%
Volatility	1,98%	2,29%	2,59%	3,32%	2,03%	2,31%	2,37%	3,22%
MVaR	0,0848	0,0907	0,1262	0,1442	0,0823	0,0895	0,1122	0,1286
Sharpe*	1,0677	0,6113	1,3944	0,8889	0,8677	0,5745	1,3718	0,8512
MSharpe*	0,2495	0,1541	0,2864	0,2048	0,2137	0,1483	0,2903	0,2130

*Risk-free rate 4,29%

As we concluded before in chapter 7, the assets High-Yield and indirect real estate were not allocated in the efficient portfolio. We could see that the FoF asset was less allocated in max MSharpe (i.e. the higher moments are taken into account) in comparison with max Sharpe. On the other hand, the weights of the assets stock, bond and direct real estate in max MSharpe are increased in comparison with max Sharpe. The max Sharpe (Unsmoothed) outperforms max MSharpe (Unsmoothed) by 21 bps with a slightly higher volatility (10 bps).

Since the last half year there has been a lot of turmoil in the financial market. The raise of the oil price, the sub-prime crisis are among other things. Therefore we investigated the impact of the developments in the financial market by means of a sensitivity analysis on the historical return and volatility. We concluded in section 7.5.2 that the recent developments in the financial markets had an impact on the allocation. Consequently, stock and FoF are less allocated. Indirect real estate was again not allocated in the optimal risky portfolio. However, High-Yield is also allocated. The developments in the financial market did also influence the portfolio return which is decreased by 93 bps and the volatility is increased by 16 bps.

8.3 Recommendations

A drawback of the MVaR model is the assumption of normality, beside the bond and direct real estate, none of the asset classes are significantly normal distributed. However, the analysis provided the importance in understanding issues in portfolio selection such as the inclusion of higher moments and parameter uncertainty (i.e. volatility). Using an approach called Copulas could provide an improvement concerning the evaluation and analysis of the dependency of the different distributions of the asset classes.

Parallel with the drawback of the MVaR model we run into another issue, namely estimating the correlation of the assets with different time intervals. We estimated in Chapter 7 the missing values rather slender and intuitively which we think it is scientific ill-founded. We recommend further research on estimation on missing value combined with estimating the dependency with Copulas.

This study was based on asset only optimisation, we recommend further research on asset-alloaction by means of MVaR in ALM context. Moreover, consider also the liabilities in the optimisation analyses.

To conclude our findings, we recommend that the data underlying asset optimisation analyses is properly analysed.

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http://srgintranet.concern.srg

www.yourdictionary.com

www.wikipedia.org

Exercised software programmes:

