Predicting Private Equity Performance

The development of a private equity performance-forecasting model for AEGON Asset Management

Master's thesis

Author: Coen Tolkamp
Student number: 0006564
Final report: May 2007

University of Twente, Enschede
Professors: Dr. D. Dupont
Dr. B. Roorda

AEGON Asset Management, The Hague
Company supervisor: Drs. M. Entzinger

Predicting Private Equity Performance

The development of a private equity performance-forecasting model for AEGON Asset Management

Master's thesis "Industrial Engineering & Management"
University of Twente

Doctoraalprogrogramma Technische Bedrijfskunde
Universiteit Twente

Company:	AEGON Asset Management AEGONplein 20 2591 TV The Hague The Netherlands
Company supervisor:	Drs. M. Entzinger Portfolio Manager Alternative Investments +31 (0) 70 344 8717 mentzinger@aegon.nl
Professors:	Dr. D. Dupont d.dupont@bbt.utwente.nl Dr. B. Roorda b.roorda@bbt.utwente.nl
Student:	C.T. Tolkamp Herengracht 12 2511 EH The Hague The Netherlands +31 (0) 6 52657611 Student number: 0006564 c.t.tolkamp@student.utwente.nl ctolkamp@aegon.nl

“Fun, Friendship and Finance!”
(Sjors, 2002)

Management Summary

Private equity is a growing asset class and is renowned for its opaque characteristics. Being a large investor in private equity AEGON Asset Management is interested in macroeconomic factors that drive private equity performance. Evaluation and forecasting of private equity performance in two distinct geographic areas, Europe and the United States, are of key interest to AEGON Asset Management.

This research shows that it is reasonably well possible to evaluate and forecast private equity performance albeit under a series of assumptions and without back-testing results. The used estimation model based approach is constructed flexibly to adapt to more available information in the future. The validity of the results will increase with the availability of more quantitative and qualitative information on private equity (performance) and with improvements to the used algorithm.

Potential macroeconomic drivers are based on a literature search and the opinion of professional portfolio managers at AEGON Asset Management and external professionals. Aggregated private equity performance data of both the US and Europe is used as the basis for an estimation model to determine a “private equity index”. Linear regression is used to relate this index with the determined macroeconomic drivers.

The results of this research quantitatively confirmed the expectations of AEGON Asset Management about private equity: private equity performance is highly cyclical and thus depends strongly on economic conditions. This research was not aimed at determine risk adjusted performance or alpha performance. High yield credit spreads and stock market developments are important drivers / forecasting indicators for private equity performance.

A quadrant model has been developed for AEGON Asset Management. This is an automated tool to evaluate and forecast private equity annually or semi-annually. This tool is based on the results of the regression analysis.

Management samenvatting

Private equity is een groeiende asset class en staat bekend om haar ontransparante karakteristieken. AEGON Asset Management is als grote investeerder in deze asset class geïnteresseerd in macro economische factoren die private equity performance beïnvloeden. AEGON Asset Management is vooral geïnteresseerd in het evalueren en voorspellen van private equity performance in twee verschillende geografische gebieden: Europa en de Verenigde Staten.

Dit onderzoek laat zien dat het redelijk mogelijk is om private equity performance te evalueren en te voorspellen zij het onder een aantal aannames en zonder backtest resultaten. Het gebruikte schattingsmodel is flexibel geconstrueerd en kan zich aanpassen aan betere toekomstige informatie. De validiteit van de resultaten zal toenemen als er meer kwantitatieve en kwalitatieve informatie beschikbaar komt over private equity (performance) en met de verbetering van het gebruikte algoritme.

Potentiële macro economische factoren zijn gebaseerd op literatuuronderzoek en de inzichten van professionele portfolio managers van AEGON Asset Management en enkele externe partijen. Geaggregeerde private equity rendementen van zowel de Verenigde Staten als Europa zijn gebruikt als basis voor een schattingsmodel methode om een “private equity index” te bepalen. Lineaire regressie is gebruikt om de private equity index te relateren aan macro economische factoren.

De resultaten van dit onderzoek bevestigen kwantitatief de verwachtingen van AEGON Asset Management over private equity. Private equity performance is sterk cyclisch en dus sterk afhankelijk van macro economische factoren. Dit onderzoek is niet bedoeld om risico gecompenseerde rendementen of alfa rendementen bepalen. High yield credit spread en aandelenmarkten zijn belangrijke waardestuwers / voorspellende indicatoren voor private equity performance.

Een kwadrantenmodel is ontwikkeld voor AEGON Asset Management. Dit is een geautomatiseerde tool om private equity performance jaarlijks of halfjaarlijks te evalueren of te voorspellen. De tool is gebaseerd op de resultaten van de regressie analyse.

Preface

During the intense period of the last examinations of my graduation programme I solicited at AEGON Asset Management for a thesis project. This project concerned the attribution of macro economic performance drivers to private equity performance. I have a strong interest in the private equity asset class since I did an earlier internship at a corporate finance / merger & acquisition advisory organisation. I was aware of the potential pitfalls in researching private equity regarding the lack of appropriate information. Nevertheless this thesis project appeared to me a wonderful opportunity to learn more about private equity in combination with asset management so I gladly accepted the challenge.

After the initial phase of literature analysis and data collection I spent a long time determining an appropriate research method. This research lacked the data that is available to other academic researchers; this made it difficult to execute a straightforward analysis. The challenge of this research was to find a research method that could cope with the available data and the research objectives. After three attempts I created an alternative research method to attribute macro-economic performance drivers to private equity performance under a series of assumptions.

This research could not be completed without the help of several people. Since this thesis project marks the end of my study I would like to thank my parents who supported me and never lost confidence in me actually completing this study. I would like to thank my girlfriend, Martine, who supported me at all times, especially in the last period when I spent most of my time working and writing this thesis.

At AEGON Asset Management I would like to thank Michael Entzinger and Rutger Schreuder. Michael Entzinger, my company supervisor, helped me arranging private equity industry contacts, finding other information sources and helped me whenever possible. Michael and I held weekly sessions about the research developments, which were helpful to reflect on my progress. Other colleagues at AEGON Asset Management helped me with gathering useful information as well and provided a pleasant and interactive working environment.
I would like to thank Sam Robinson, from SVG Capital Plc, for providing the most important information for this research: private equity performance data! Without this information I could not perform this research at all.

Last but not least I would like to thank Dominique Dupont and Berend Roorda, my professors from the University of Twente, who took the time to understand my estimation model, gave me valuable feedback during several meetings and stimulated alternative research methods.

I hope that one, after reading this thesis, better understands private equity in an asset management environment and finds that alternative research methods can provide a useful perspective in the absence of extensive information.

Coen Tolkamp
The Hague, May 2007

List of figures and tables

Table of contents

Introduction

What drives private equity performance? And how do certain factors influence private equity performance? These questions are stated by AEGON Asset Management in the perspective of the US and European private equity markets. The ultimate objective of this research is to construct a model that evaluates and forecasts private equity performance based on macro-economic parameters.

This research report is structured as follows to provide answers to all questions of AEGON Asset Management regarding private equity.

First a general of AEGON is given in Chapter 1. This chapter presents the organisational structure of AEGON, AEGON Asset Management and the Alternative Investments team. This chapter will also give a general introduction to so-called quadrant models. This is a modelling philosophy used by AEGON Asset Management and is a blueprint for the private equity quadrant model, which is developed in this research.

Chapter 2 describes explicitly what the research background of this research is, culminating in two research objectives.

Thirdly, a thorough background on private equity as an asset class is given in Chapter 3. All private equity characteristics and risk and return properties are discussed. This chapter is especially interesting for people that are not familiar with private equity in general.

In Chapter 4 and Chapter 5 private equity risk and return characteristics are discussed in a CAPM and portfolio management perspective. These chapters analyse private equity with conventional finance theories and methodologies.

The 6th Chapter evaluates private equity literature that relates private equity performance to macro-economic drivers. This chapter discusses the research methods in literature and gives an overview of all performance indicators that will be used in this research.

Chapter 7 describes the methodology used in this research. The results of this research hold under a series of assumptions. The research results are presented in Chapter 8 and the construction of the quadrant model is given in Chapter 9.

Chapter 10 and 11 will respectively present the conclusions and recommendations of this research. The final chapter, Chapter 12, will give a personal reflection on this research and gives the reader a more personal insight of the important graduation period.

Chapter 1: AEGON

AEGON is one of the world's largest listed life insurance and pension companies and an important provider of investment products. AEGON is mainly active in the Netherlands, the United States and the United Kingdom. Besides these main markets, AEGON is also active in a number of other countries including Canada, China, Poland, Slovakia, Spain, Taiwan and the Czech Republic. Headquartered in The Hague, the Netherlands, AEGON employs approximately 27,000 people worldwide. Total revenues in 2005 were EUR 30.3 billion and the income after tax was EUR 2.7 billion.

AEGON serves both private individuals and corporate clients like SME's (Small / medium enterprises), large companies and pension funds. The products AEGON offers range from collective and individual pensions, life insurance, indemnity insurance, social welfare insurance, wealth management to saving and investing.
(Source: annual report 2005 AEGON)

Originally AEGON started in 1759 in Haarlem, the Netherlands, where one of its predecessors, called "De Broederlijke Liefdesbeurs" started the first cooperative funeral insurance company in the Netherlands. After merging in a larger entity, called "De Groot-Noordhollandsche van 1845", of life insurers, funeral funds, widow funds, social welfare insurers and endowments, this group became one commercial enterprise in 1983.
The name AEGON incorporates the characters of 5 of its most important predecessors: "Algemeene Friesche" (1844), Eerste Nederlandsche"(1882), "Groot-Noordhollandsche" (1845), "Olveh" (1879) and "Nillmij"(1859). After the last merger, between the cooperative "AGO" and the listed company "ENNIA", the name AEGON was born. The name AEGON would be a "Greek name with a classy charisma: reliable, correct and solid". [1]

AEGON The Netherlands consists of 5 service centres (or business units) for administrative organisation and product innovation. These service centres are: Life Insurance (life insurance, mortgages and funeral insurances), Banking (savings and investing), Asset Management (asset management), Pensions (individual and collective pensions) and Non-life insurance (social welfare insurance and indemnity insurance). The service centres provide the sales organisation with new products, services and take care of the contract administration.

AEGON The Netherlands employs approximately 5690 people. The head office is located in The Hague. Total revenues in The Netherlands were EUR 6.1 billion in 2005.

[1] Source: corporate website of AEGON, the Netherlands

1.1 AEGON Asset Management

Like other large insurance companies AEGON N.V. has its own asset management services. Being a multinational company there are several business units at AEGON N.V. that execute asset management services. AEGON USA and AEGON UK have their own asset management business units that serve these geographic areas. In the Netherlands, AEGON Asset Management in The Hague and TKPI in Groningen execute asset management services.

AEGON Asset Management in The Hague serves internal clients and external clients. Internal clients provide insurance premiums and products that need to be invested in all kinds of assets depending on insurance mandates. External clients are mostly institutional clients such as pension funds and a minority of investments are for retail clients.

AEGON Asset Management is a business unit of AEGON Nederland with approximately 125 employees. The figure below presents the organisational chart of AEGON Asset Management with all functional and servicing departments or teams.

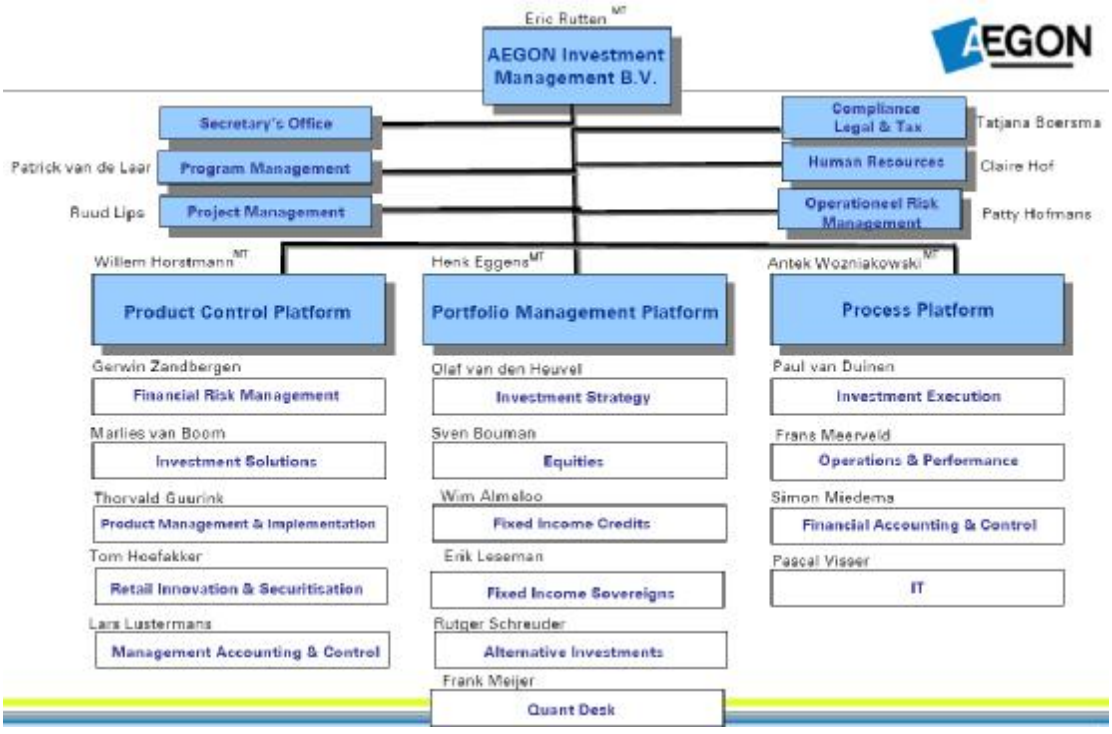


Figure 1 Organisational chart AEGON Asset Management

AEGON Asset Management (functional name) or officially AEGON Investment Management B.V. consists of three functional groups: Product Control Platform, Portfolio Management Platform and the Process Platform. The Product Control Platform is responsible for new and existing asset management products for internal and external clients. The process platform is the back-office of AEGON Asset Management and is responsible for all supporting processes in the entire business unit. The Portfolio Management Platform is responsible for all assets under management. An in-depth analysis of all departments or teams will not be given here.

Depending on desired risk / return and liquidity preferences clients of AEGON Asset Management can choose from a large range of different funds to invest their capital in. These funds have different mandates that impose restrictions on the investments regarding asset classes, benchmarks, accounting & tax benefits, allocation limits, etc. For large institutional accounts funds are constructed upon request and designed according to specified desired mandates. At AEGON Asset Management the Product Management & Implementation team designs these funds.

The different investment categories or asset classes at AEGON Asset Management are managed by the different departments or teams at the Portfolio Management Platform. The Equities team is responsible for European and Asian equity investments. The Fixed Income Credits team is responsible for investment grade and high yield corporate bonds (global focus). The Fixed Income Sovereigns team manages governmental bonds (global focus). The Investment Strategy activities will be described in the Quadrant models section. The Quant Desk is responsible for data analysis and decision model development for the different teams at the Portfolio Management Platform. The Alternative Investments team is mainly responsible for fund-of-fund investments in hedge funds and private equity. This team will be described in the next section.

1.2 Alternative Investments

The Alternative Investments team consists of two separate functional groups: *Derivatives, Hedging and Fund Management* and *Alternative Investments*.

The former is a group that performs a range of tasks that are not covered by other teams within AEGON Asset Management. These tasks comprise of foreign exchange risk hedging for (international) equity portfolios, execute liquidity management and the development of hedging solutions for fund management.

The latter is the group that coordinates private equity and hedge fund investments at AEGON Asset Management. These investments are not direct investments. The investments are indirect via a fund-of-fund concept. This means that AEGON invests in diversified portfolios of funds managed by a fund-of-fund manager. The Alternative Investments team selects the fund-of-funds manager, monitors the managers and reports to AEGON on the private equity portfolio under management. The private equity investments are Europe-based. The hedge fund investments are mainly exposed to US and European markets.
The Alternative Investments team is currently orienting towards single fund investing and focussing on other alternative asset classes such as timber funds and infrastructure funds.

1.3 Quadrant models

At AEGON Asset Management so-called quadrant models are used for the decision making process concerning asset allocation. The quadrant models are used at different levels of asset allocation. Below a figure present the general outlay of a quadrants model.

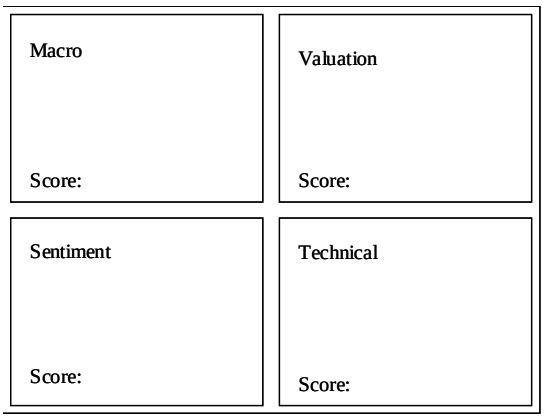


Figure 2 General outlay quadrant model

Quadrant models are used in several forms but have the same underlying framework. First the underlying systematic will be discussed and subsequently the different forms of quadrant models.

Investment decisions are based on numerous aspects. To structure this decision process at AEGON Asset Management quadrant models have been introduced. Quadrant models consist of four quadrants or four decision categories. The four decision categories are: macro, valuation, sentiment and technical. The macro and valuation quadrant are used for long-term indicators and the sentiment and technical quadrant contain short-term indicators. The macro quadrant usually contains macroeconomic indicators such as inflation, industrial growth and GDP growth. The valuation quadrant usually contains valuation indicators such as price/earnings ratios or liquidity premium proxies. The sentiment quadrant contains indicators that are believed to drive market sentiments such as IPO numbers or headlines in news papers. The technical quadrant incorporates technical analysis components of an investment decision. The macro-, valuation- and technical quadrant are usually driven by quantitative information. (Sentiment factors, often hard to define quantitatively, are qualitatively defined in the sentiment quadrant.)

The different quadrant model forms which will be described hereafter apply scores per quadrant ranging from -2 to +2 depending on the performance of the particular indicators on market or asset conditions. The total quadrant model consequently has a score ranging from -8 to +8. With -8 being the worst score and + 8 being the best score for an asset (class) or market. These scores are used to *forecast* and *evaluate* performance of a certain market or asset (class) over a certain time period. Some quadrant model forms are used daily (individual asset classes), monthly to yearly (tactical asset allocation) and some for even longer periods (dynamic strategic asset allocation).

Investment decisions are based on these scores and the relative scores in a certain timeframe (being a day, a month or even a year). For example, a stylised application could be: “The quadrant model of European equity markets indicated a score of +5 for the coming year (2007) compared to +4.5 of 2006, this increase is largely driven by a stronger macro quadrant. Low inflation and strong employment rates indicate a good year for the European equity market.” Maybe the Asian equity markets have a less fortunate forecast for coming year and on the highest portfolio level European equity markets are overweighed compared to Asian equity markets.

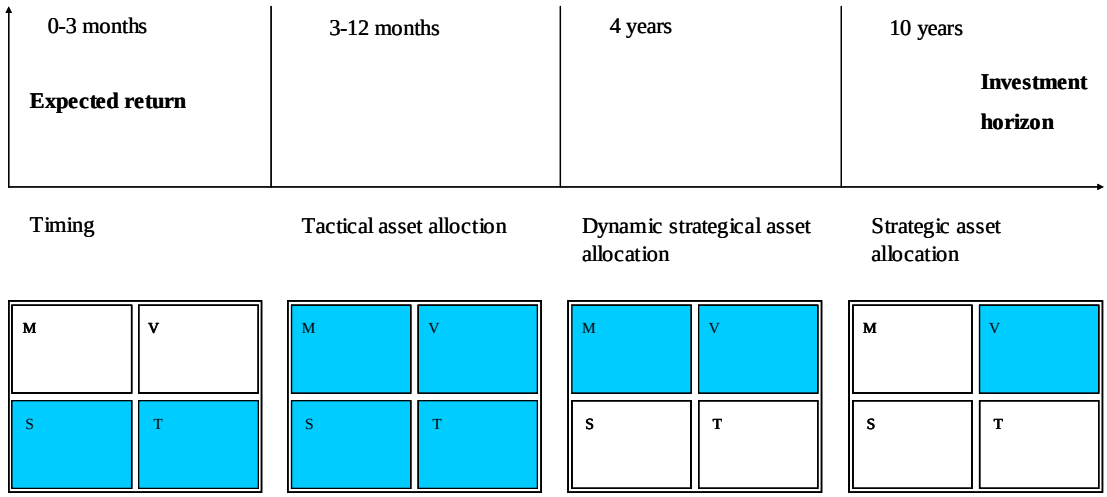


Figure 3 Quadrant models with different time horizons

The figure above represents the different quadrant model forms used at AEGON Asset Management. As one can see, the different forms are used for different time periods.

The strategic asset allocation is a very long-term decision tool and is only based on the valuation quadrant. The main question is: how much value does every asset class add to the total portfolio over the very long term? The Investment Strategy team at AEGON Asset Management tries to answer this question. Obviously this is not a very realistic question for asset management since performance over such a long period is generally hard to predict for asset managers! Therefore the dynamic strategic asset allocation forms the basis for strategic asset allocation.

The dynamic strategic asset allocation is usually based on macroeconomic reports. AEGON Asset Management publishes a quarterly and yearly macroeconomic report with long-term scenario forecasts. This outlook contains AEGON’s view on global markets and reports expected return, expected volatilities and correlations of all asset classes (equities, bonds, commodities, real estate, hedge funds, emerging market debt etc). Combined with international reports and the Global Fixed Income Strategy report (a combined report of TKPI in Groningen, AEGON Asset Management in The Hague and AEGON Asset Management in the US) the yearly macroeconomic report is used as input for the dynamic strategic asset allocation quadrants model. This results in a medium term asset allocation (1-4 years) for the total investment portfolio of AEGON Asset Management. For this decision process only the macro and valuation quadrant, both consisting of long term indicators, are used. This decision process creates the possibility to upgrade or downgrade portfolio weights and is executed by the Investment Strategy team.

The tactical asset allocation also depends strongly on macroeconomic views of the various reports. This process is used to add value across assets classes (for example stocks versus bonds) and within asset classes (regional or country allocation in stocks) over a longer time period (3-12 months). Tactical asset allocation is executed by the Investment Strategy team with the use of the tactical asset allocation quadrant model. This quadrant model uses all four quadrants for its forecasts.

Timing quadrant models are used to evaluate and forecast most asset classes also called "timing" asset classes. Liquid asset classes such as stocks and (corporate) bonds are timing asset classes and are evaluated on a daily basis or longer ranging from 0-3 months. For such short forecasting periods, the short-term focus becomes more important and therefore usually the sentiment and technical quadrants are leading.

Illiquid asset classes, the focus of this research, are obviously not a timing asset class. Due to illiquidity issues purchase and selling decisions are not executed in short-term periods. Especially private equity investments are long term investments and decisions concerning this asset class are only made at the strategic asset allocation level. Forecasting and evaluating private equity performance is only reasonable over longer periods, such as a year.

The last three quadrant models in the figure are used by the Investment Strategy team. This team is responsible for strategic portfolio management. This means that this team determines the long term asset allocations of the different asset classes at AEGON Asset Management.

The first model, meant for timing asset classes are used by the different asset class teams at AEGON Asset Management. Portfolio managers run quadrant models daily, weekly or monthly depending on the preferred decision support.

Chapter 2: Research formulation

2.1 Problem identification

Like other asset management teams at AEGON Asset Management, the Alternative Investments team wants to gain more insight in their alternative investments portfolio. Unlike other asset classes, industry information and academic research is not as widespread as with other asset classes. Hedge funds and private equity funds are both relatively young asset classes that are developing and are regularly related to controversies.

Besides the controversies both hedge funds and private equity funds are said to offer favourable risk / return properties. Other relevant aspects of hedge funds and private equity are that these funds are said to offer positive returns independent of market movements. Low correlation with general market movements is a desired property for diversifying market portfolios.

The characteristics of private equity, the risk / return properties, its dependency on market conditions and its correlation with other asset classes and macro economic variables are of interest to Alternative Investments.

As mentioned before AEGON Asset Management uses quadrant models for the evaluation and forecasting of asset class performance. Currently Alternative Investments only uses a qualitative quadrant model for private equity.

Asset management and portfolio management are always viewed in a risk / return perspective. This research only focuses on returns and forecasts of returns. The model developed in this research will not specifically generate risk forecasts. On the strategic level of portfolio management at AEGON Asset Management a certain allocation is assigned to private equity. If that allocation is determined it is very important that the allocated capital is monitored closely. Risks are minimised within the private equity allocation by diversification over managers, geographic regions and different years. For portfolio management it is important to understand what influences private equity performance in a macroeconomic perspective.

Private equity is not a so-called timing asset class, it is not possible to invest today and sell tomorrow or in three months. Nevertheless, a quantitative analysis of how the market conditions influence private equity performance can be useful for long-term decision-making processes.

With the problem identification in mind the main research goal is stated as follows:

Develop a quantitative quadrant model for private equity performance.

The goal of this research is translated into a research problem:

How can private equity performance be forecasted quantitatively?

It is not the intention of AEGON Asset Management to evaluate individual funds or specific sectors. The research is meant to forecast private equity performance in general or otherwise in a large geographical perspective, for example the United States and Europe. Therefore the quality of fund managers, the sector focus or other fund specific aspects is not included in this research.

Based on the research problem several sub-problems are identified:

- What are performance drivers for private equity?

- What private equity performance data is available to AEGON Asset Management?
- What is an appropriate research method to relate private equity performance data to performance drivers given the availability of private equity performance data?
- What is the reliability of the forecasting method?

2.2 Research approach

To find an answer to the research problem and the additional sub-problems two research objectives are stated to structure this research.

Find relevant performance drivers for private equity.
This objective requires analysis of the private equity industry and relevant academic literature. Specific characteristics of the private equity industry as well as risk / return properties are analysed. In this analysis research methods in literature are discussed.

Find and use an appropriate research method to forecast private equity performance.
Based on the results of the first objective a research method is to be specified. Private equity industry characteristics, data availability and research methods used in literature have a large influence on the research method used. This method should be able to reliably relate macroeconomic factors to (future) private equity performance.

The results from both objectives are used as input for the goal of this research: the development of a quantitative quadrant model for private equity. This quadrant model assigns values to different forecasting factors and each quadrant gives a private equity performance forecast for six months to one year based on its unique set of factors. It is not the goal of the quadrant model to find one single measure of expected future performance.

Chapter 3: Private equity characteristics

3.1 Introduction

In the search for risk diversification or return enhancement, institutional and other investors are always looking for new opportunities. Easier access, ICT developments, globalisation, increased liquidity, an increased product offering and a growing complexity characterise the financial markets in the past two decades. All these developments are driving new investment opportunities. These new opportunities are offering risk / return characteristics that are appealing but sometimes are complex to understand. In this relatively young asset class, also known as alternative investments, private equity and hedge funds are the most prominent categories. Other alternative investments are for example commodities, real estate, infrastructure, timber or carbon emission trading. These investments are not discussed in this research.

These investment categories are said to offer a different alpha / beta exposure compared to traditional asset classes. Beta exposure indicates how sensitive security returns are towards general market movements. Alpha exposure indicates that a part of a security returns are independent of market movements.

Institutional investors are always looking to outperform certain benchmarks. Currently, institutional investors are very interested in alpha exposure, adding value independently of market movements is an appealing idea when trying to deliver strong positive returns. Due to the illiquidity and opacity of the alternative investment categories it is not always easy to determine whether institutional investors face alpha or beta exposure.

Hedge funds offer a wide range of trading strategies based on bonds, stocks, futures, interest rates and commodities which are able to generate returns in both up and downwards markets. This asset class is best known for its alpha exposures. Hedge funds are among the most complicated asset classes due to opacity and complexity of trading strategies. Some trading strategies are even controversial. An example of controversial hedge fund strategies are the “activist-fund” strategies. These funds use activist shareholder methods and publicly “attack” listed companies. Recent examples are Paulson and Centaurus targeting Stork N.V. or TCI targeting ABN Amro. For a more detailed discussion on hedge funds I refer to Nicholas (1999).

Private equity funds are topic of this research. Whereas hedge funds are based on shorter term trading strategies, private equity funds are focusing on long-term value creation. Just like hedge funds, private equity funds do not have undisputed reputations. The historical evolution of this alternative investment category has known some controversial activities as well. In the search for cost-reductions private equity funds could sell real estate and fire employees. The use of considerable amounts of debt to structure transactions is also a well-known argument against private equity. In the next sections the characteristics of private equity will be discussed.

3.2 Definition

What is private equity? In essence private equity is the universe of all privately held equity stakes. Usually private equity is not associated with all privately held equity stakes.

The EVCA, the European Venture Capital Association uses the following definition for private equity: “Private equity is the universe of all Venture and Buyout investing, whether such investments are made through funds, fund of funds or secondary investments”.

Venture capital funds invest in companies that are in the first phases of the company life cycle. These funds invest in and support young entrepreneurial companies, which often do not generate profit or even sales yet. There is a low emphasis on active management of the portfolio companies by the venture capital fund. These funds invest in approximately in 20-40 companies during their lifetime.

Buyout funds invest in more mature companies with steady (free) cash flows. Free cash flows can be defined as the cash flows that remain after all projects with a positive net present value are financed. Compared to venture capital funds there is more emphasis on active management of the portfolio companies. These funds invest in 10-15 companies during their lifetime.

Other forms of private equity funds are related with mezzanine financing or distressed securities financing. These latter categories will not be discussed because of their minor importance in the private equity industry.

3.2.1 Venture capital funds

Venture Capital (VC) funds often specialise in different stages of the company life cycle. A venture capital fund can also lead a young company through the different phases depending on the performance and potentials. Usually venture capital funds hold minor equity interests.

VC funds are considered to be the riskiest investments in the private equity industry. The target companies are small and not well diversified. The value created by VC funds is based on finding the best potential revenue generating ideas and companies. By accumulating a portfolio of these companies, the probability that one or more of the portfolio companies will grow exponentially increases. The few successful companies are the value generators for VC funds.

VC funds can be distinguished by the maturity of the target companies:

- *Seed stage*: Investments in the seed stage are meant for research & development and prototype development. This phase is the predecessor of the early stage phase.
- *Early stage*: In this phase marketing and product development are the important activities that need financing. Sales and thus profit are not generated yet.
- *Late stage*: This phase requires financing for expansion and growth. The company is breaking even and needs financing for production capacity or working capital. Product or marketing development activities could require financing as well.
- *Expansion capital*: The company reaches maturity and other investors purchase a minority of shares. The majority of shares are still owned by the company founder.

3.2.2 Buyout funds

Where venture capital funds end financing, at the maturity of companies, buyout funds start financing. Buyout funds usually acquire the majority of shares of mature companies with steady free cash flows. These cash flows are essential for the repayment of debt. In essence the companies repay the debt used for their own acquisition. The target companies are often

restructured or strategically repositioned. After a few years the target company will be sold by the private equity fund.

This mechanism of buying, reorganising and selling of companies obviously creates different risk and return properties than ordinary stocks have. Industry professionals often relate the skills of the private equity fund manager to alpha generating capabilities. Due to the lack of appropriate market information it is debated if private equity funds generate alpha at all.

In this research the definition of private equity is narrowed to buyout funds only.

3.2.3 Fund Structure

A private equity fund is a financial vehicle (Limited Partnership) that invests in companies during a limited time period of in general 10-12 years. After a fund raising period, the private equity fund closes and new entrants are not allowed. It is also not allowed to leave the fund once you are in. After this initial period, the private equity fund starts investing in companies. If the general partner (GP) finds investment opportunities, he will give a *capital call* to each of the limited partners (LP), the investors. At that moment the LP's are obliged to submit a portion of their commitment. If a portfolio company is sold the revenues are distributed to the limited partners. The *vintage year* of a fund marks the start of the funds investing activities.

The general partner usually earns management fees and a performance incentive, also known as a *carried interest*. The carried interest is based on value growth beyond a certain level, the *hurdle rate*.
The mandate of the limited partnership arranges aspects of the investment scope, commitment features and financial agreements. Typical aspects are: the geographical investment scope, the frequency and magnitude of capital calls, the specific sector focus, type of deals, type of exit strategy etc. The fund is usually structured to benefit the investor in terms of tax regulations and legal jurisdictions. To prevent an additional tax layer the fund is based on a transparent limited partnership.

There are several ways to invest in private equity. A direct investment in private equity means that you select and invest in companies yourself.
An indirect investment in private equity is established with a private equity fund. A fund manager (the GP) controls the fund you are investing in. This construction inevitably requires a management fee.
The most indirect approach is the fund-of-fund investment. A fund-of-fund manager selects private equity funds for investors. A disadvantage of this construction is that it requires a double fee layer. The advantage is that your investment in private equity is well diversified over different vintage years, geographies and possibly different stages and phases.

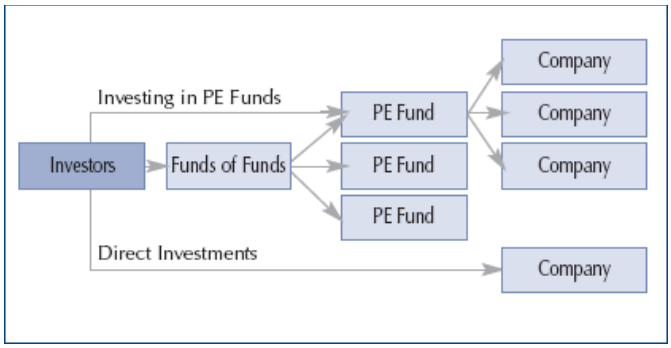


Figure 4 Direct and indirect private equity investing

Some investors prefer publicly listed private equity vehicles because of liquidity issues. A disadvantage of listed private equity vehicles is that their stocks usually trade at a discount to the Net Asset Value (NAV) of the underlying fund. These stocks are also highly correlated to stock market movements, a potentially undesired characteristic.
The secondary market for private equity investments or even entire private equity portfolios is developing but mostly offer unfavourable conditions to sellers.

3.3 Historical development

The first private equity funds date back to 1945 and 1946. The Industrial and Commercial Finance Corporation was the first official private equity fund, founded in 1945 in the United Kingdom. This fund still exists under the name Investors in Industry or 3i and is a large player with thousands of companies in its portfolio. One year later, the first United States private equity fund, Whitney, was founded.

The private equity industry has grown significantly since that first period. Governments stimulated the availability of capital for small businesses in the post war period. In the 1970's the legal possibilities increased by the introduction of the limited partnership construction. With this limited partnership construction and the regulatory changes for banks and pension funds in the 1980's, the private equity industry really started to grow in size. In this period, large institutional investors took over the role of private individuals in investing in private equity. In the 1980's the industry became generally known when large takeovers were executed by private equity funds. After a small recession in the early 1990's, the number of private equity funds increased enormously in the late 1990's. After the "internet-bubble" in the year 2000, the private equity industry and its venture capital category experienced a few hard years. However, the industry has showed its resilience, mostly based on global macro economic growth.[2]

3.3.1 The development of private equity strategies in the past 25 years

According to Smit (2002) the strategy of private equity funds evolved in the past decades. In the 1980's, highly leveraged buy-outs were the main method for private equity funds to earn money. A short-term profit making focus was the main driver for the industry. This resulted in a bad reputation for the private equity industry. In 1992, at the peak of this development,

[2] Source: Robeco research paper

private equity strategies started anticipating more on growth. Instead of being aggressive takeover firms, private equity cooperated with the takeover target and invested in growth with capital, management advice and business network support. A more long-term vision replaced the short-term money making vision. At the end of the nineties in the last century, strategic industrial players became fierce competitors for private equity funds. Private equity funds turned their growth strategy into a buy-and-build strategy. Private equity funds may for examply purchase several companies and ultimately merge them in one consortium with the objective to create added value.