Crystal Ball version 7.3.1

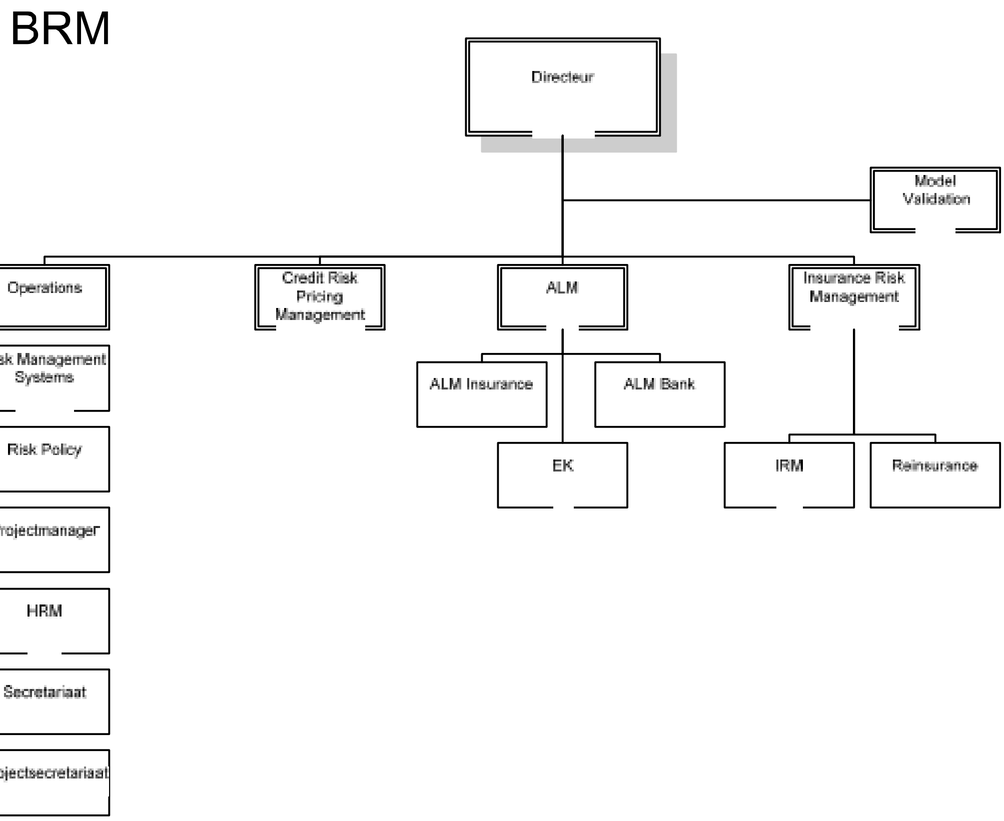
EViews version 6

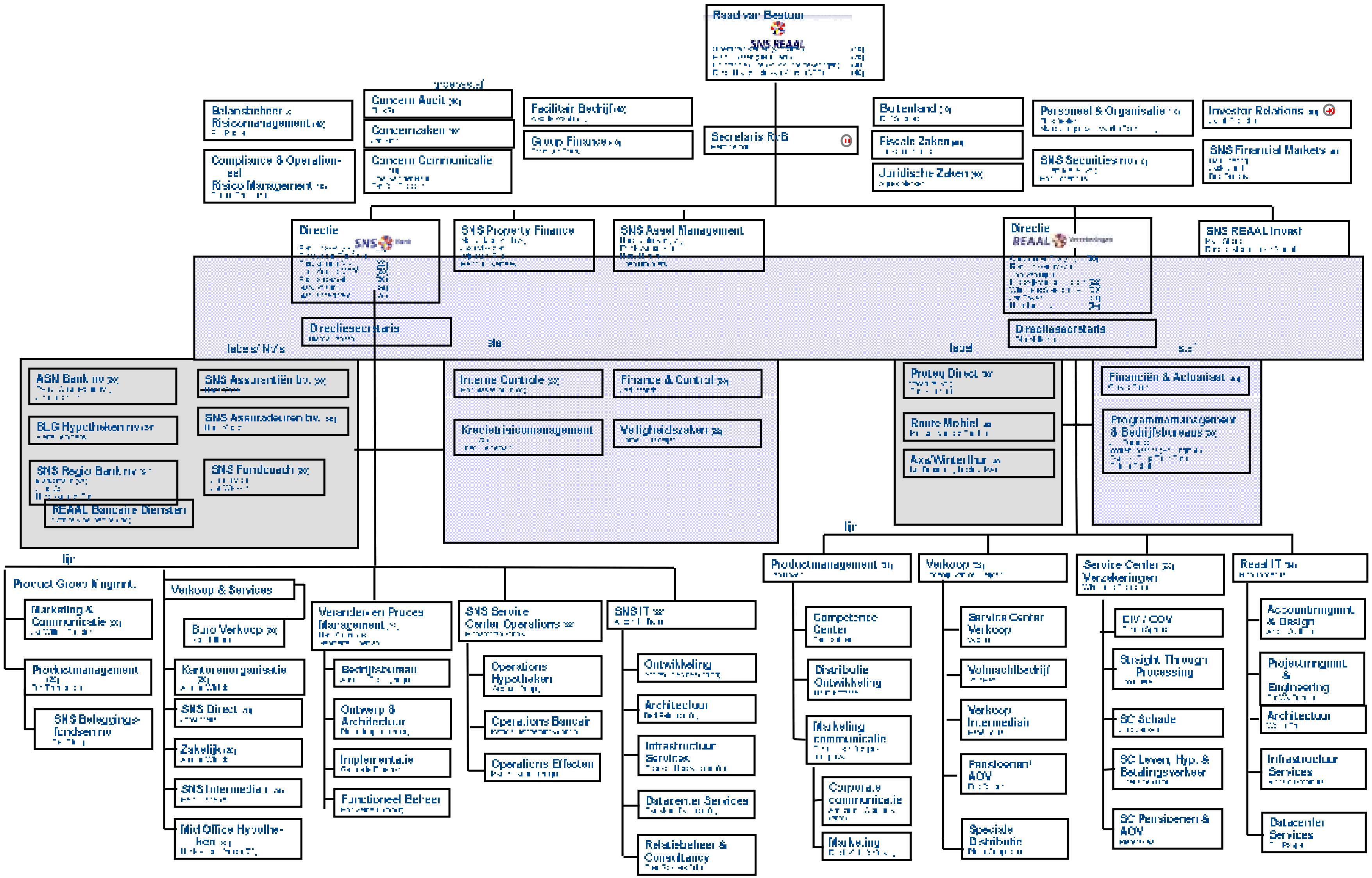
MATLAB version R2006a

SPSS version 13.0

Appendix

I. Organisation Chart of SNS Reaal & BRM




Raad van Bestuur
SNS REAAL
Balansbeheer & Risicomanagement
Compliance & Operational Risico Management
Concern Audit
Concernzaken
Concern Communicatie
Facilitair Bedrijf
Group Finance
Secretariaat RvB
Buitenland
Fiscale Zaken
Juridische Zaken
Personeel & Organisatie
SNS Securities nv
Investor Relations
SNS Financial Markets
Directie SNS Bank
SNS Property Finance
SNS Asset Management
Directie REAAL Verzekeringen
SNS REAAL Invest
Directiesecretaris
Directiesecretaris
ASN Bank nv
SNS Assurantiën bv
SNS Assuradeuren bv
BLG Hypotheken nv
SNS Regio Bank nv
SNS Fundcoach
REAAL Bancaire Diensten
Interne Controle
Finance & Control
Kredietrisicomanagement
Veiligheidszaken
Proteq Direct
Route Mobiel
Axa/Winterthur
Financiën & Actuariaat
Programmamanagement & Bedrijfsbureaus
lijn
Product Groep Mngmnt.
Marketing & Communicatie
Productmanagement
SNS Beleggingsfondsen nv
Verkoop & Services
Buro Verkoop
Kantorenorganisatie
SNS Direct
Zakelijk
SNS Intermediair
Mid Office Hypotheken
Veranderen en Proces Management
Bedrijfsbureau
Ontwerp & Architectuur
Implementatie
Functioneel Beheer
SNS Service Center Operations
Operations Hypotheken
Operations Bancair
Operations Effecten
SNS IT
Ontwikkeling
Architectuur
Infrastructuur Services
Datacenter Services
Relatiebeheer & Consultancy
lijn
Productmanagement
Competence Center
Distributie Ontwikkeling
Marketing communicatie