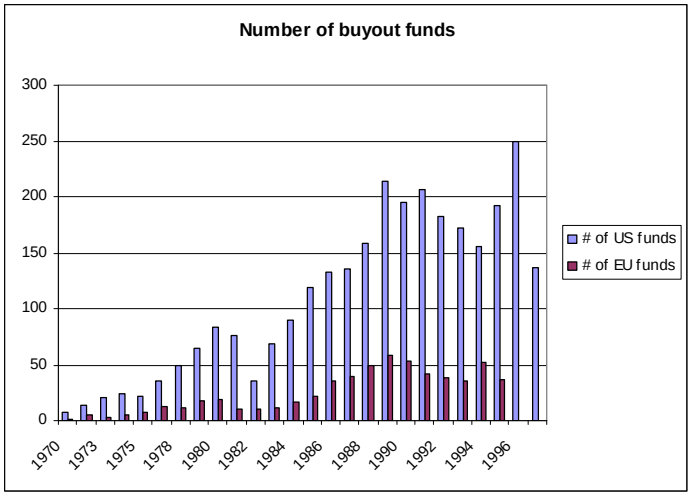


Figure 5 Number of buyout funds (US and Europe)

3.4 Fund lifecycle

The lifecycle of a private equity fund consists of 4 phases that are overlapping. All of the four phases are crucial to the performance of a private equity fund. In the next section all phases with their specific characteristics will be described.

3.4.1 Fundraising phase

The fund raising phase starts the cycle. Without funds a private equity fund is not able to invest. This phase normally takes between half a year and two years.

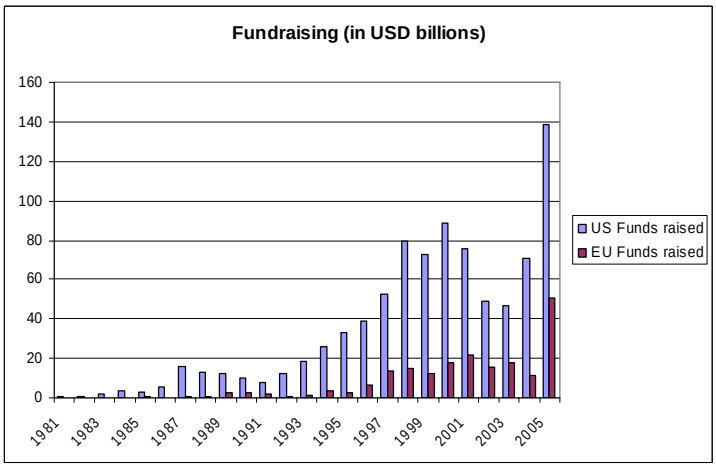


Figure 6 Fundraising buyout funds (US and Europe)

3.4.2 Investing phase

After the fundraising phase private equity funds start investing. The investment phase can last up to 6 years. The target companies are either publicly listed or privately held. If companies are publicly listed, private equity funds preferably delist these companies.

Usually private equity funds use debt to finance their acquisitions. So for successful investing, private equity funds rely in this phase on favourable market conditions to purchase debt and to acquire a company. Short-term and intermediate-term interest rates for low-grade bonds are the most important factor in this phase.

3.4.3 Holding phase

The phase between investing and divesting is called the holding phase. In this phase the target company is restructured or strategically reoriented. Aim of a private equity fund is to create shareholder value in this phase. In this phase the private equity fund, as a large (or largest) shareholder, has a large influence on the management of the company. With this influence the private equity fund tries to maximise the value of the target company. The factors described below are only important in the holding phase of the private equity fund.

According to Van der Wurf & Mertens (2001) private equity funds create shareholder value with three different factors: stakeholder, operational and financial factors.

3.4.3.1 Stakeholder factors

According to the agency theory there is a distinction between management and the shareholders. The agent, the management, makes the operational decisions for the principal, the shareholders. The interests of the management may not comply with the shareholders' interests. Due to these potential conflicting interests agency costs will emerge like monitoring costs and bonding costs. Bonding costs are costs that arise from legal issues between the principal and the agent.

In a leveraged buyout (LBO) the management usually gets a stake in the new company. In the new situation the management's interests are aligned with that of the new shareholders, the private equity fund. In this situation no costs are related to the principal-agent problem.

The management of companies usually has an information advantage compared to its current shareholders. Due to this information asymmetry the management could be able to buy the company (with the help of a private equity fund) because of hidden value unrecognised by the current shareholders (Van der Wurf & Mertens (2001)).

3.4.3.2 Operational factors

After alignment of interests the management will focus more on profitability (instead of growth by acquisitions). This focus is driven by management equity stakes and interest / redemption of the debt burden used for the acquisition. Non-core activities (and sometimes real-estate) will be sold.

With active cost management and working capital management the productivity of leveraged buyouts is usually higher than before the LBO. Higher profit margins, higher capital

investments, higher turnover per employee and a more efficient use of working capital are measured indicators in reported research (Van der Wurf & Mertens (2001)).

3.4.3.3 *Financial factors*

Short-term cost management is used to serve the debt; this increases efficiency of a company. Ultimately this short-term cost management will be the basis for long term performance. This last statement has not been confirmed in literature yet.

High financial leverage used in the acquisition requires management to make value creating decisions and efficiency improvements. The capital structure of the company will be improved and non-core activities will be sold. High interest and redemption costs will affect the resilience of a company. This can be compensated by the increased operational efficiency.

The free cash flow theorem states that managers try to invest as much as free cash flow as possible in new investment projects because their bonuses are related to company size. The free cash flow is defined as the remaining cash flow after all investment projects with positive net present values are financed. By financing an LBO with debt, the free cash flow will be minimised and this will prevent managers from investing and making acquisitions (Van der Wurf & Mertens (2001)).

3.4.4 Divesting phase

From year 3 private equity funds start divesting up to the last year of the funds lifetime.

An exit of the companies is either done by an Initial Public Offering (IPO), a trade sale, a secondary buy out or even a write off. A paradoxical result could be a delisted company that is brought back to the stock market by a private equity fund.

An IPO is not a commonly used exit route. Only experienced private equity funds use this (expensive) exit route if the market conditions are favourable. IPO's are usually clustered in small time intervals with strong market sentiments often related to strong stock market performance. An IPO could generate significantly more value for the private equity fund than other exit routes.

A trade sale, or an exit via a strategic buyer, is the most preferred exit route. This route usually generates the best value compared with the internally reported value.

A secondary buyout is used when an IPO or a trade sale are not available options. A secondary buyout is the sale of a company to another private equity fund. A secondary buyout will generate less value compared to an IPO or a trade sale. A lack of trade sale and IPO opportunities and the increase in private equity investments created an increase in popularity of this exit route in the past 5 years.

3.5 Cash flows

Unlike stocks or bonds there is no continuous trading in private equity funds. Because continuous trading does not exist, prices or valuations are not available at any given moment. Usually private equity funds provide financial information on a quarterly basis. This information is only meant for LP's and not for public markets. This financial information

includes the valuation of the current portfolio, which is a subjective figure. The financial information is not broadly available in the market, which is a specific characteristic of private equity. This makes it hard to do quantitative performance research on private equity. Jenkinson (2006) and others acknowledged this issue and this is still a big challenge in researching this asset class.

For LP's it is difficult to measure performance of their private equity investment. Besides the fact that the portfolio of companies is valued subjectively, the timing and magnitude of capital calls and the timing and magnitude of return distributions are often unknown. These capital calls and return distributions are usually analyzed in a *cash flow* framework to measure performance. Of course market and deal conditions combined with the quality of the private equity fund influence these uncertain distribution properties.

3.5.1 Private equity phases and the J-Curve

Every phase in the private equity lifecycle has a distinct effect on the cash flow pattern of a private equity fund. The investment phase obviously generates negative cash flows. When the fund starts divesting, positive cash flows are generated. When both cash flow sequences are combined a net cash flow sequence emerges. A private equity fund can also be characterised by its Net Asset Value (NAV) pattern. The net cash flow pattern of a private equity fund is often called the J-Curve. In the figure below a stylised J-curve is presented.

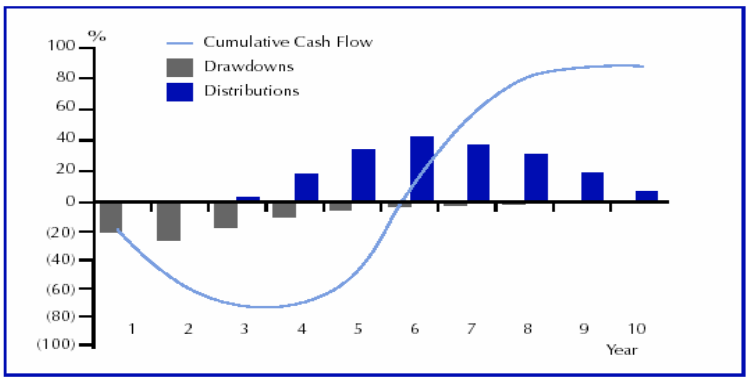


Figure 7 J-curve private equity

Only fully liquidated funds have a determined performance measured by the Internal Rate of Return (IRR) or a multiple. For funds that are not liquidated yet, the performance is calculated based on the investments and divestments so far and the reported estimated NAV. The companies in the private equity fund portfolio, or the NAV, are valued by the general partner on a quarterly basis and provide an indication for future cash flows. Valuing companies is an arbitrary exercise. The GP could provide too positive or too conservative valuations to the fund's LP's and this distorts performance measurement for the LP's.

3.5.2 Company valuation methods

Private equity funds frequently value their portfolio to inform the limited partners. With this valuation the limited partners can evaluate the value development and "performance" of their investment. Private equity funds use the NAV metric to indicate the value of the companies in portfolio. Obviously, the portfolio companies are not sold yet and the determined valuation

does not need to be equal to the price offered by the market in case of an exit. Ergo, valuing companies is a subjective matter and evaluating performance based on subjective valuation requires caution.

A vast body of literature is written on valuing companies. Both professional and academic literature provides a range of valuation techniques and methodologies. The next section will classify the most commonly used methods for valuing companies. Key determinants in using a certain valuation method are expected growth, the size and maturity of a company.

Corporate finance professionals usually use several methods parallel and generate a certain bandwidth for the value of a company. This bandwidth is based on unfavourable, intermediate and favourable future scenario forecasts.

Asset valuation and income valuation are the two main approaches for valuing companies. (Source: http://www.ventureline.com/bizval.asp) The former method will be treated first and subsequently the latter. The two main approaches are not inflexible; they can be combined to improve the valuation. A third approach is based on company comparisons, also known as "multiple-analysis", which will be described as well.

3.5.2.1 Asset valuation

Asset valuation uses mainly the balance sheet as a foundation for the company valuation. Traditionally this was the only method of valuing a company. In the early days, you only used the book value of assets minus debts and that was the value of a company. Asset valuation is still based on this basic principle but new (additional) methods have been developed. The adjusted book value method, economic balance sheet method and the liquidation method are examples of the extended book value method.

3.5.2.2 Income valuation

Income valuation uses the P&L account for valuation calculations. The methods based on income valuation analyze the cash flow and profit generating abilities of a company. Methods in this category are: capitalization of earnings, discounted future income, discounted cash flow and the economic income method.

3.5.2.3 Multiple analysis

The previous two methods were implicit methods. The valuation is based on internal, company unique information. This method, the multiple analysis, is an explicit method that compares certain profit and sales multiples with comparable publicly listed companies. For this analysis, comparable companies preferably are from the same industry and have the same size and maturity.

3.5.3 Remarks

It is beyond the scope of this research to give a thorough analysis of the methods mentioned, for more information on this subject I refer to Brealey & Meyers (2003). It is important to understand that there is no general rule for determining the value of a company, which gives room for subjective valuations. The uncertainty of subjective valuations will affect the way private equity performance is measured.

3.6 Private equity performance measurement

This research focuses on factors influencing future performance of private equity. For this reason it is of key importance to have methods to measure private equity performance. Measuring private equity performance is not straightforward and not immediately comparable with other (more liquid and publicly listed) asset classes. The next section will describe several performance measurement methods with their (dis-) advantages. Usually several methods are used to measure and present private equity performance, in this way the disadvantages of each method are diminished.

A simple but effective private equity performance measurement method is the multiple method. The multiple is the ratio of the cash inflow and the cash outflow. If this multiple is larger than one, the private equity fund has created value. Usually when investments are held for longer periods the private equity fund is able to create more value. The related distributions are larger and thus positively influencing the multiple. The multiple can be subdivided in distributed value to paid in capital (DPI) and residual value to paid in capital (RVPI); combined it is total value to paid in capital (TVPI):

$$\text{TVPI} = \text{DPI} + \text{RVPI} = \frac{\Sigma Distributions}{\Sigma Contributions} + \frac{\Sigma \text{Re}\, sidualValue}{\Sigma Contributions}$$

But as mentioned before, the time value of money is important to calculate the real performance of a private equity fund. The disadvantage of this method is that it does not incorporate the time value of money.

A method that incorporates the time value of money is the Internal Rate of Return (IRR) method. For example Ljungqvist & Richardson (2003) use the excess IRR based on the S&P 500 index to analyze the profitability of private equity funds. This method is based on in and outgoing cash flows and on the Net Present Value (NPV) method. The IRR is the return rate that results in a NPV of zero. Obviously, the NPV method is also a way of measuring private equity performance. The disadvantages of the NPV method are equal to that of the IRR method. The first disadvantage is that the fund managers determine the NAV of an unsold portfolio. The second disadvantage of the IRR method is that the time pattern of cash flows is unknown so officially the cash flows need to be reinvested at an interest rate equal to the IRR. The second disadvantage is that the IRR rate is not straightforward comparable with stock and fixed income markets. In these markets, performance is measured accurately with recorded returns in predetermined time intervals with so called Time Weighted rates of Return (TWR). The returns in each of these periods are equally weighted unlike the IRR method that depends on the time pattern of cash flows.

In the case of IRR measurements it is important to notice that IRR numbers can be non unique. If a sequence of cash flows has more than one sign change (For example: -3, +2, +2, -1) more than one IRR number can be calculated (Brealey & Meyers (2003)) In the rest of this research it is assumed that J-curves only have one sign change and thus exhibit one unique IRR number.

To compare returns of private equity with stock market returns, one can adjust the IRR metric. This metric is a TWR metric using periodic IRR's. The NAV of a portfolio at the beginning of a quarter is marked as a negative cash flow and the NAV of a portfolio at the end of that quarter is marked as a positive cash flow. The cash flows in this period generate an

IRR, which in his turn is comparable with an ordinary stock time series. The time-weighted-IRR of several funds can be combined to create a "private equity market" rate of return series. This method still relies heavily on subjective NAV figures.[3]

The IRR method uses the NAV of a private equity portfolio to be calculated. The NAV is a subjective metric as mentioned before. To cope with this subjective figure one could use the Public Market Equivalent (PME) measurement method. Kaplan & Schoar (2003) use the PME and find that the average fund returns are comparable with the S&P 500 returns. This method is able to compare the IRR results with public markets. The methodology is based on timing investments and divestments in an index when a private equity fund has draw downs and distributions. This strategy replicates the irregular investment and divestment pattern. The investments and divestments in the return index can be adjusted in magnitude to ensure a better fit in NAV at the end of the investment period. An improved version of PME is PME+, which will not be discussed here.[4]

Phalippou & Zollo (2005) use a profitability index (PI) to measure the return of a sample of mature private equity funds. This profitability index uses the present value of cash inflows and divides them with the present value of cash outflows. In their research the return of the S&P 500 is used as the discount factor. Outperformance of this index is measured if the PI is larger than one.

3.7 Private equity risks & risk measurement

Compared to other asset classes private equity exhibits unique risks. This section will describe the most important distinguishing risk factors. Private equity risks are described by numerous authors and in this section the risk descriptions are based on the Partners Group Research Series.

3.7.1 Liquidity risk

Private equity fund investments are subject to liquidity risk. Liquidity of public securities is measured by the bid-ask spread (among others). A larger spread indicates a lower liquidity of the security. Due to infrequent and subjective valuations of portfolio investments by private equity funds it is complex to determine a bid-ask spread. The question is: are potential buyers willing to pay the price you ask for the investment given your valuation?

Rational investors would demand a compensating liquidity premium for the liquidity risk. What is a reasonable premium for private equity investments? There are several factors influencing the bid-ask spread of private equity investments. Infrequent and subjective valuations, asymmetric information, long holding periods, transfer restrictions and other factors are of importance to answer the question.

A quantitative analysis of liquidity risk will not be given here. For private equity it is important that portfolio companies cannot be sold at any moment for your desired price. Unless you lower the price (this is the bid ask spread) and sell it, but this obviously affects private equity performance.

[3] Source: Robeco research paper

[4] Source: Private equity benchmarking with PME+, Christophe Rouvinez

Financial markets circumvent these liquidity issues. Listed private equity funds offer the possibility to invest in private equity stocks with high liquidity. Securitisation of private equity portfolios creates securities with private equity exposure but with more liquidity. Secondary buyouts, a portfolio company is sold to another private equity fund, are increasingly popular with private equity funds. Obviously this liquidity solution affects private equity performance due to the applied discount (bid-ask spread). Secondary buyouts are expected to become one of the most important exit routes for private equity in the future.

3.7.2 Business risk

Private equity funds invest in companies with specific characteristics like for example large, stable cash flows (for debt repayments), mature industries and with the potential to improve efficiency. Although the portfolio companies are stable companies, they still are exposed to the business cycle or economic conditions.
Funds starting in the same vintage year will face comparable economic exposures during their life time. For example if private equity funds of a certain vintage year experience low or even negative economic growth the underlying companies will not perform as good as in other periods. Diversification across several vintage years is a way to mitigate this risk and other business risks.

3.7.3 Interest rate risk

Private equity performance depends largely on the leverage used in the acquisition of companies. The debt as well as the interest has to be repaid by the company. The large and stable cash flows of the company should be sufficient to repay both within a certain period, usually 5-6 years, until the exit of the company is planned.
Depending on the type of debt used, changing interest rates could threaten the available free cash flow of a company. If interest rates increase substantially a portfolio company may fail to meet its financial obligations. This research will not discuss all possible (exotic) kinds of debt financing used in the private equity industry.

3.7.4 Manager risk

For institutional investors it is important that their private equity portfolio generates good results. Selecting the right private equity fund managers is of high importance. Managers differ in experience, network, strategy, sector-focus, regional focus, deal-size, reputation, integrity, historical track record, consistency of returns etc. A thorough due diligence phase prior to investing in private equity funds based on the before mentioned aspects is necessary. Manager risk can be mitigated by investing in several managers based on thorough due diligence.

3.7.5 Risk measurement

Due to high leverage and liquidity risk in private equity, it is said that private equity investments exhibit more risk than ordinary assets. But it is also mentioned that private equity funds strongly focus on efficiency programs and overall cost reduction. This should make portfolio companies less vulnerable to economic downturns in comparison to industry related companies.

Unlike most other investments private equity is illiquid and does not exhibit continuous pricing. Changes in valuation levels are measured on a quarterly basis. For other asset classes, like stocks, it is common to measure the volatility as an indication for risk. This measure cannot be used in private equity because of the absence of unbiased and high frequent valuations. Private equity valuations are subjective and infrequent.

Chapter 4: Risk / return properties of private equity

Since private equity funds differ substantially from other asset classes a structural analysis of the risk and return properties is desired. The risk and return properties of private equity are not easy to deduce from available performance information in the industry. Several authors use different measurement methods to analyse risk and return properties of private equity. The results of this academic research are not unanimous. Different measurement methods seem to generate different results. An ongoing academic debate is the potential premium or alpha generated by private equity funds. Related to this debate is the extent of the correlation between private equity and stock markets. It seems that a proper risk adjustment for performance is important to determine reliable results.

After a short introduction in the conventional analysis framework, the capital asset pricing model, the second section discusses the systematic risk and return properties of private equity. Thirdly, the complementary unsystematic risk and return properties are analysed.

4.1 Capital asset pricing model

In financial literature risk and return properties are often analysed with the Capital Asset Pricing Model (CAPM). This model determines how risk and return characteristics of a security are related. This model will also be used in the analysis of the risk and return characteristics of private equity.

The return of a security can be seen as a combination of systematic return and unsystematic return. The systematic return is proportionally related to the market return R_M. The factor β indicates the sensitivity of the security with the market. The idiosyncratic return is independent of market movements and is expressed by α. The formula is completed by the error term with a zero mean.

$$R = a + bR_M + e$$

The capital asset pricing model only uses the beta of the security to determine the expected return. Alpha returns, both positive and negative, can be added to the expected return calculated according to CAPM. Alpha is a measure for excess return and related to unsystematic risks. Factors like liquidity and information asymmetry are not incorporated as in the CAPM model. R_F is the risk free rate. This model describes the return of an individual security in relation to the market.

$$E(R_i) = R_F + b_i[E(R_M) - R_F]$$

Systematic risk can be expressed as: $b * stdev(R_M)$
Unsystematic risk can be expressed as: $stdev(e)$

For a more detailed discussion on the CAPM model I refer to Luenberger (1998) and Fabozzi & Modigliani (2003)

4.2 Systematic risk & return

Private equity investments and thus private equity funds have a complex risk profile. The risk profile is changing over time (due to strategic, operational and capital structure changes of underlying investments) and cannot be compared easily with other asset classes. The risk profile of a single private equity investment changes during its lifetime. A company is purchased with a certain equity beta. The initial leverage amplifies this market exposure. During the lifetime of the investment the leverage decreases due to the debt repayment and thus the market exposure decreases consequently. The declining leverage in private equity investments creates a dynamic risk profile. An average private equity fund holds approximately 10-15 investments. These investments all have this dynamic risk profile. The investments, probably differing in industry sectors or geographical areas, all have different initial market exposures and different market exposures at exit. It is very complex to analyse the risk exposure of the complete private equity fund portfolio during the different phases. For fund of funds it is even more complex to analyse the market exposure of the portfolio.

Systematic risk or undiversifiable risk is related to beta or market exposure. This risk depends on market developments and cannot be diversified. Like other companies (privately held and listed) private equity companies are exposed to the market and thus exhibit undiversifiable risk as well. Private equity funds initially focus on low volatility companies with a low correlation to market movements (Groh & Gottschalg (2006)). This allows the funds to reorganise a company without having too much market exposure with potential negative consequences. However a company is acquired with a considerable amount of leverage that increases the business risk of the equity. This leverage decreases over time and the business cycle sensitivity of the equity (or NAV) decreases as well. One could draw a beta exposure curve that represents the theoretical market exposure of a private equity fund. This curve depends on the investment and divestment timing of the individual investments of a private equity fund and is thus related to the J-curve. Other driving aspects are the leverage profile, equity weights of each investment, portfolio investment maturities and investment industry sectors.

Groh & Gottschalg (2006) analysed operating and leverage risk to adjust private equity performance for systematic risk in the US. In their article comparable companies (size and sector) are “re-leveraged” to get the same risk profile as the already leveraged buyout companies. Both groups then exhibit the same equity beta. During the holding period the leverage in the buyout group decreased and so the leverage of the control group was adjusted consequently. After the holding period of the leveraged buyouts, the company values of both groups were compared. In their analysis the authors find that when adjusted for systematic risk leveraged buyouts outperform comparable companies. The method the authors used required confidential company specific information which was available for the first time. The calculations the authors used are an indirect way to measure market risks related to private equity investments. Re-leveraging comparable companies can reveal market risk exposure.

Other authors also analysed private equity performance and adjusted risks differently. The different risk adjustment methods result in different research results (Ljungqvist & Richardson (2003), Kaplan & Schoar (2005) and Phalippou & Zollo (2005))

To determine risks related to private equity investments it appears necessary to use precise information regarding target companies and their capital structure developments as well as precise industry related data.

4.3 Unsystematic risk & return

Unsystematic risk or diversifiable risk is related to company specific events. Unsystematic risks can be diversified; unsystematic returns occur independent of market movements. Alpha is a measure for the average unsystematic return over a certain period.

Private equity is believed to generate high alpha returns and low beta returns. This means that private equity funds are able to generate returns largely independent of (stock) market movements. Whereas in traditional asset management alpha is generated by superior stock selection skills by portfolio managers, in private equity investing, it is believed that alpha is generated by superior skills of the general partner. The GP is able to raise sufficient funds, finds good investment opportunities, is able to structure a deal, is able to add value to the investment company by reorganising (strategically, operationally or financially), and is able to exit the investment successfully. All these and supporting activities are said to generate alpha returns independent of market movements.

Ick (2006) analysed risk and return characteristics of private equity compared with public equity. He bases his analysis on the IRR and PME measure and finds that downside deviation and shortfall are better risk measures than standard deviation because of the non-normal return distribution of private equity. The author compares the Sharpe-ratio, a modified Sharpe-ratio and Omega as an alternative risk measure.

The Sharpe-ratio represents the excess return per unit of risk: $S = \frac{\tilde{r} - r_f}{s}$, where the numerator represents the excess return over the risk free rate. The latter two risk measures are not discussed here. The author acknowledges that the volatility measure used in all used risk measurement techniques is based on industry clusters and is not representative for private equity investments according to other research. The author concludes that private equity investments are of limited quality and that finding a good GP is very important.

4.4 Remarks

Capturing private equity in the conventional CAPM framework is not as easy as with other asset classes. The underlying risk and return characteristics of private equity funds and investments are not clear and not calculated uniformly by all authors. This problem will remain as long as there is an information scarcity about private equity investments.

Chapter 5: Private equity investments in an institutional portfolio

5.1 Markowitz portfolio theory

To analyse private equity in a portfolio perspective, a thorough understanding of portfolio theory is necessary. The portfolio theory developed by Nobel Prize laureate Harry Markowitz (Markowitz (1952)) is the most frequent used framework in the financial industry.

The construction of an asset portfolio is based on maximizing return with a given level of risk. The portfolio theory provides the framework to generate the optimal portfolio for its investor. Due to diversification effects the total risk of a portfolio with assets is not equal to the aggregated risk of the included assets. The return of a portfolio is equal to the weighted average of the included assets.

The Markowitz portfolio theory is based on a mean-variance framework. The return or the mean of a portfolio ($E(R_P)$) is equal to the weighted average of the expected returns of the individual stocks (R_j):

$$E(R_P) = \sum_{j=1}^{n} P_j R_j$$

The risk or the variance of the portfolio ($Var(R_P)$) is based on a weighted covariance matrix that eliminates correlations between G stocks (the diversifiable part of risk):

$$Var(R_P) = \sum_{g=1}^{G} \sum_{h=1}^{G} w_g w_h Cov(R_g, R_h)$$

Both the return and the risk data can be based on different data series. Historical data or Monte Carlo simulations can be inputs for the portfolio analysis (Crouhy, Mark, Dalai (2000)).

By changing the weights of the individual assets in the portfolio, other risk/return combinations are generated. With the available assets any portfolio can be created and are called feasible portfolios. The collection of all feasible portfolios can be graphically represented as a feasible set of portfolios.

A portfolio that generates the highest expected return of all feasible portfolios with the same level of risk is a Markowitz efficient portfolio. These portfolios are all portfolios on the upper part of the curve in the graphical representation of the feasible set of portfolios, the so-called Markowitz efficient frontier. For more information on Markowitz portfolios and portfolio theory I refer to Fabozzi & Modigliani (2003) and Luenberger (1998).

The Markowitz portfolio theory assumes that the assets included have comparable risk and return measurement characteristics. Originally the theory only compared listed stocks. The inclusion of illiquid assets (like private equity) and assets with other risk measures (like private equity) need special attention in portfolio theory. The next section will discuss these issues.

5.2 Private equity in an institutional portfolio

Since private equity doesn't have easy to compute mean-variance and correlation characteristics, it is not simple to analyse private equity in a portfolio perspective as discussed in the previous section. Alternative approaches or assumptions on characteristics are used to analyse institutional portfolios with private equity added to them.

Several authors analysed private equity investments in an institutional portfolio (Koren & Szeidl (2002), Zimmermann et al. (2005), Schneeweis, Karavas, Georgiev (2002) and Schmidt (2004)). In their articles they try to assign portfolio allocation weights to private equity and analyse the risks and return characteristics of the entire portfolio (in different market conditions). The authors use different proxies for private equity performance and this leads to different conclusions. At this moment there is no accurate and unanimous method to analyse private equity in a portfolio context.

5.3 AEGON, private equity and portfolio management

AEGON adopted fund-of-fund investing as a way to structure private equity exposure. The Net Asset Value of AEGON's private equity investments on the 31st of December 2006 were EUR 591 million. Not all committed capital has been called at this moment, but this is inherent to private equity investing.

As mentioned in the introduction, AEGON offers a range of investment funds and has added private equity exposure to some mix funds. AEGON does not offer funds that are entirely exposed to private equity. The current private equity fund-of-fund investments at AEGON Asset Management have a European focus.

As of per June 1st 2004, AEGON Asset Management launched the AEGON Private Equity Fund. Not all characteristics described earlier are applicable to this fund. The AEGON Private Equity Fund is more customised and gets round the illiquidity issues and the structure of commitments and capital calls. No long-term commitment is necessary; there is a possibility to enter or to leave the fund twice a year. It is not possible to invest directly in this fund, in the near future it is meant as an improvement of the risk-return profile for existing funds.

AEGON uses private equity to generate alpha in portfolios and not specifically for risk diversification. The general opinion at AEGON is that private equity has a strong correlation with stock markets and that it does not offer specific risk diversification. By investing in a fund-of-fund approach risks are diversified across industry sectors, vintage years, managers and countries.

Chapter 6: Private equity performance related literature

This chapter discusses private equity performance attribution in literature, gives an overview of the (non-) literature related performance indicators and briefly highlights research methods in literature as well as frequently mentioned biases.

In the first section performance drivers in literature are discussed. This part is structured as follows. The first subsection describes the effects of the financing environment. Private equity investments are structured with a significant amount of debt. The leverage aspect is a critical element of the success of private equity. The second subsection describes performance factors in the business environment. Obviously private equity funds invest in companies that are kept in portfolio for a certain period. These portfolio investments will depend on the same business environment as other companies. The last subsection describes the dependency of private equity on market conditions. Private equity funds need to raise money, buy companies and sell them eventually. For these transactions participating counterparties are necessary.
In the second section an overview of all (non-) literature related performance drivers are presented. The performance drivers are based on literature, advice by portfolio managers at AEGON Asset Management and the current qualitative quadrant model. The parameters mentioned are used in subsequent chapters (7&8) for further research.
The last section discusses research methods in literature. It is important to understand commonly used research methods to determine a research methodology for this project. This section also discusses a few information biases, often reported by academics in private equity research.

This research focuses on the private equity market in general. A lot of literature is devoted to individual fund and investment company performance. For example fund size; geographical focus, sector focus or GP skills are popular research subjects. These subjects will not be treated in this literature section.

The problem with private equity research is the availability of relevant data. The available data mainly comes from commercial databases. These databases are compiled of self-reporting private equity funds. A self-selection bias and survivorship bias are inevitable. Private equity funds that report performance base these numbers on valuations of portfolio companies. The arbitrary nature of these numbers creates a valuation bias. In the second part research methods in literature will be discussed and bias reduction methods will be highlighted.

6.1 Performance drivers

Private equity depends on several phases to be successful. In each of these phases private equity is exposed to certain risks. In literature this fact is recognised and certain performance drivers are related to certain performance aspects. In perspective of the different phases and risk exposures the performance drivers are discussed in subsequently the financing environment, business environment and the market environment.

6.1.1 Financing environment

Private equity investments are structured with significant amounts of debt. The investment companies repay the financing debt that is used in the acquisition. Van der Wurf & Mertens (2001) discuss how the acquisition capital structure and its underlying legal structure work

(the structure is based on a fiscal unity). Preferably potential target companies have a large free cash flow to be able to repay the debt loads. For private equity funds the availability of debt and the interest rates are important factors that influence private equity performance. Several authors analysed the effects of interest rates and credit spreads on the performance of private equity funds.

Groh & Gottschalg (2006) analysed buyout performance by comparing buyout companies with a replicating strategy. The authors re-leveraged a sample of comparable S&P 500 companies with an equal risk-profile. In their analysis the IRR's of both categories were compared and buyout investments appeared to significantly outperform the replicating strategy sample.

Phalippou & Zollo (2005) find that the level of corporate bond yields at the time that investments are made are significantly affecting private equity performance. The authors used BAA-rated corporate bond yields for their study. Credit spreads at the time that investments are made affect private equity performance but not as strong as BAA-rated corporate bond yields. Private equity performance decreases if BAA-rated corporate bond yields increase during the holding period of investments. In this research all relevant factors were related to all specific private equity fund phases: fund raising, investing, holding period and divesting. The authors have found several other significant factors that will be treated in a later stage in this literature section.

Bauer, Bilo & Zimmerman (2001) find that listed private equity is sensitive to changes in credit spreads and TED spreads. The authors measure credit spreads as the difference between AAA-rated and BAA-rated corporate bonds. TED spread is the spread between the 90-day US treasury bills and the 3-month Eurodollar deposits.

6.1.2 Business Environment

Buyout funds prefer investing in mature companies with large free cash flows and potential reorganisation possibilities. A reorganisation could be financial, operational or strategic. Mature companies that operate in stable sectors exhibit a lower operational risk profile than average in the market (Groh & Gottschalg (2006)). The free cash flows are used to repay the debt used for its own acquisition. Despite a low operational risk profile the buyout investment companies are still exposed to the general economic environment. Several articles have identified business environment or macro economic factors that influence private equity performance. The business environment mainly influences the holding phase of the private equity fund cycle.

Phalippou & Zollo (2005) find that private equity is significantly pro-cyclical. GDP growth and the average level of interest rates (already discussed) respectively affect private equity performance positive and negative. Both relationships are significant. The authors find that these factors are particularly important when investments are made. Stock markets are significantly correlated with private equity performance, especially during the holding period of investments. The authors also related the returns of call options on the S&P composite index to private equity performance and found a significant positive relationship especially during the holding period of investments. Concluded from this finding is that private equity funds possess tail risk or non-linear systematic risk.

Bauer, Bilo & Zimmerman (2001) find a positive correlation between listed private equity and stock markets. The authors also find that global GDP growth rate is significantly positively correlated.

Contrary to other research Diller & Kaserer (2005) find that for European private equity funds stock markets are unrelated and that the state of the economy is negatively correlated with private equity performance. The focus of their research is the analysis of fund inflows and the effects on performance. The authors related the stock market performance of the vintage year of the fund to the final return of the vintage year. This approach is quite misleading when compared with other articles.

6.1.3 Market Environment

Private equity investments do not have continuously quoted prices. The exact price or valuation of an investment only occurs at the moment of investment and divestment. Private equity funds face specific risks at every phase of the private equity fund cycle. First, private equity funds need money; a successful fundraising phase is of key importance. After the fundraising phase private equity funds need to invest their money. Dependency on credit markets and the merger and acquisitions (M&A) market is unambiguous. After a certain holding period where private equity depends on general market developments an investment needs to be exited due to the limited lifetime of a private equity fund. The exit phase depends on favourable exit conditions such as a strong M&A and IPO market.
In the three phases described here, market interaction is inevitable. Private equity funds depend on willing markets. The competition on these markets affects these phases in another way than in the holding phase. Private equity funds have to compete with each other as well as other strategic buyers and sellers, hedge funds, other asset managers etc. This makes private equity a complex asset class with very specific risks related to specific phases.

6.1.3.1 Fundraising phase

An important article on the fundraising phase and the impact on private equity performance is written by Gompers & Lerner (1999). These authors state that capital inflows in venture capital funds increase valuations of new investments. Obviously this impacts venture capital performance negatively. A comparison with buyout funds is not straightforward but a parallel pattern could be evident.

Gottschalg & Zipser (2006) analysed the effects of supply and demand of private equity financing on the performance of buyouts. The authors assess whether the efficient market hypothesis or price pressure effects in behavioural finance theory is valid. The results are twofold: a “money chasing deals”-effect and a “deals chasing money”-effect. Supply of buyout funding has a significant negative impact on buyout performance and the demand for buyout funding has a positive impact on buyout performance. This article confirms that buyout firms share comparable behaviour as venture capital funds in the article of Gompers & Lerner (1999).

Determinants of venture capital fundraising activities are GDP growth and increases in R&D spending according to Gompers & Lerner (1998). Another important driver is capital tax gains on interest. Previous fund performance and the age of funds are the main drivers of venture capital fund raising.

6.1.3.2 Investing & divesting phase

Investing and divesting are comparable activities. Favourable conditions for buying and selling companies depend on various factors. Good M&A and IPO markets are necessary for private equity to thrive. But what is the effect of these markets on performance of private equity?

Schmidt, Nowak & Knigge (2004) analysed the market timing abilities of private equity funds and the impact on performance. The authors find that for venture capital funds the investment timing has impact on fund performance. Divestment timing had no impact on venture capital fund performance. For buyout funds market timing was not a driver for performance.

Ljungqvist & Richardson (2003b) analysed the timing behaviour of private equity fund managers. They find that in good investment times, private equity fund managers invest their capital and exit their investments fast in order to take advantage of the positive climate. This leads to better fund performance. In times of fiercer competition private equity fund managers draw down capital at a slower pace and holding periods tend to become longer. Performance is significantly lower when competition is fiercer. Deal flow competition affects investment timing and private equity fund performance negatively.