Corporate communicatie
Marketing
Verkoop
Service Center Verkoop
Volmachtbedrijf
Verkoop Intermediair
Pensioenen AOV
Speciale Distributie
Service Center Verzekeringen
EIV / OOV
Straight Through Processing
SC Schade
SC Leven, Hyp. & Betalingsverkeer
SC Pensioenen & AOV
Reaal IT
Accountmngmnt. & Design
Projectmngmnt. & Engineering
Architectuur
Infrastructuur Services
Datacenter Services

II. Basic Statistical Definitions

Mean /Expected Return: The arithmetic of a data distribution; Average of possible returns weighted by their probabilities.

Variance: A measure of score dispersion about the mean; calculated as the squared deviation scores from the data distributions mean; the greater the dispersion of scores, the greater the variance in the data set.

Standard Deviation/Volatility: The Square root of the variance: A measure of the uncertainty of the realized return of an asset.

Correlation: The relationship by which two or more variables change together, such that systematic changes in one accompany systematic changes in the other.

Covariance: Measure of the linear relationship between two variables (equals the correlation between the variables times the product of their standard deviations).

Skewness: A measure of a data distributions deviation from symmetry.

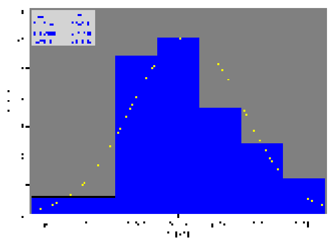
Kurtosis: A measure of the fatness of the tails of a distribution.

Normal Distribution: Symmetric bell-shaped distribution.

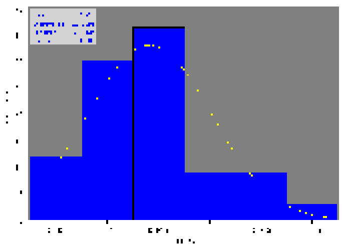
Goodness of fit: A measure of how well the regression model is able to predict dependent variable.