Bauer, Bilo & Zimmerman (2001) state that M&A activity has a positive and negative impact on private equity funds. High M&A activity facilitates a good exit climate for investments but private equity funds have to pay higher prices for their acquisitions. In their model M&A markets do not have a significant impact on listed private equity returns. The volume of the global IPO market does affect the performance of listed private equity positively.

6.2 Overview of (non-) literature related performance drivers

The introductory chapters on private equity and the literature discussion provided a scattered view on all factors driving private equity performance. This section will give a structural overview of all performance drivers or parameters that will be used in further research. This overview will be complemented with some additional performance drivers currently qualitatively used by AEGON to forecast private equity performance. This section will be the result of the private equity industry analysis and literature search and partially cover the first research objective.

6.2.1 Current performance indicators used by AEGON

The private equity quadrant model currently used by AEGON is entirely qualitatively driven. It is not based on quantitative analysis. This section will briefly discuss the indicators currently used to evaluate and forecast private equity performance.

The macro quadrant comprises the development of high yield credit spreads, the development of M&A markets, the development of the absolute level of the 5 year yield of US and EU government bonds, accommodating policy of the FED (proxy: real interest rate) and the development of the debt/equity ratios of US and EU companies.

The valuation quadrant consists of the spread between the average E/P ratio and the 5 year government bond + high yield spread and the development of the liquidity premium (proxy: yield spread between 2 and 10 year government bonds)

The sentiment quadrant consists of the development of stock markets (FT All World), the IPO climate and fund raising (number of funds and size of funds)

There is no technical quadrant applicable for private equity.

6.2.2 Overview

The figure below presents all performance drivers that will be used for further research. These parameters are based on all mentioned literature and current qualitative quadrant model input. These relevant performance parameters are the result the first research objective. The second research objective will proceed with this information in subsequent chapters (7&8).

Parameters US	Parameters Europe
BAA bond yield	FTSE Europe
High yield	Leverage buyouts
High yield credit spread with government bond	Buyout fundraising
Industrial production US	High yield
Leverage US Buyouts	FED rate
S&P 500	BAA Bond
P/E ratios S&P 500	High yield credit spread with government bond
FTSE USA	FTSE All world
FED rate	M&A volume Europe
FTSE All World	IPO volume Europe
GDP growth	
Buyout fundraising	
Liquidity premium: 10-2 year government bond	
M&A volume US	
IPO volume US	

Figure 8 Macroeconomic parameters (US and Europe)

6.3 Research methods in literature

In most private equity research, access to a private equity database is crucial. There are several commercial databases available for private equity research. These databases are supplied by Thomson Venture Economics, the Centre for Management Buy Out Research and Sand Hill Econometrics. For example Thomson Venture Economics provides information on investments and cash flow between GP's and LP's. The price of the commercial databases is the reason why this research has to do without it.

Most researchers correct the database for certain biases and compose a sample of the database. This sample is then adjusted, for risk or other purposes, and used for their field of interest. Risk adjustment methods are discussed in chapter 4. (Multiple) Regression is used to generate results. Based on these results conclusions are formulated.

The next section will describe what biases are acknowledged and how they can be reduced.

6.3.1 Bias reduction

As mentioned most commercial databases have biases. Several authors have acknowledged that and developed methods to correct the databases for these biases.

Selection bias and survivorship bias are comparable biases. Funds that perform very well or poorly are not eager to report their performance. These funds are not likely to report their performance to commercial databases. Poor performing funds fear that future fundraising will become problematic and good performing fund fear undesired attention. This effect is called selection bias.
Private equity funds that are not able to raise new funds (due to bad performance) will not report their performance to commercial databases anymore. These funds did not "survive" and only good performing funds will survive. This effect is called survivorship bias.

Private equity funds are known for their arbitrary valuation methods. As long as private equity funds are not liquidated, their performance is partially based on the fund's residual value. Kaplan & Schoar (2005) constructed a method based on quasi-liquidated funds. Phalippou & Zollo (2005) also write-off "living-deads". Living-deads are funds that did not divest in the past 4 years and still had a large residual value.

Gottschalg & Zipser (2006) completely removed the unrealised investments from their sample composition. The authors also removed a transaction if it lacked information on the industry Sector Identification Code (SIC), the investment amount, acquisition and exit date and the location. The authors constructed a method to roughly calculate gross performance numbers from net performance number since Thomson Venture Economics (the commercial database) reports data net of all fees. This is done because all their other data is based on gross performance numbers.

Chapter 7: Methodology

The second objective of this research is to find an appropriate method to analyse and forecast private equity performance based on the results of the first objective. This chapter will explain what research method is used.

In this research method the illiquid alternative asset fund model by Takahashi & Alexander (2002) is used. In their article these authors use a fixed annual growth rate (equal to the estimated final IRR of an illiquid alternative asset fund) and other fixed parameters to model illiquid alternative asset funds. In this research two estimation models are constructed based on their illiquid alternative asset fund model. The first model assumes variable annual growth rates and all other parameters being fixed. The second model assumes variable annual growth rates and some other fixed parameters are varied. Both models are used to construct a private equity index which benchmarks private equity performance.

In section 7.1 an introduction in the underlying issues concerning the availability of data is given. In the second section (7.2) the rationale behind the research methodology is given. In this section both the illiquid alternative asset fund model (7.2.1) by Takahashi & Alexander (2002) and the underlying research assumptions (7.2.2) are introduced. The third section (7.3) gives a mathematical description of the general estimation model of this research. To solve the objective function of the mathematical function an algorithm is constructed. This algorithm is described qualitatively in the fourth section (7.4). Stability issues of the algorithm are subsequently discussed in section 7.4.1. The fifth section (7.5) will present a private equity benchmark or index based on the first estimation model (variable annual growth rates and fixed parameters). The sixth section (7.6) will present a private equity index based on the first estimation model (variable annual growth rates and adjusted fixed parameters). In section 7.7 the second estimation model will be presented. This estimation model assumes both variable annual growth rates and some other variable parameters. This model will ultimately result in the best fitting private equity index for this research. In section (7.8) the robustness of private equity indices based on this modelling methodology is discussed. In the last section (7.9) two estimation model improvements are proposed for future research.

7.1 Introduction

The methodology in this research largely depends on scarce quantitative and qualitative information about private equity performance. Ironically the appropriateness of the research objective can be explained as: the method that is able to generate the best possible results given the lack of sufficient private equity performance data. The only data available for this research is aggregated performance data (pooled TVPI and IRR) per vintage year (1986-2005) for certain geographic regions (US and EU). This performance data is from the Thomson Venture Economics database, which is considered to be the most representative database in the industry by academics and practitioners. Because this performance data consist solely of IRR and TVPI numbers they cannot be compared straightforwardly with other macroeconomic factors or performance data of other asset classes. The available performance data needs to be modified in such a way that it can be related to other macroeconomic factors. The absence of detailed individual fund or vintage year cash flow data, which is used in literature, forces the use of an unconventional research method.

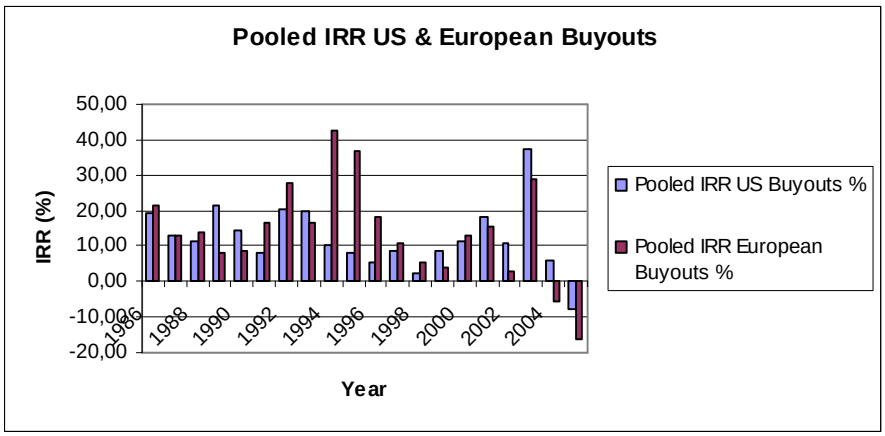


Figure 9 Pooled IRR's (US and Europe)

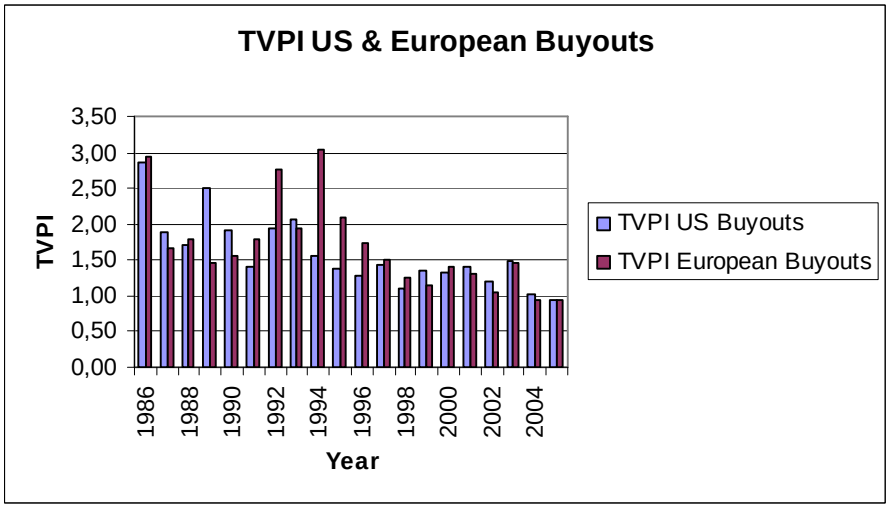


Figure 10 Pooled TVPI (US and Europe)

7.2 Rationale

When analysing the historical IRR and TVPI sequences of private equity performance of a certain geographic region (US or Europe) one could argue that two neighbouring vintage years are somehow correlated. If for example both vintage years last 10 years (the lifetime of the average fund), they are exposed to the same economic environment for 9 of the 10 years. So, in a way all the historical IRR and TVPI numbers are correlated albeit in another way than in the analysis of ordinary time series. To be more precise, one could assume one economic environment that facilitates/drives private equity performance and relates all historical IRR and TVPI numbers. This general idea is the most important assumption in this research.

Every private equity fund consists of the different phases of the private equity fund lifecycle: fundraising, investing, holding and divesting (explained in section: 3.4). The success and thus performance of a private equity fund depends on all phases. Every phase depends or interacts differently with economic conditions during its time horizon. This holds for every vintage year during every fund's lifetime. This reasoning further crystallises the general idea of the section before: there is one economic environment that facilitates/drives private equity

performance and relates all phases of individual vintage years and therefore affects historical IRR and TVPI numbers.

The phases of a single private equity fund are always in the same order. After fundraising a fund starts investing and after a certain holding period the portfolio of investments are divested. After the divestment period the fund closes. In this process the investment, holding and divestment phase will inevitably overlap. If one analyses all single funds of a particular vintage year the individual phases of all these funds will overlap as well. For example the investment phase takes the same amount of time on average for each individual fund. One could argue that this holds for all phases of single funds of a certain vintage year. In this research it is assumed that this is the case. To put it more precise: one could assume that one large vintage-year-J-curve can be constructed if all phases of all single funds of a certain vintage year are aggregated.

A common way in financial research to relate (economic) performance drivers to a certain asset class is to use a benchmark and perform regression analysis with that benchmark. Unlike most asset classes, private equity does not have a publicly available industry benchmark. This research approach will result in an appropriate private equity benchmark or index and cope with that void. The essence of the methodology is based on the assumption that one macro economic environment facilitates the performance of all individual vintage years and that the performance of these vintage years is related. In other words: one performance index drives the returns of all individual vintage years. This index can then be related to the macroeconomic environment that facilitates private equity performance. This idea is presented in the figure below.

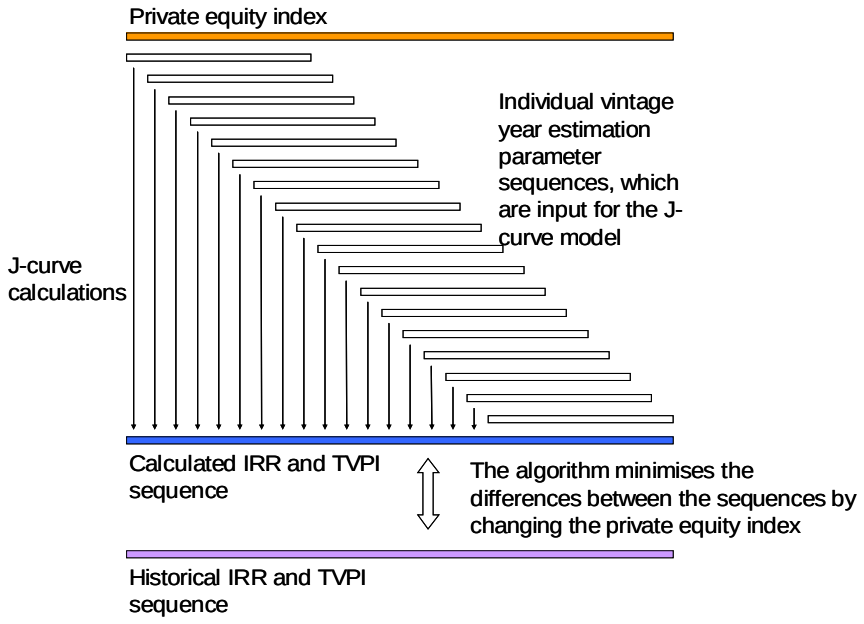


Figure 11 Private equity index and historical private equity performance

In the top of this figure one can see the private equity index. This index consists of growth rates. Each growth rate stands for the NAV growth private equity funds were able to generate in that specific year. A specific growth rate affects every vintage year that exhibits this year (regardless whether it is the first or the tenth year). Based on this private equity index one can make shifted copies, or convolutions. Every vintage year has its own copy or partial sequence

of growth rates depending on the private equity index. With the model of Takahashi & Alexander (2002) J-curves can be calculated based on every individual vintage year's sequence of growth rates. Based on this model individual vintage year performance measures (IRR and TVPI) can be calculated. By choosing the private equity index in such a way it is assumed that it is possible to fit the (real) historical performance measures with the calculated performance measures. By using an algorithm the private equity index is calculated that is able to fit calculated performance with actual performance best. Once the best private equity index is determined regression analysis is used to relate macroeconomic variables to private equity performance and ultimately forecast private equity performance. This chapter will discuss how the private equity index is developed.

7.2.1 Illiquid alternative asset fund model

Takahashi & Alexander (2002) (T&A) describe a J-curve model that is based on three principles: NAV growth, Capital Contributions and Capital Distributions. With these three principles the authors construct a simple method to deterministically construct J-curves for individual illiquid alternative asset funds like real estate funds, venture capital funds, oil and gas funds and private equity funds. According to their article the modelling approach fits historical performance data surprisingly well. Below a short (mathematical) summary of their model is given. For simplicity the dividend or yield aspect of the original model of T&A is left out.

7.2.1.1 Input factors

RC_t = Rate of contribution at time t, in the article 25% in year one, 33.3% in year two and 50% thereafter
CC = Capital Commitment (in USD)
L = Life of the fund (in years)
B = Factor describing changes in the rate of distribution over time
G = Annual growth rate (%) (fixed)

7.2.1.2 Output factors

C_t = Capital contributions
D_t = Distributions (in USD)
NAV_t = Net asset value (in USD)

7.2.1.3 Model equations

$$NAV_t = (NAV_{t-1}(1+G)) + C_t - D_t$$

The Net Asset Value (NAV_t) of an illiquid alternative asset fund at time t depends on the yearly contributions (C_t), distributions (D_t) and autonomous annual (fixed) growth (G). The NAV_t increases with positive autonomous annual (fixed) growth and contributions. The NAV_t decreases with positive distributions.

$$C_t = RC_t(\text{CC-}PIC_t) \qquad \text{à} \quad PIC_t = \sum_{0}^{t-1} C_t$$

Contributions (C_t) at a certain time t depend on the initial amount of committed capital (CC), the amount of capital that is already paid-in (PIC_t) and the rate of contribution (RC_t). The paid-in capital consists of the total of previous contributions. The rate of contribution (RC_t) determines how much of the remaining capital (CC- PIC_t) at time t can be used for an additional contribution cash flow.

$$D_t = \text{RD}(NAV_{t-1}(1+\text{G})) \qquad \text{à} \quad \text{RD} = \min\left(\left(\frac{t}{L}\right)^{B}, 1\right)$$

Distributions (D_t) at time t depend on the NAV of the fund at time t-1 and the rate of distribution (RD). Every year a portion of the NAV is distributed via the rate of distribution (RD). The rate of distribution itself is a function of t, L and B. This function describes whether the rate of distribution increases or decreases during the life (L) fund. Factor B describes whether the rate of distribution is larger in the beginning or the end of the fund. The rate of distribution can never be larger than 1 because otherwise you would distribute more than the NAV_t of the fund. This justifies the minimum function of the rate of distribution (RD). If B has the value 1, the rate of distribution is equal in every year. If B has a value larger than 1, the rate of distribution is larger at the end of the fund. If B has a value smaller than 1, the rate of distribution is larger at the beginning of the fund. The figure below gives an intuitive presentation of the distribution rate during the life of an illiquid alternative asset fund.

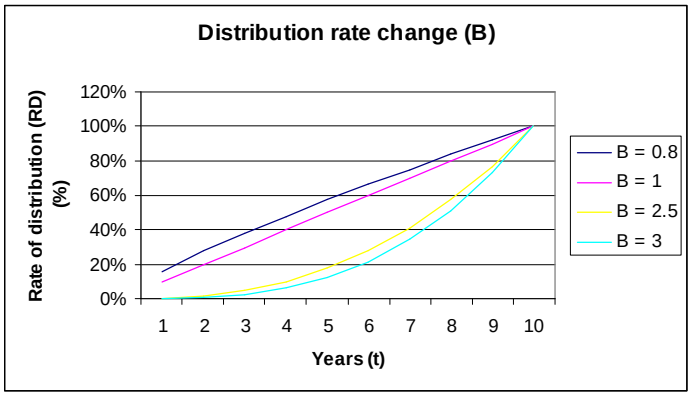


Figure 12 Different divestment paces

The model equations actually present the J-curve of a private equity fund. The Net Asset Value grows each year with a fixed growth rate (G) and contributions (C_t) and distributions D_t will increase and decrease the NAV over the lifetime (L) of the fund. On their turn the contribution and distribution characteristics ultimately depend on investment pace (RC_t) and divestment pace (B).

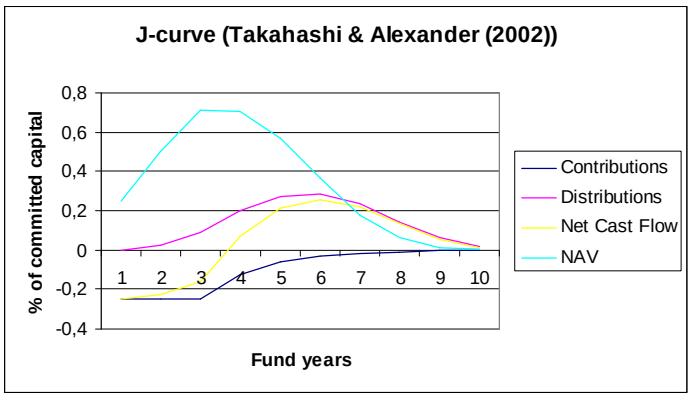


Figure 13 J-curve model by Takahashi & Alexander (2002)

As one can see in the figure above this model represents the phases of a private equity fund. The capital commitments (CC) depend on the fundraising phase. The investment phase strongly depends on the investment pace (RC_t), the holding period depends strongly on the growth (G) of the NAV and the divestment phase is driven by the distribution rate change (B).

7.2.2 Assumptions

The lack of detailed performance data forces an alternative research method. The results of this research method are consequently more or less biased. For the results to be valid the adopted research method requires a series of assumptions. All assumptions are discussed below. The assumptions are divided in general assumptions and modelling assumptions.

7.2.2.1 General assumptions

- Private equity performance partially depends on prevalent economic conditions like all other asset classes. This assumption holds best for geographically and economically bounded areas like the US and Europe. Private equity funds investing in the US depend on economic conditions in the US, the same holds for European private equity funds.
- Economic conditions affect the specific phases of the private equity life cycle differently.
- Private equity funds of different vintage years overlap each other in terms of time and thus face equal economic conditions albeit lagged. Economic conditions affect the timing of the phases and affect the specific private equity lifecycle phases differently.
- The performance of two neighbouring vintage years is related. Performance cannot vary significantly.
- There is one “index” driving all private equity performance. This index is able to explain historical private equity performance.

7.2.2.2 Modelling assumptions

- Private equity funds do not exhibit fixed yearly NAV growth rates like Takahashi & Alexander (2002) assume.

- Entire vintage years of private equity funds can be modelled with an adjusted version of the model of Takahashi & Alexander if the cash flows and related performance numbers are pooled.
- The validity of the private equity index increases with better estimated investment and divestment conditions. Ergo, more detailed vintage year cash flow information will increase the validity of the private equity index.
- The J-Curve model constructs J-Curve patterns that exhibit unique IRR's (only one sign change)

7.3 Mathematical formulation of the estimation model

Section 7.3.1 presents the modified model of T&A mathematically. The index estimation model is based on the modified model of T&A and is presented in section 7.3.1. Two versions of this model will be used in further analysis.

7.3.1 Modified Takahashi & Alexander model

7.3.1.1 Fixed parameters (q_F)

η = 1986, 1987,…, 2005 (Indication of a certain vintage year)
t = 1986, 1987,…, 2006 (Indication of a certain year)

Exogenous fixed parameters

$RC_{h,t}$ = Rate of contribution (Investment pace) of a certain vintage year η in a certain year t
CC_h = Capital commitment of a certain vintage year η (always fixed at 100%)
L_h = Life of a closed fund of a certain vintage year η (in years)
TT_h = Total Time, the life of an open fund of a certain vintage year η (in years)
B_h = Factor describing the rate of distribution over time of a certain vintage year η (Divestment pace)

The endogenous fixed parameter B_h will be fixed in the first estimation model (section 7.5 & 7.6) and will be "varied" in the second estimation model (section 7.7). This will be explained in section 7.7.

The exogenous parameters are the only parameters that can be set at initial values that are representative for certain vintage years.

Endogenous fixed parameters

$RD_{h,t}$ = Rate of distribution of a certain vintage year η
$C_{h,t}$ = Capital contributions of a certain vintage year η in a certain year t
$D_{h,t}$ = Capital distributions of a certain vintage year η in a certain year t
$NAV_{h,t}$ = Net Asset Value of a certain vintage year η in a certain year t
$PIC_{h,t}$ = Paid-In-Capital of a certain vintage year η in a certain year t

The endogenous fixed parameters are directly or indirectly determined by the exogenous fixed parameters and the estimation parameters. The endogenous fixed parameters can considered to be *process* parameters.

7.3.1.2 Parameters to be estimated (q_E)

G_t = Growth rate in a certain year t

7.3.1.3 Model equations

$$NAV_{h,t} = (NAV_{h,t-1}(1+G_t)) + C_{h,t} - D_{h,t}$$

The NAV of a certain vintage year at time t depends on the NAV at t-1, a uniform growth rate (all vintage years have the same growth rate in NAV in year t) and the contributions and distributions of this vintage year at time t.

$$C_{h,t} = RC_{h,t}(CC_h - PIC_{h,t}) \qquad \text{à} \quad PIC_{h,t} = \sum_{0}^{t-1} C_{h,t}$$

Contributions ($C_{h,t}$) depend on the rate of contributions ($RC_{h,t}$), the paid-in capital ($PIC_{h,t}$) and the committed capital (CC_h) just like in the original model of Takahashi & Alexander (2002). The only difference is that each vintage year has its own certain contributions, rate of contributions, paid-in capital and committed capital.

$$D_{h,t} = RD_{h,t}(NAV_{h,t-1}(1+G_t)) \qquad \text{à} \quad RD_{h,t} = \min\left(1, \left(\frac{t}{L_h}\right)^{B_h}\right)$$

Like the Net Asset Value ($NAV_{h,t}$) and the contributions ($C_{h,t}$) the distributions ($D_{h,t}$) are almost identical to the original model by Takahashi & Alexander (2002). The only difference is that each vintage year has its own distributions, rate of distributions and a uniform growth rate independent of the vintage year. The rate of distributions ($RD_{h,t}$) depends, just like the original model, on the factor B_h (and t and L_h).

7.3.1.4 Model output

IRR_h^{Calc} = Calculated IRR of a certain vintage year η

$TVPI_h^{Calc}$ = Calculated TVPI of a certain vintage year η

Both IRR_h^{Calc} and $TVPI_h^{Calc}$ are calculated in Excel and are based on Contributions, Distributions and Net Asset Values as presented in the model equations. Only $TVPI_h^{Calc}$ is expressed in an analytical form. In their turn Contributions, Distributions and Net Asset Values depend on the fixed parameters (q_F) and the estimation parameters (q_E). Ergo, in a

short notation both IRR_h^{Calc} and $TVPI_h^{Calc}$ can be expressed as functions f_h and g_h depending on q_F and q_E.

$$IRR_h^{Calc} = \text{f}\,(D_{h,t} - C_{h,t}, D_{h,t+1} - C_{h,t+1}, \ldots, D_{h,t+L_h} - C_{h,t+L_h}) = f_h\ (q_F, q_E)$$

$$TVPI_h^{Calc} = \text{g}\,(C_{h,t}, C_{h,t+1}, \ldots, C_{h,t+L_h}, D_{h,t}, D_{h,t+1}, \ldots, D_{h,t+L_h}) = \frac{\sum_{t}^{t+L_h} D_{h,t}}{\sum_{t}^{t+L_h} C_{h,t}} = g_h\ (q_F, q_E)$$

The calculation of both IRR_h^{Calc} and $TVPI_h^{Calc}$ is partly based on the residual NAV when funds are not closed yet. (For example vintage year 2001, the residual NAV is used for the calculation of the IRR and TVPI number.)

If $L_h > TT_h$ then $IRR_h^{Calc} = \text{f}\,(D_{h,t} - C_{h,t}, D_{h,t+1} - C_{h,t+1}, \ldots, D_{h,t+TT_h} - C_{h,t+TT_h}, NAV_{h,t+TT_h}) = f_h\ (q_F, q_E)$

If $L_h > TT_h$ then $TVPI_h^{Calc} = \text{g}\,(C_{h,t}, C_{h,t+1}, \ldots, C_{h,t+TT_h}, D_{h,t}, D_{h,t+1}, \ldots, D_{h,t+TT_h} + NAV_{h,t+TT_h}) = \frac{NAV_{h,t+TT_h} + \sum_{t}^{t+TT_h} D_{h,t}}{\sum_{t}^{t+TT_h} C_{h,t}} = g_h\ (q_F, q_E)$

7.3.2 Estimation model for the private equity index

The modified model of Takahashi & Alexander will be used to fit calculated performance data to actual performance data. This will be done with an algorithm. This algorithm optimises the objective function of the estimation model. The result of this algorithm, and the objective function, is the private equity index. Below the input parameters (7.3.2.1) and the objective function (7.3.2.2) of the estimation model are discussed.

7.3.2.1 Input parameters

Calculation parameters

$IRR_h^{Calc} = f_h\,(q_F, q_E)$ = Calculated IRR of a certain vintage year η
$TVPI_h^{Calc} = g_h\,(q_F, q_E)$ = Calculated TVPI of a certain vintage year η

The calculation parameters depend on the fixed parameters (q_F) and the estimation parameters (q_E) for their initial values.

Historical parameters

$IRR_h^{Hist} = d_h$ = Historical IRR of a certain vintage year η

$TVPI_h^{Hist} = g_h$ = Historical TVPI of a certain vintage year η

The historical parameters are from the Venture Economics database.

Endogenous parameters

l = Weight assigned to importance of IRR as a performance measurement in the objective function, in this research always set at 1

m = Weight assigned to importance of TVPI as a performance measurement in the objective function, in this research always set at 1

y_h = Weight assigned to the importance of the difference between $f_h(q_F, q_E)$ and d_h for vintage year h in the objective function

j_h = Weight assigned to the importance of the difference between $g_h(q_F, q_E)$ and g_h for vintage year h in the objective function

The endogenous parameters depend entirely on how important they are considered to be. Both l and m are weights for the importance of respectively IRR or TVPI as performance measure for private equity. One could consider one measure to be more important than the other in finding a private equity index. It is up to the end user to determine what the best distribution is. It is important that both parameters are chosen in relationship with each other. In this research both parameters are set at 1. Both parameters are considered to be equally important.

The weights y_h and j_h are meant for "eliminating" the valuation bias in the historical data. Especially immature vintage years have estimated or subjective valuation measures. In this research the vintage years 2000, 2001, 2002, 2003, 2004 and 2005 have weights other than 1. The endogenous weights are equal for every vintage year. The year 2000 has both parameters set at 0.9, 2001 at 0.5, 2002 at 0.2, 2003 at 0.1, and 2004 and 2005 have both parameters set at 0. It is again up to the end user to adjust these weights.

With these adjusted weights the algorithm will not assign equal importance to fully realised vintage years and immature vintage years. With this weight adjustment the algorithm does not "price" the valuation bias in its resulting private equity index. Again it is up to the end user to determine appropriate weights.

7.3.2.2 Objective function

$$\text{Min}\left[l \sum_{h=1986}^{2005} y_h \left(f_h(q_F, q_E) - d_h \right)^2 + m \sum_{h=1986}^{2005} j_h \left(g_h(q_F, q_E) - g_h \right)^2 \right]$$

The objective function minimises the quadratic differences between the historical IRR (&TVPI) sequence and the calculated IRR (&TVPI) sequence. Since the historical IRR and TVPI sequence cannot change the calculated IRR and TVPI should change. Since the fixed parameters (q_F) of the calculated IRR and TVPI are fixed at certain values the estimation parameters (q_E) or G_t are the only parameters that change when the algorithm runs.

7.4 Algorithm for the general estimation model

The objective function implies that 21 estimation parameters (q_E) should be calculated (21 dimensions). The underlying functions $f_h(q_F, q_E)$ and $g_h(q_F, q_E)$ are non-linear. The algorithm that optimises the objective function should thus be able to find a solution to a high-dimensional non-linear optimisation problem. Theoretically there are more than 2^{21} possibilities that have to be checked for the optimal solution. To solve this problem a time-efficient algorithm is constructed to find the optimal solution (or more expectedly a suboptimal solution) and ultimately create a private equity index. In practice, the algorithm is expected to find sub-optimal solutions given the complexity of the optimisation problem. Nevertheless the best possible sub-optimal solution could provide a reasonable private equity index for the objectives of this research.

An excel program, with several macro's or VBA-functions is constructed to solve this optimisation problem. This optimisation problem could be solved in several ways. For pragmatic reasons a simple algorithm is constructed to find a reasonable private equity index.

In this section only the algorithm of the general estimation model will be discussed. In the subsequent sections the two versions of the general model will be described. An initial sequence of estimation parameters is used to start the algorithm (for example all values are 10%). The fixed parameters are also set at predetermined values.

Given all fixed input parameters the algorithm calculates the private equity index in three phases. In the first phase the algorithm calculates the result of the objective function for every individual estimation parameter G_t (for example 10%) and two surrounding values of this parameter (9% and 11%) based on an initial step size h = 1 (1 / h = 1%). Consequently the algorithm calculates for every individual estimation parameter which of the three values minimises the objective function most. If all combined local minimising values minimise the global minimum the combination of the related growth values is used as the next "initial" sequence of estimation parameters. If all combined local minimising values do not minimise the global minimum the step size is doubled (1 / 2 = 0.5%, the three values are now: 9.5%, 10%, 10.5%) with a maximum of h = 1024. In every run all estimation parameters are adjusted to minimise the objective function. Once the algorithm has found the region of the (sub-) optimal solution the gains in each run become smaller and smaller. It is up to the end user to determine at what moment the (sub-) optimal solution is reached (depending on the number of predetermined runs or the change in decrease of the objective function per run).

Summarised, the algorithm calculates a new "optimal" solution based on the previous "optimal" solution and repeats that process several times. In this way the algorithm calculates a sequence of estimation parameters culminating in the private equity index. Actually the algorithm reversely calculates convolutions of the private equity index.

7.4.1 Stability of the algorithm

This optimisation problem is classical; high-dimensional non-linear optimisation problems usually exhibit stability issues. Therefore it is important to analyse the stability of the algorithm in combination with the estimation model.

After initial estimation runs, two potential biases appeared in the private equity index. Both biases are related to the used algorithm. The first bias is related to the objective function and the second bias is related to the design of the iterative algorithm.

7.4.1.1 Objective function bias

It appeared that after a while the algorithm always ends with large second and the third estimation parameters (1987 and 1988) to irrational large values and the first estimation parameter (1986) cannot be changed at all. One could think that these years where exceptionally good for private equity performance or one can question the robustness of the model. Since the surrounding vintage years are not exceptionally good, growth rates of over 60% per year are not to be considered rational.

The algorithm has a declining progress in finding smaller results of the objective function at each run. In the process of finding smaller absolute differences the model will continue to adjust estimation parameters. Unlike the other estimation parameters that affect vintage years ranging from 4 to 10 (depending on the average fund life time of course), the first three estimation parameters only affect the first three vintage years. When the differences in results of the objective function between consecutive algorithm runs are getting smaller it becomes harder to find estimation parameters that are easy to adjust (most estimation parameters affect between 4 and 10 vintage years). Consequently the algorithm starts adjusting the first 3 values to irrational heights because of the limited effect on other vintage years.

A solution to this problem could be to prevent the algorithm to fix these first three growth values and adjust these values manually (within reasonable boundaries) later. The calculation of the objective function will use the fixed values of these first vintage years. By adjusting the growth rates later by hand it can create biases in the IRR and TVPI numbers of these and subsequent vintage years.

One could also set hard boundaries as restrictions in the algorithm for the first three estimation parameters (For example: -10% <= estimation parameter <= 30%). After some tests with this construction it appeared that the algorithm consequently assigns the maximum value of this boundary to the first three estimation parameters. For subsequent regression analysis these values are not useful, since they are still “manually” adjusted.

The solution used in this research is that the first three estimation parameters will not be used in the regression analysis. These parameters are highly biased and it is not expected that they influence the other parameters because the bias occurs only in a later stage of the iterative process when all other estimation parameters almost have reached their ultimate values.

7.4.1.2 Algorithm design bias

It is important that the algorithm generates stable results. With another set of fixed parameters another private equity index will emerge after a certain amount of runs. This is a desired property of the model but it is not possible to analyse and explain the differences between the resulting private equity indexes. What can be analysed is the robustness or stability of the algorithm with different initial estimation parameter sequences with equal fixed parameter settings. The algorithm is programmed to minimise the summed squared differences between the calculated and historical TVPI and IRR sequences (the objective function). For the algorithm being stable different initial estimation parameter sequences should eventually converge to the same private equity index with the same final summed squared differences number. To test the stability of the algorithm an analysis of the sensitivity to different “first guesses” of initial estimation parameters is performed.

The figures below represents the output of the algorithm with the same fixed parameters but with different initial estimation parameter sequences for both the US and Europe. The used initial estimation parameter sequences are: 0% fixed for all years, 5 % fixed for all years, 10% fixed for all years, 15 % fixed for all years, 20% fixed for all years, 0% - 20% ascending and 20% - 0% descending. The result of the objective function for each initial parameter sequence in the figure is shown between brackets.