III. Distribution Analyses ROZ/IPD Index

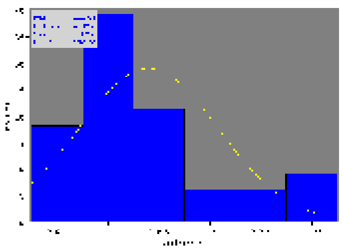
Histograms



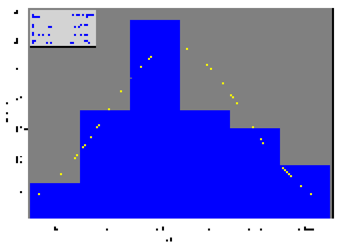
Histogram Quarterly Return Retail



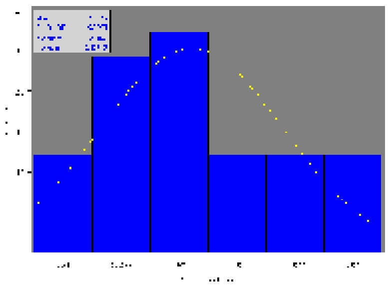
Histogram Quarterly Return Office



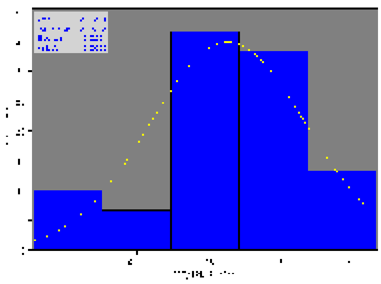
Histogram Quarterly Return Residential



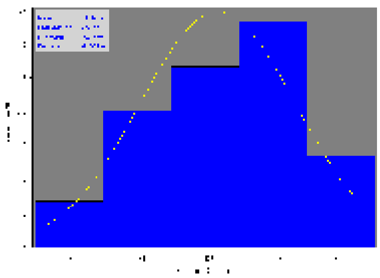
Histogram Quarterly Return Industrial



Histogram Quarterly Return All Property

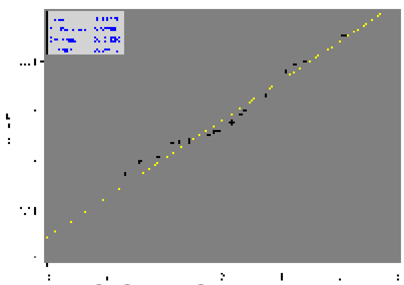


Histogram Extended Yearly Return ROZ/IPD Series

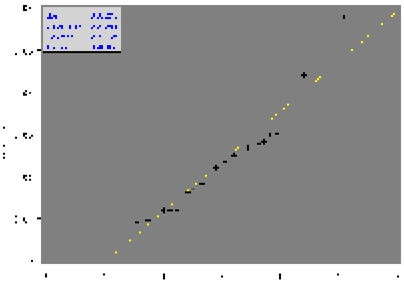


Histogram Extended Yearly Return Ortec Series

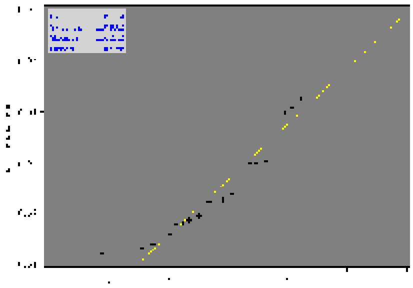
Q-Q plots