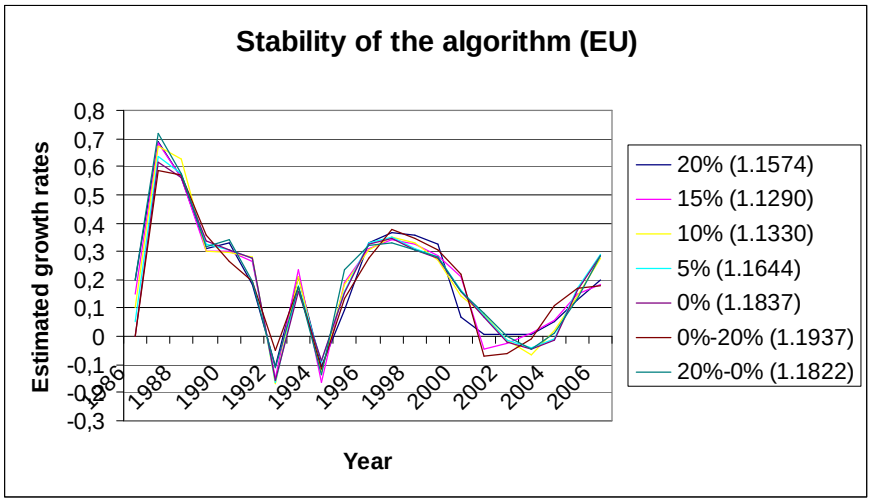


Figure 14 Stability of the algorithm (Europe)

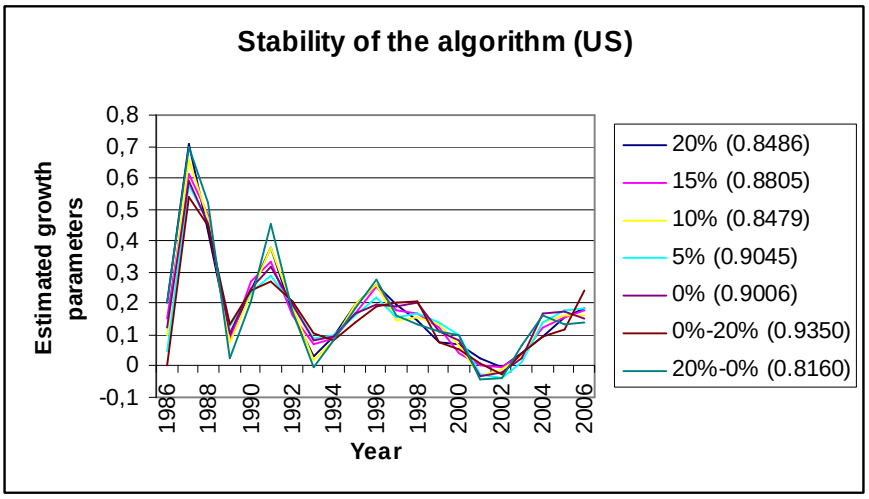


Figure 15 Stability of the algorithm (US)

The fixed parameters in both stability tests are set according to the proposed leveraged buyout parameters in the article of Takahashi & Alexander (2002). These settings are:

$RC_{h,t}$ = Rate of contribution: 25% in year 1, 33.3% in year two and 50% in subsequent years

CC_h = Capital commitment: always fixed at 100%

L_h = Life of a closed fund: always set at 10 years

TT_h = Total Time: like in reality (for example 4 years for vintage year 2003)

B_h = Factor describing the rate of distribution: always set at 2.5

As one can see in the figure, the algorithm does not return converging private equity indices based on different initial estimation parameter sequences. For this stability test the algorithm calculated every index based on the change in decrease of the result of the objective function. When this change reached a value of 0.001 the algorithm stopped and the resulting indices are shown in the figures above.

The algorithm does not generate fully converging private equity indices for both the Europe and the US. All resulting indices are sub-optimal solutions of the objective function. Again this phenomenon is encountered often in classical optimisation problems. By analysing different "first guesses" as input parameters the best possible suboptimal solutions can be identified. In certain years there are more deviations than in other years. But the general movements of all indices have the same direction. There are no real outliers in this stability test. It can be concluded that the algorithm generates stable results within certain boundaries. The initial estimation parameter sequence with all values set at 15% returns the best sub-optimal solution of the objective function for Europe. For the US this is the descending initial parameter sequence 20%-0%.

It is important that the algorithm generates stable results. The resulting private equity index is more valid and the subsequent regression analysis is more reliable. This algorithm does generate reasonably stable results but improvements are always desirable.

7.5 Estimation model Ia

The first estimation model will be split in two separate models, estimation model Ia and estimation model Ib. This section will describe estimation model Ia.

Estimation model Ia is entirely based on the proposed leveraged buyout settings in the article of Takahashi & Alexander (2002). Actually, estimation model Ia is the best resulting private equity index from the stability test in the previous section. The figure below represents the private equity index for both the US and Europe.

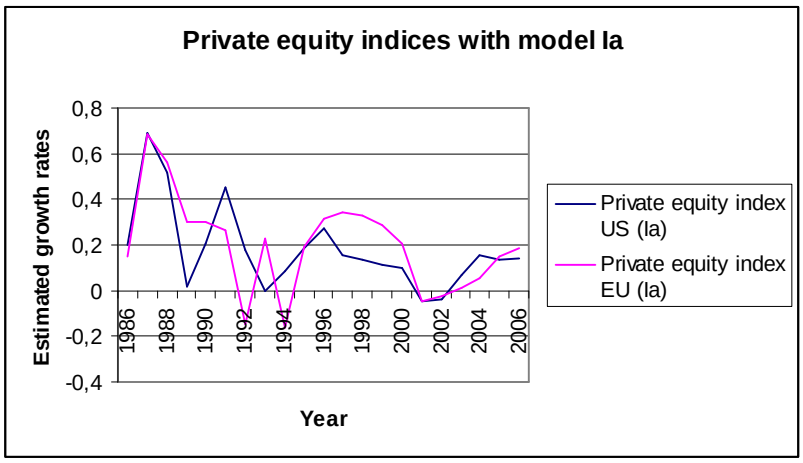


Figure 16 Private equity indices estimation model Ia (US and Europe)

The fixed parameters for both private equity indices are set according to the proposed leveraged buyout parameters in the article of Takahashi & Alexander (2002). These settings are:

$RC_{h,t}$ = Rate of contribution: 25% in year 1, 33.3% in year two and 50% in subsequent years

CC_h = Capital commitment: always fixed at 100%

L_h = Life of a closed fund: always set at 10 years

TT_h = Total Time: like in reality (for example 4 years for vintage year 2003)

B_h = Factor describing the rate of distribution: always set at 2.5

The best initial estimation parameter sequence of Europe (15% fixed for all years) generates a result of the objective function of 1.1290 (based on a decrease change in the result of the objective function of 0.001). For the US, this result is 0.8160. The resulting actual and fitted TVPI and IRR sequences of the US are presented in the figure below. For Europe comparable fitted lines can be drawn.

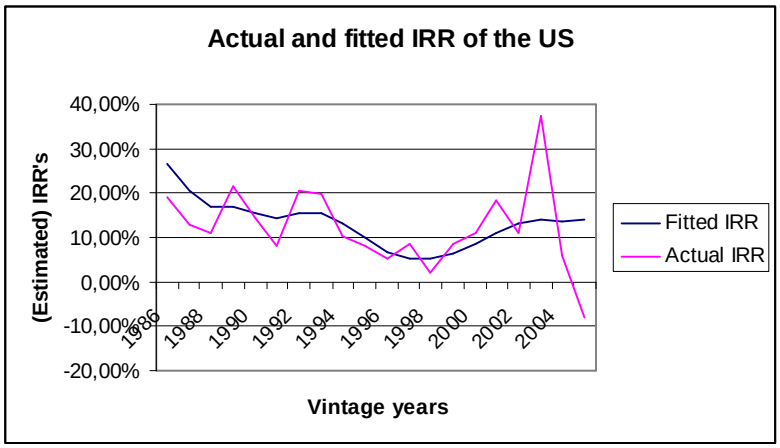


Figure 17 Actual and fitted IRR estimation model Ia (US)

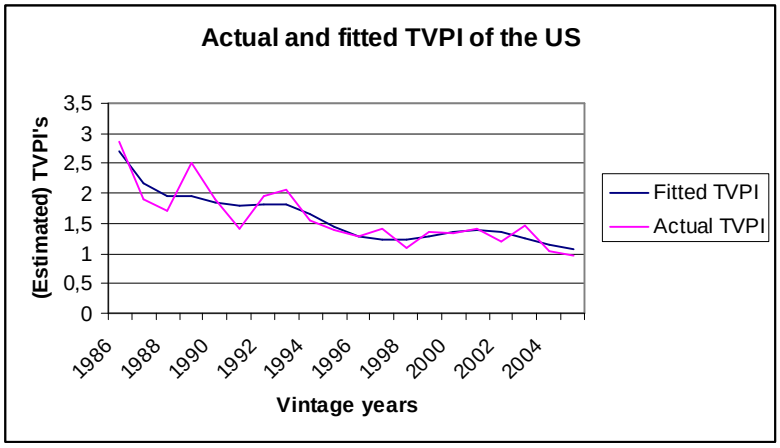


Figure 18 Actual and fitted TVPI estimation model Ia (US)

It is clear that private equity index of the US does not describe private equity performance accurately. This holds the same for the European private equity index. Estimation model Ib is constructed to generate a better fit with actual performance data.

7.6 Estimation model Ib

For finding a better fit to the actual performance data a further analysis of the relationship between IRR and TVPI is used. Whereas estimation model Ia uses the divestment paces proposed by Takahashi & Alexander (2002); estimation model Ib uses adjusted divestment paces. Just like in estimation model Ia this model the divestment paces are fixed parameters.

The divestment paces are based on the "relationship" between the IRR and TVPI of an individual J-curve. The figure below presents this relationship graphically. With constant estimation parameters (10%) the IRR of this J-curve is 10%. If one computes this J-curve with a divestment pace of 1.5, 2 and 2.5 the resulting TVPI numbers are respectively 1.33, 1.41 and 1.49. This effect will be more complex when different estimation parameters are used.

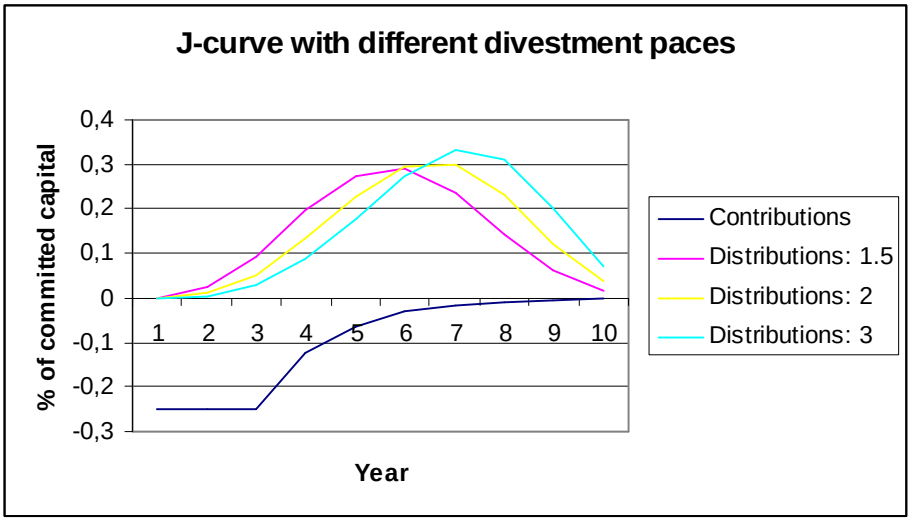


Figure 19 J-curve with different divestment paces

The timing of cash flows is very important for both IRR and TVPI numbers. Based on the "relationship" between IRR and TVPI numbers of individual cash flows new divestment paces for both Europe and the US are estimated. These new divestment paces are presented in the figure below.

Vintage year	Divestment pace US	Divestment pace EU
1986	4,85	3,55
1987	3,45	2,25
1988	3,3	3
1989	2,65	2,6
1990	2,95	2
1991	2,4	1,95
1992	1,7	2,05
1993	2,05	1,5
1994	2,65	2,5
1995	2,35	1
1996	3,2	1,55
1997	2,35	2,15
1998	2,5	2,2
1999	2,65	2
2000	1,3	1,5
2001	0,8	2
2002	2,5	2,5
2003	2,5	2,5
2004	2,5	2,5
2005	2,5	2,5

Figure 20 Divestment paces estimation model Ib (US and Europe)

The other fixed parameters for both private equity indices are set according to the proposed leveraged buyout parameters in the article of Takahashi & Alexander (2002). These settings are:

$RC_{h,t}$ = Rate of contribution: 25% in year 1, 33.3% in year two and 50% in subsequent years

CC_h = Capital commitment: always fixed at 100%

L_h = Life of a closed fund: always set at 10 years

TT_h = Total Time: like in reality (for example 4 years for vintage year 2003)

The resulting private equity index of Europe exhibits a lower result for the objective function (0.5104 compared to 1.1290 in estimation model Ia) and the calculated performance numbers better fit the actual performance numbers. The resulting private equity index for the US exhibits a higher result for the objective function (1.0508 compared to 0.8160 in estimation model Ia). (Again these values are based on an ultimate decrease change in the result of the objective function of 0.001.) For the US his is not a desired result. But this issue will be addressed by estimation model II.

The figure below presents both private equity indices for both Europe and the US.

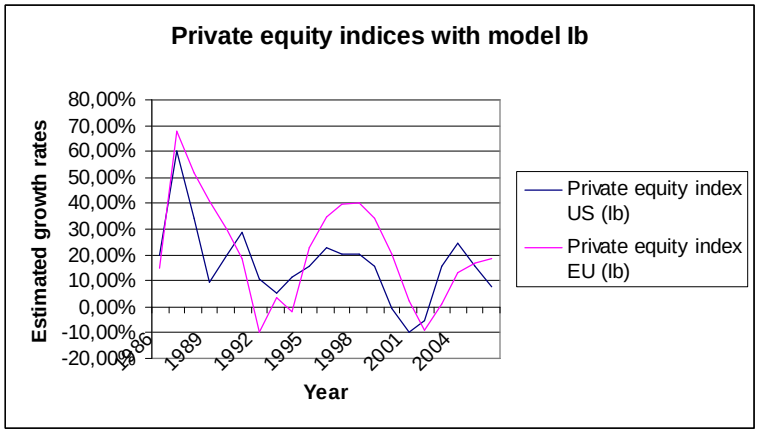


Figure 21 Private equity indices estimation model Ib (US and Europe)

The resulting actual and fitted TVPI and IRR sequences of the US are presented in the figure below. For Europe comparable fitted lines can be drawn.

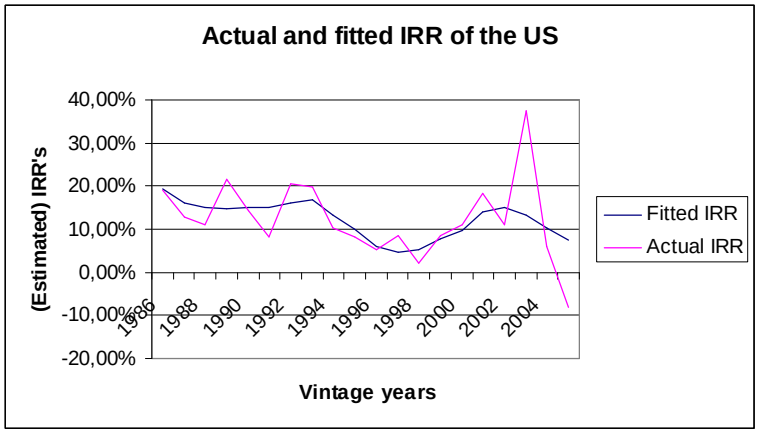


Figure 22 Actual and fitted IRR estimation model Ib (US)

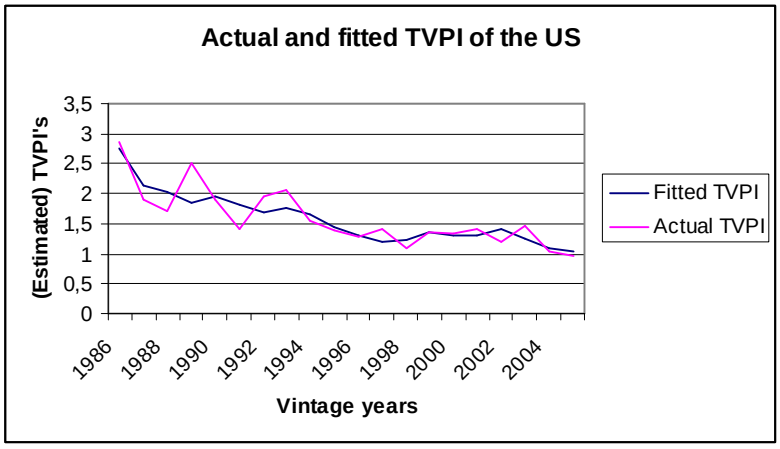


Figure 23 Actual and fitted TVPI estimation model Ib (US)

It is clear that by changing the standard fixed Takahashi & Alexander (2002) parameters the estimation models can be adjusted to fit the actual performance data better, although this first attempt was not fruitful for the private equity index of the US. Estimation model II will further analyse private equity indices with other fixed parameter settings.

7.7 Estimation model II

Estimation model Ib showed that it is possible to find better results of the objective function and better fit the calculated performance with the actual performance measures if one changes divestment paces. The purpose of estimation model II is to find the best possible divestment pace for each vintage year by constructing several indices with the general estimation model. These indices will all start with the initial estimation parameter sequence used in estimation model Ia and Ib and with the same fixed parameters. Only the divestment paces will differ between the generated indices. After the construction of these indices one can see what initial divestment pace range resulted in the best fitting private equity index. The best private equity index exhibits the lowest result of the objective function and therefore is able to fit the calculated performance with the actual performance best.

For all indices constructed in this model the divestment paces are presented in appendix A.2. These divestment paces are variants of the divestment paces used in estimation model Ib. The figures below represent the results of the objective function of the several indices (based on different divestment paces) for both Europe and the US.

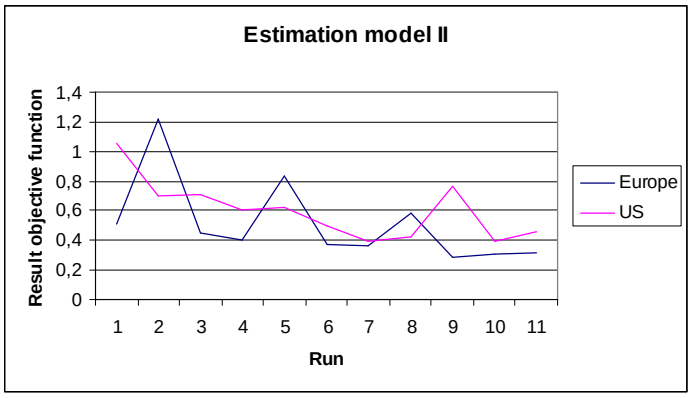


Figure 24 Results objective function with different divestment paces (US and Europe)

One can see that the 10th run of the estimation model in the US resulted in the best fitting model. The result of the objective function is 0.3909. For Europe it is the 9th run with 0.2892 as a result of the objective function. These results are considerably lower that the results of estimation model Ia (Europe: 1.1290, US: 0.8160) and Ib (Europe: 0.5104, US: 1.0508). (Again these values are based on a decrease change in the result of the objective function of 0.001.)