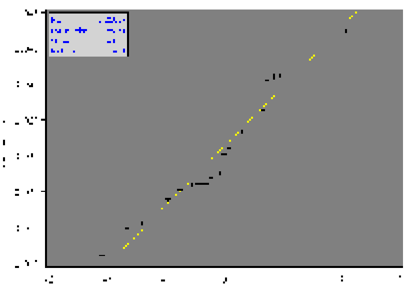
Q-Q plot Quarterly Retail Return



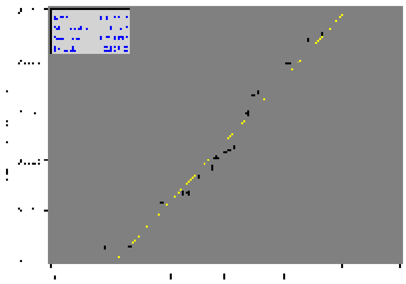
Q-Q plot Quarterly Office Return



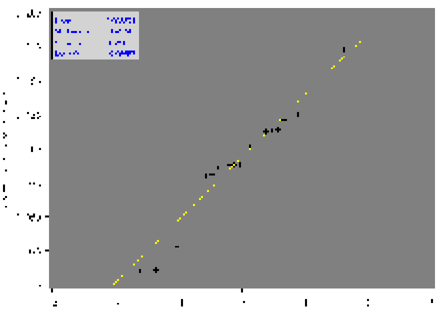
Q-Q plot Quarterly Residential Return



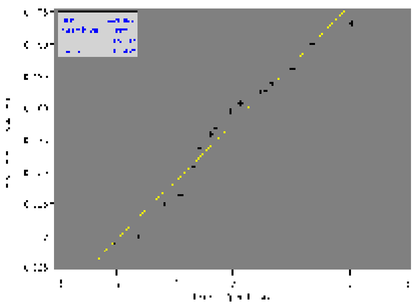
Q-Q plot Quarterly All Property Return



Q-Q plot Quarterly Industrial Return

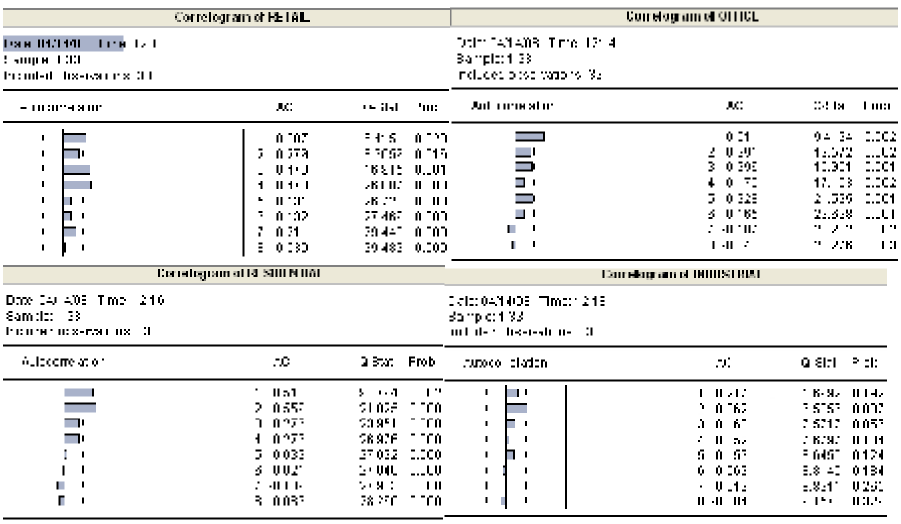


Q-Q plot Extended Yearly Return Ortec Series

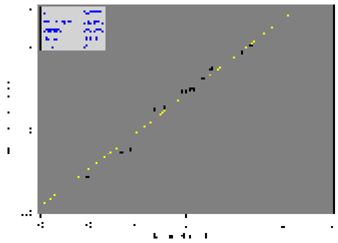


Q-Q plot Extended Yearly Return ROZ/IPD Series

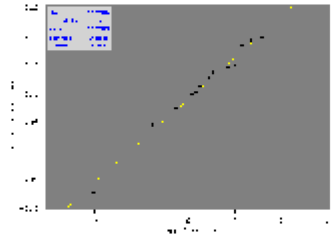
IV. Autocorrelation of Quarterly ROZ/IPD Index



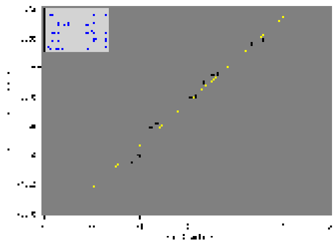
V. Distribution analyses of unsmoothed ROZ/IPD return series



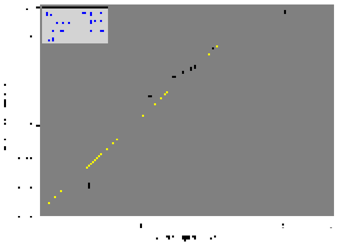
Q-Q plot unsm ROZ/IPD Series 0.4



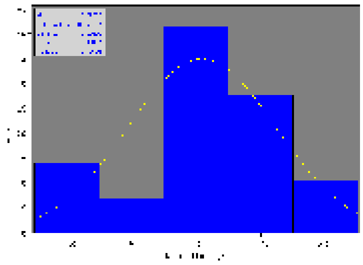
Q-Q plot unsm ROZ/IPD Series 0.5



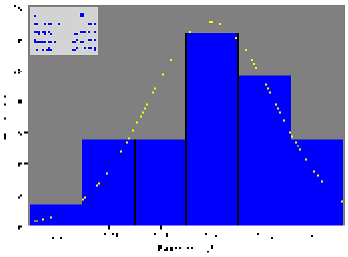
Q-Q plot unsm Ortec Series 0.4



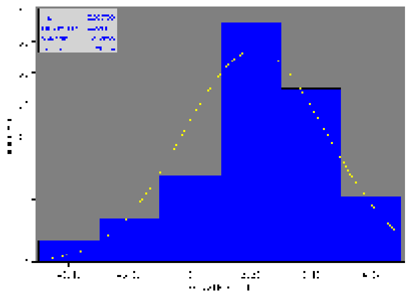
Q-Q plot unsm Ortec Series 0.5



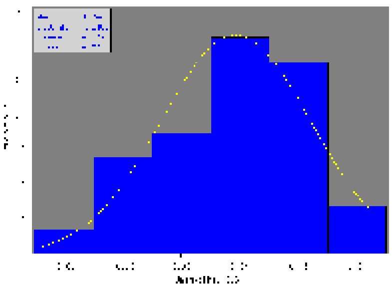
Histogram unsm ROZ/IPD Series 0.4



Histogram unsm ROZ/IPD Series 0.4

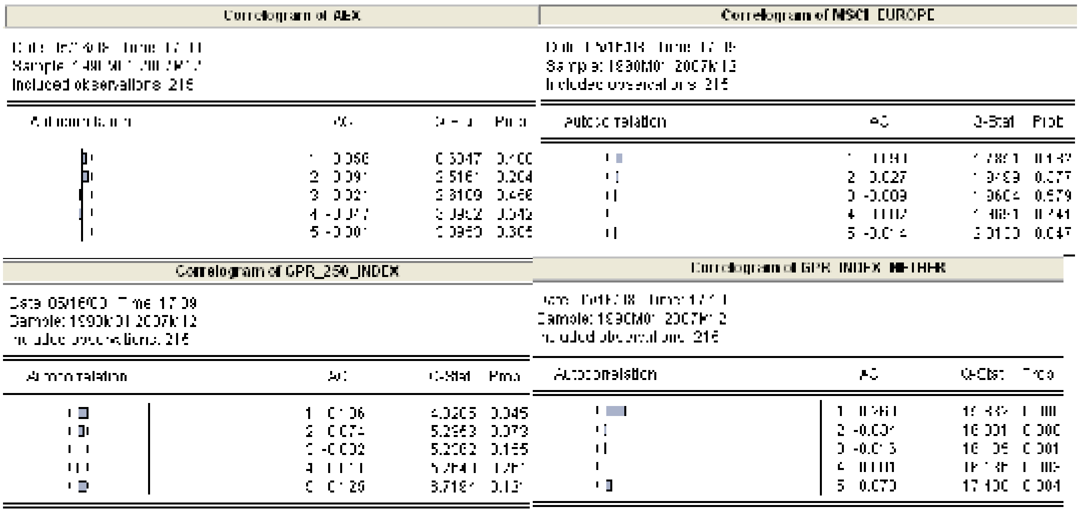


Histogram unsm Ortec Series 0.4



Histogram unsm Ortec Series 0.4

VI. Autocorrelation of Indirect Real Estate



Correlogram of AEX

Included observations: 215

Autocorrelation		AC	Q-Stat	Prob
	1	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]	0.204
	3	[illegible]	[illegible]	[illegible]
	4	[illegible]	[illegible]	[illegible]
	5	[illegible]	[illegible]	[illegible]

Correlogram of MSCI EUROPE

Included observations: 215

Autocorrelation		AC	Q-Stat	Prob
	1	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]	[illegible]
	3	-0.009	[illegible]	0.579
	4	[illegible]	[illegible]	[illegible]
	5	[illegible]	[illegible]	[illegible]

Correlogram of GPR_250_INDEX

Included observations: 215

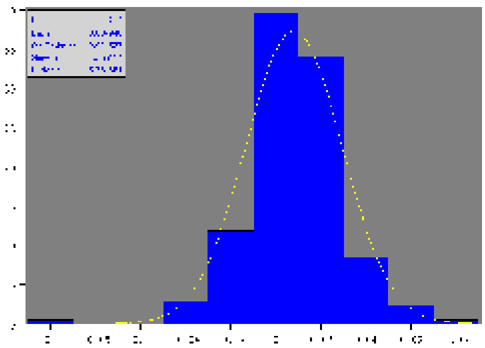
Autocorrelation		AC	Q-Stat	Prob
	1	[illegible]	[illegible]	0.045
	2	[illegible]	[illegible]	[illegible]
	3	[illegible]	[illegible]	[illegible]
	4	[illegible]	[illegible]	[illegible]
	5	[illegible]	[illegible]	[illegible]

Correlogram of GPR INDEX NETHER

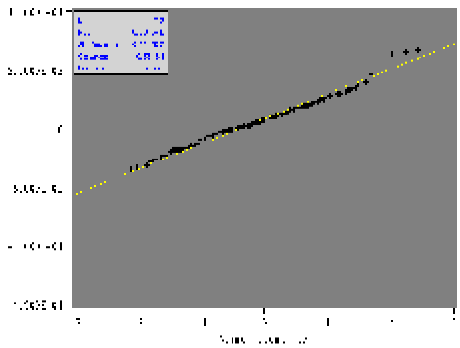
Included observations: 215

Autocorrelation		AC	Q-Stat	Prob
	1	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]	[illegible]
	3	[illegible]	[illegible]	[illegible]
	4	[illegible]	[illegible]	[illegible]
	5	[illegible]	[illegible]	[illegible]

VII. Distribution analysis of the unsmoothed FoF return series



Histogram unsmoothed FoF return series



Q-Q plot unsmoothed FoF return series

VIII. Construction of Markowitz Model in Excel

In this appendix the Excel formulas are specified which are used for the portfolio modelling. Since Excel has been built on columns and rows the necessary computations can be done by applying linear algebra. In Excel the portfolio return (expected return), the portfolio weight, portfolio VaR and portfolio MVaR can be expressed by column vectors. The matrix notation with the Excel format can be written as follows[108]:

Formula	Mathematical Expression[109]	Matrix Notation	Excel Format[110]
Portfolio Return	$E[R_p] = \sum_{i=1}^{n} w_i E[R_i]$	$\mathbf{w}^{\mathbf{T}}\mathbf{E}$, where $\mathbf{w}$ is the weight: $\mathbf{w} = [w_1 \cdots w_n]$	=Sumproduct(**w**, **E**)
Portfolio Variance[111]	$\sigma_p^2 = \sum_{i,j=1}^{n} w_i w_j \sigma_{ij}$	$= \mathbf{w}^{\mathbf{T}}\boldsymbol{\Sigma}\mathbf{w}$, where $\boldsymbol{\Sigma}$ is the covariance matrix: $\boldsymbol{\Sigma} = \begin{pmatrix} \Sigma_{11} & \cdots & \Sigma_{1n} \\ \vdots & \ddots & \vdots \\ \Sigma_{m1} & \cdots & \Sigma_{mn} \end{pmatrix}$	=MMULT(TRANSPOSE (**w**), MMULT(Σ, **w**))
Portfolio VaR	$VaR_P = \sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N} \rho_{i,j} w_i VaR_i w_j VaR_j}$	$\sqrt{\mathbf{W}\boldsymbol{\rho}\mathbf{W}^{\mathbf{T}}}$, where $\mathbf{W}$ is the vector matrix: $[w_1 VaR_1 \cdots w_n VaR_n]$ and $\boldsymbol{\rho}$ the vector matrix: $\boldsymbol{\rho} = \begin{pmatrix} \rho_{11} & \cdots & \rho_{1n} \\ \vdots & \ddots & \vdots \\ \rho_{m1} & \cdots & \rho_{mn} \end{pmatrix}$	=SQRT(MMULT(**W**, MMULT(**ρ** ,TRANSPOSE(**W**)))
Portfolio MVaR	$MVaR_P = \sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N} \rho_{i,j} w_i MVaR_i w_j MVaR_j}$	$\sqrt{\tilde{\mathbf{W}}\boldsymbol{\rho}\tilde{\mathbf{W}}^{\mathbf{T}}}$, where $\tilde{\mathbf{W}}$ is the vector matrix: $[w_1 MVaR_1 \cdots w_n MVaR_n]$	=SQRT(MMULT($\tilde{\mathbf{W}}$, MMULT(**ρ** ,TRANSPOSE($\tilde{\mathbf{W}}$)))

Appendix Table 1: Matrix Notation of the optimization portfolios

The computation of the optimization problems (minimizing the variance, VaR and MVaR, and maximizing the return, Sharpe and MSharpe) can be solved with Excel add-in Solver. Solver contains a range of iterative search methods for optimization. The Solver requires 'changing' cells, a 'target' cell for minimization/maximization and the specification of 'constraints' which act as restrictions on feasible values for the changing cells. The 'changing' cells are the cells containing the weights. The target cell contains the optimization problems. The tables below illustrate the calculation for the six asset classes (smoothed & unsmoothed), for several optimization portfolios.

[108] Jackson M. and Staunton M., Advanced modelling in finance using Excel and VBA, John Wiley & Sons, Ltd, England 2001.
[109] See section 4.3 for more details.
[110] When entering the formulas one needs to press Ctrl + Shift + Enter to be executed.
[111] The portfolio volatility is the square root of the portfolio variance.

Markowitz Portfolio Optimizer for Unsmoothed Asset Classes

MARKOWITZ PORTFOLIO OPTIMIZER UNSMOOTHED

Rf = 4,29%
Z VALUE= -2,33

ASSET ALLOCATION	X PORTFOLIO VOLATILITY	Y PORTFOLIO RETURN	MSCI Europe Index	Lehman Brother European Aggr Bond Index	Lehman Brother European High-Yield Index	GPR Index Netherlands	HFRI Composite FoF Index Unsmoothed	ROZ/IPD Unsmooted*	PORTFOLIO VaR	PORTFOLIO MVaR	PORTFOLIO SHARPE	PORTFOLIO MSHARPE
NO RESTRICTIONS												
MINIMUM VARIANCE	2,29%	5,69%	6,57%	75,69%	0,00%	0,00%	11,33%	6,42%	0,0668	0,0907	0,6113	0,1541
MAXIMUM RETURN	7,37%	9,59%	0,00%	0,00%	0,00%	0,00%	100,00%	0,00%	0,2678	0,3487	0,7193	0,1521
MINIMUM VaR	2,36%	5,83%	9,50%	70,86%	0,05%	0,00%	11,71%	7,87%	0,0650	0,0916	0,6539	0,1682
MINIMUM MVaR	2,31%	5,62%	7,32%	76,24%	0,00%	0,00%	7,93%	8,20%	0,0665	0,0895	0,5745	0,1483
MAXIMUM SHARPE	3,32%	7,24%	4,59%	42,67%	0,00%	0,00%	35,60%	16,95%	0,1175	0,1442	0,8889	0,2048
MAXIMUM MSHARPE	3,22%	7,03%	5,66%	45,50%	0,00%	0,00%	25,25%	23,60%	0,1104	0,1266	0,8512	0,2133
EQUAL WEIGHT	5,97%	7,02%	16,67%	16,67%	16,67%	16,67%	16,67%	16,67%	0,1741	0,2222	0,4571	0,1225

COVARIANCE MATRIX

ASSET CLASSES	MSCI Europe Index	Lehman Brother European Aggr Bond Index	Lehman Brother European High-Yield Index	GPR Index Netherlands	HFRI Composite FoF Index Unsmoothed	ROZ/IPD Unsmooted*
MSCI Europe Index	0,023680	-0,001693	0,008121	0,009592	0,000204	0,003534
n Brother European Aggr Bond Index	-0,001693	0,000905	0,000033	-0,000299	-0,000204	-0,000438
an Brother European High-Yield Index	0,008121	0,000033	0,012407	0,004932	0,000731	0,000286
GPR Index Netherlands	0,009592	-0,000299	0,004932	0,017163	0,000628	0,004030
FRI Composite FoF Index Unsmoothed	0,000204	-0,000204	0,000731	0,000628	0,005439	0,000736
ROZ/IPD Unsmooted*	0,003534	-0,000438	0,000286	0,004030	0,000736	0,008380

CORRELATION MATRIX

ASSET CLASSES	MSCI Europe Index	Lehman Brother European Aggr Bond Index	Lehman Brother European High-Yield Index	GPR Index Netherlands	HFRI Composite FoF Index Unsmoothed	ROZ/IPD Unsmooted*
MSCI Europe Index	1	-0,366000	0,474000	0,476000	0,018000	0,251000
n Brother European Aggr Bond Index	-0,366000	1	0,010000	-0,076000	-0,092000	-0,159000
an Brother European High-Yield Index	0,474000	0,010000	1	0,338000	0,089000	0,028000
GPR Index Netherlands	0,476000	0,076000	0,338000	1	0,065000	0,336000
FRI Composite FoF Index Unsmoothed	0,018000	-0,092000	0,089000	0,065000	1	0,109000
ROZ/IPD Unsmooted*	0,251000	0,159000	0,028000	0,336000	0,109000	1

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Markowitz Portfolio Optimizer for Smoothed Asset Classes

MARKOWITZ PORTFOLIO OPTIMIZER SMOOTHED

Rf =	4,29%
Z VALUE=	-2,33

ASSET ALLOCATION	X PORTFOLIO VOLATILITY	Y PORTFOLIO RETURN	MSCI Europe Index	Lehman Brother European Aggr Bond Index	Lehman Brother European High-Yield Index	GPR Index Netherlands	HFRI Composite FoF Index Smoothed	ROZ/IPD Smooted*	PORTFOLIO VaR	PORTFOLIO MVaR	PORTFOLIO SHARPE	PORTFOLIO MSHARPE
NO RESTRICTIONS												
MINIMUM VARIANCE	1,98%	6,40%	4,36%	61,06%	0,09%	0,00%	15,19%	19,30%	0,0791	0,0848	1,0677	0,2495
MAXIMUM RETURN	5,47%	9,81%	0,00%	0,00%	0,00%	0,00%	100,00%	0,00%	0,2235	0,2857	0,9731	0,1863
MINIMUM VaR	2,04%	6,24%	6,97%	62,12%	1,51%	0,00%	14,49%	14,92%	0,0778	0,0843	0,9546	0,2310
MINIMUM MVaR	2,03%	6,05%	6,07%	67,95%	0,00%	0,00%	10,45%	15,54%	0,0792	0,0823	0,8677	0,2137
MAXIMUM SHARPE	2,59%	7,90%	0,64%	29,62%	0,00%	0,85%	28,30%	40,59%	0,1098	0,1262	1,3944	0,2864
MAXIMUM MSHARPE	2,37%	7,55%	1,70%	36,17%	0,00%	1,55%	21,17%	39,41%	0,0999	0,1122	1,3718	0,2903
EQUAL WEIGHT	5,47%	7,08%	16,67%	16,67%	16,67%	16,67%	16,67%	16,67%	0,1603	0,2071	0,5099	0,1346

COVARIANCE MATRIX

ASSET CLASSES	MSCI Europe Index	Lehman Brother European Aggr Bond Index	Lehman Brother European High-Yield Index	GPR Index Netherlands	HFRI Composite FoF Index Smoothed	ROZ/IPD Smooted*
MSCI Europe Index	0,023660	-0,001663	0,009159	0,009589	0,000141	0,001602
n Brother European Aggr Bond Index	-0,001653	0,000905	0,000006	-0,000256	-0,000287	-0,000228
an Brother European High-Yield Index	0,008159	0,000006	0,012407	0,005023	0,000331	-0,000148
GPR Index Netherlands	0,009589	0,000256	0,005023	0,017163	0,000230	0,000992
HFRI Composite FoF Index Smoothed	0,000141	-0,000287	0,000331	0,000230	0,002950	0,000554
ROZ/IPD Smooted*	0,001602	0,000228	0,000148	0,000992	0,000554	0,001911

CORRELATION MATRIX

ASSET CLASSES	MSCI Europe Index	Lehman Brother European Aggr Bond Index	Lehman Brother European High-Yield Index	GPR Index Netherlands	HFRI Composite FoF Index Smoothed	ROZ/IPD Smooted*
MSCI Europe Index	1	-0,359501	0,476190	0,475843	0,016823	0,268009
n Brother European Aggr Bond Index	-0,359501	1	0,001761	-0,065071	-0,174757	-0,173379
an Brother European High-Yield Index	0,476190	0,001761	1	0,344237	0,054381	-0,030484
GPR Index Netherlands	0,475843	-0,065071	0,344237	1	0,032056	0,173253
HFRI Composite FoF Index Smoothed	0,016823	-0,174757	0,054381	0,032056	1	0,231798
ROZ/IPD Smooted*	0,268006	0,173375	0,030484	0,173253	0,231798	1