It is important to mention that all the private equity indices generated with the second estimation model do not diverge a lot. In the figure below all private equity indices generated with the second estimation model are presented for both Europe and the US.

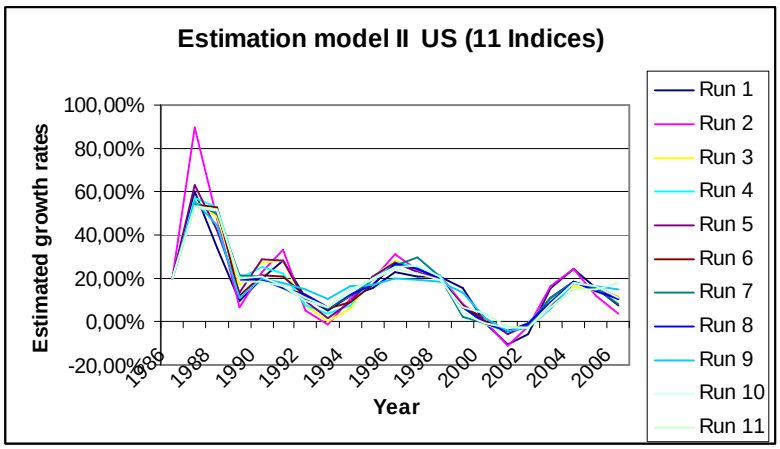


Figure 25 Output estimation model II (US)

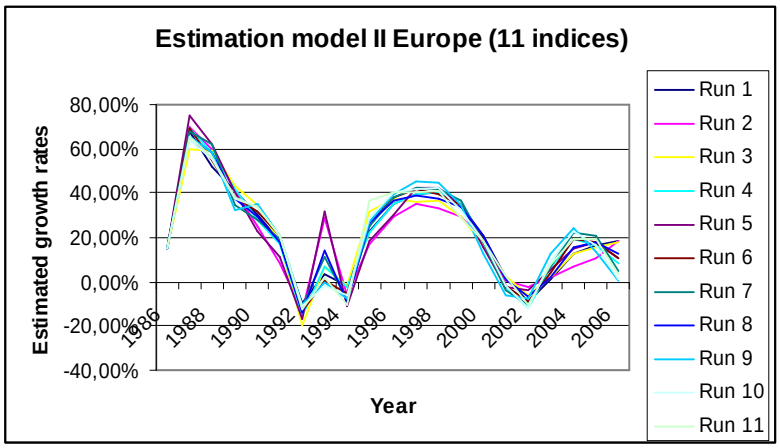


Figure 26 Output estimation model II (Europe)

The private equity indices with the lowest results of the objective function will be used in further research. These indices are presented in the figure below.

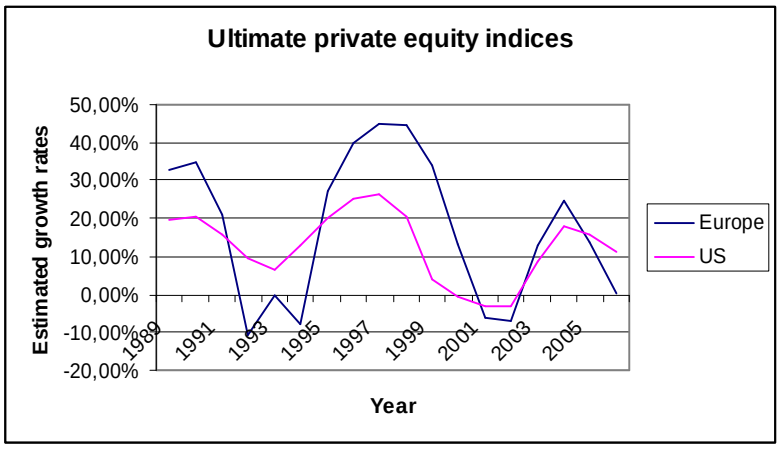


Figure 27 Best fitting private equity indices estimation model II (US and Europe)

One can see that both indices have a bit the same tendency. Up and down cycles are almost at the same time; whereas Europe seems to have higher growth rates in up times but lower growth rates in down times compared to the US. The first three estimated growth rates are left out because of the discussed modelling bias.

The corresponding fitted and actual performance measures are presented in the next four figures.

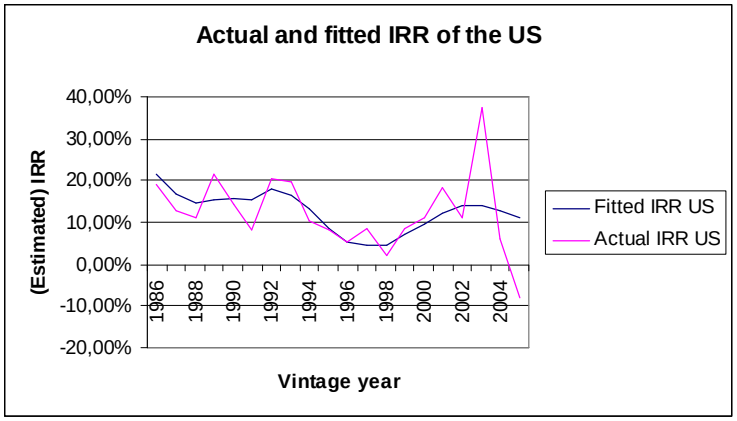


Figure 28 Actual and fitted IRR estimation model II (US)

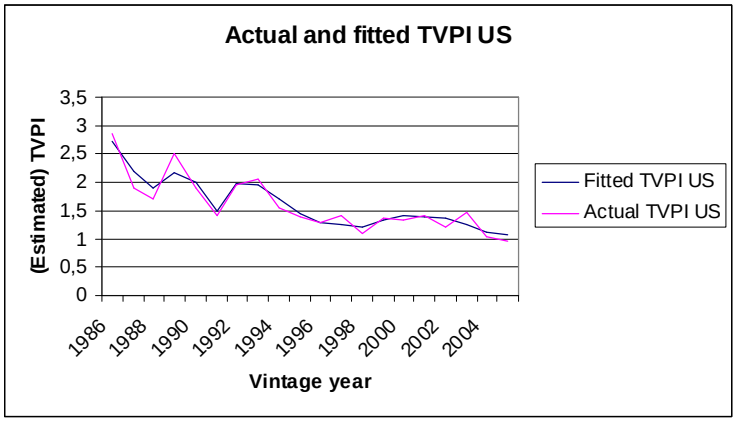


Figure 29 Actual and fitted TVPI estimation model II (US)

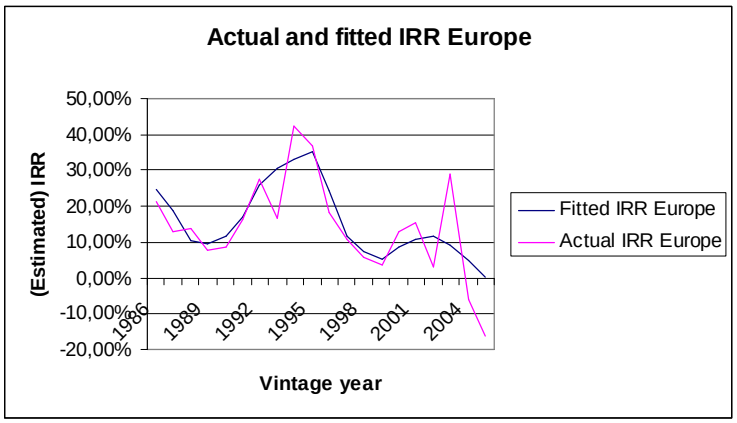


Figure 30 Actual and fitted IRR estimation model II (Europe)

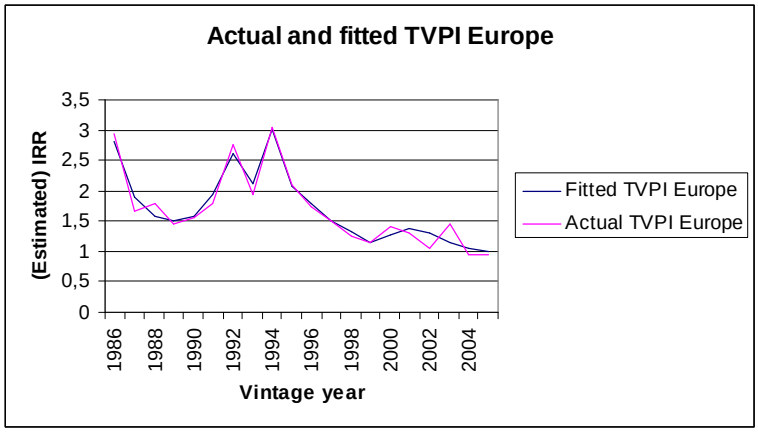


Figure 31 Actual and fitted TVPI estimation model II (Europe)

In estimation model II only the divestment paces were changed in the search for the lowest objective function result. In the model of Takahashi & Alexander (2002) the divestment paces have the strongest influence on the relationship between IRR and TVPI. One could change investment paces as well (and create an estimation model III). To avoid an increase of complexity in the modelling approach that has not been done in this research.

One could even further analyse variations of the divestment paces of the best private equity index. It is not expected that this will increase the validity of the private equity index significantly. This modelling approach is still based on a number of assumptions and a small amount of historical performance information.

7.8 Robustness of the estimation model output

This section describes how the output of the estimation model should be interpreted. The first section will describe the constructed private equity index and its shortcomings. The second section describes how the differences between actual and fitted performance measures can be analysed in a residual analysis.

7.8.1 Reliability and validity of the private equity index

The quality of the private equity index resulting from the estimation model depends on the quality of the algorithm, the historical performance data, the assumptions and the fixed vintage year parameters. In this approach it is assumed that the model of Takahashi & Alexander (2002) is the best model currently available. The quality of the algorithm is discussed in a previous section. The historical performance data has biases which are already described in the literature chapter. The largest bias, the subjective valuations bias for immature vintage years is described in a previous section and solutions for the general estimation model are given in section 7.3.
The fixed parameters are based on qualitative information supplied by industry professionals, some rough calculations on divestment paces and trial and error testing. With another set of fixed parameters, the private equity index differs. The effects of changing investment paces, divestment paces, total lifetimes and entry / exit conditions on the resulting private equity index are very complex. As long as there is not more information available about the cash flow patterns of private equity vintage years, assumptions and rough estimates of these fixed

input parameters are unavoidable. The private equity indices from estimation model II are currently the best estimations available in this research.

It is expected that investment and divestment paces depend on market conditions like M&A activity and the IPO climate. For this research there was no information available about (pooled) cash flow patterns of the underlying vintage years, otherwise the investment and divestment paces could be adjusted to match the underlying vintage year (pooled) cash flow patterns.

7.8.2 Residual analysis

The algorithm used in this research uses an objective function that minimises the summed squared differences between calculated and historical performance data (both IRR and TVPI). To gain a more detailed perspective on how individual vintage years perform a residual analysis of individual squared differences of calculated and historical performance data can be executed.
The idea is that if the final private equity index is calculated with the algorithm, the objective function is not likely to equal to zero. Certain squared differences are higher than others and affect each other as well. The figure below presents both the calculated TVPI's of the US and the historical pooled TVPI's of the US based on the private equity index. One can see that there remain differences between both series, sometimes the calculated value is larger and sometimes the calculated value is lower than the historical value in a certain year.

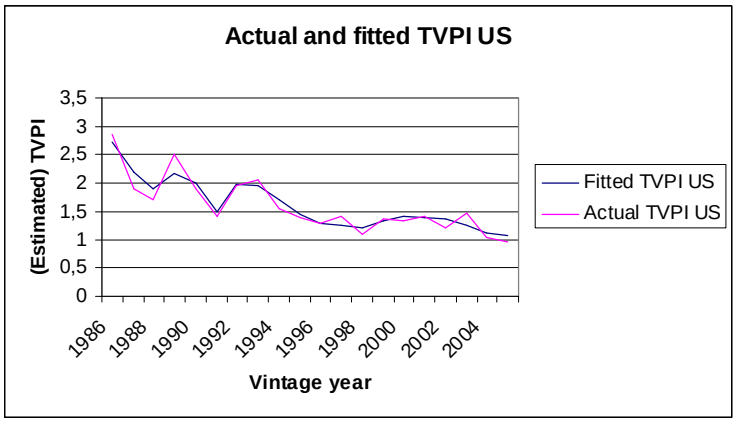


Figure 32 Actual and fitted TVPI estimation model II (US)

The residuals of these series are presented in the figure below.

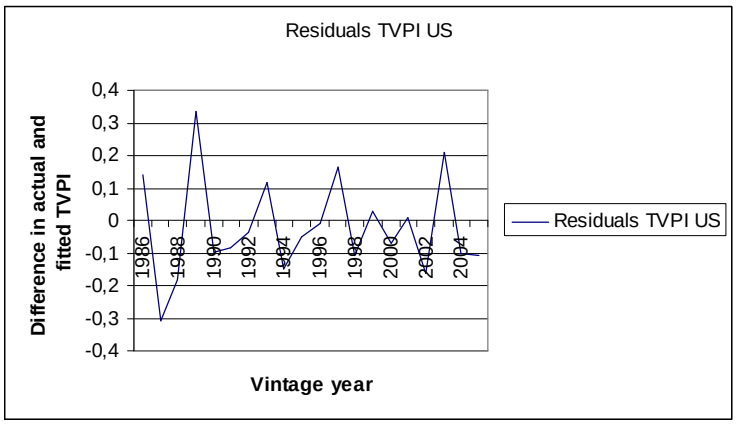


Figure 33 Residuals actual and fitted TVPI estimation model II (US)

The same effects hold for the calculated and historical IRR sequences (for both Europe and the US). There are certain years like in 1988, 1989 and 1997 where the algorithm is not able to estimate the correct performance number. If one year is not correct, subsequent years will be influenced by this effect. The figure shows the missing differences in the last years. The algorithm only calculates these differences partially or not because of the data bias (valuation bias), mentioned earlier in this report.
In this research this problem has been recognised but not analysed any further. This residual problem is related to the robustness of the algorithm, the used assumptions and the availability of more (cash flow) data.

7.9 Future development of estimation models

The main goal of the methodology chapter is the construction of a best fitting private equity index. Considering all classical optimisation problems encountered in the current estimation models the construction of an index for further regression analysis is the easiest solution. However, based on the above developed methodology one could further improve the estimation models.

At this moment the estimation model estimates 21 parameters. The underlying functions are non-linear and combined with the high dimensionality of the estimation model stability issues arise. To lower the number of estimation parameters and thus the dimensionality of the problem one could use parametric methods. Parametric methods use the fact that the next parameters depends on its predecessor. This principle can be applied to this research. The current estimation model is based on convolutions with the idea that one economic environment drives private equity performance. One of the assumptions is that performance of two neighbouring vintage years is related and thus performance cannot vary significantly. The estimation parameters are consequently related due to the convolution structure that is applied. One could think in the perspective of Maximum Likelihood Estimators. The next parameter will be estimated based on a function of its predecessors. The function exhibits one initial value (b_0) and a certain constant (α) and it depends on the time t. The corresponding algorithm only has to estimate both b_0 and α to find the best fitting private equity index. The challenge is to find a good fitting econometric function. The use of a parametric model and thus the lower amount of parameters could lead to more stable results of the estimation model.

To cope with the issue of finding a good fitting econometric function in a parametric method one could also use another approach. This approach doesn't generate a private equity index, which on its turn will be regressed with macroeconomic variables. Every estimation parameter can be stated as a function of one (or more) macroeconomic variables like in a regression equation:

$$G_t = a + b_i * Variable_{i,t} + e_t$$

G_t is the estimation parameter just like in the current estimation model. This approach has two (or more in case of more macroeconomic variables) estimation parameters α and b_i for every single macroeconomic variable. In this situation there is no issue with finding an appropriate econometric function and you directly relate private equity performance to macroeconomic variables in a regression analysis. This method avoids errors generated by using a private equity index as a medium for private equity performance.

This research is based on the current 21 estimation parameters. The two proposed improvements to the current estimation model lower the amount of estimation parameters significantly (from 21 to 2). In terms of optimisation problems this is desirable. For future research it is recommended to analyse both proposed improvements.

Chapter 8: Results

The performance parameters found in the literature section will be used in the regression analysis. In the first section all individual parameters will be regressed with their respective resulting private equity index (US or Europe) from estimation model II. This will be presented as a one-factor regression analysis (non-forecasting). This analysis is used to determine how private equity performance is related to macroeconomic variables. The found relationships are compared with literature studies in the second section. The third section will use forecasting regression analysis to determine what macroeconomic variables are able to forecast private equity performance one period ahead. This forecasting regression analysis will be used with both single and multiple factors. The selection of single and multiple factors will depend on significance and the outlay of the quadrant model. The third section will give comments on out-of-sample back-testing.
All macroeconomic variables are corrected for trend to prevent unit-roots. If a macroeconomic variable contains trend the first differences are used in the regression analysis.

8.1 (Non-forecasting) one-factor regression analysis

To give an indication how macroeconomic parameters are related to private equity performance a non-forecasting one-factor regression analysis is used. The variable y_t represents the returns of the private equity index. The macroeconomic variable that is used to explain the private equity performance is represented by x_i . The regression equation:

$$y_t = b_0 + b_i x_{i,t} + e$$

The one-factor analyses allow a consistency check of the relationships between the economic parameters and the private equity index. The two figures below present all one-factor analyses of both Europe and the US.

Correlation of variables with the European private equity index at time t				
Variables	Correlation	Adj R^2	F-value	Significance alpha
High yield credit spread	-0,46	0,21	3,45	0.01
High yield	0,08	0,01	0,09	n.s.
BAA bond yield	0,05	0,09	1,17	n.s.
M&A volume	0,63	0,40	8,56	0.025
IPO volume	-0,01	0,00	0,00	n.s.
FTSE Europe	0,30	0,09	1,61	n.s.
FTSE All world	0,56	0,32	5,09	0.05
Buyout leverage	0,26	0,07	1,20	n.s.
Buyout fundraising	0,04	0,00	0,02	n.s.

Figure 34 One-factor regression analysis Europe

European private equity performance can be significantly related to high yield credit spread, European M&A volume and the FTSE world. In the figures “n.s.” stands for “not significant”. All other variables are non-significant. As one can see and should expect is that high yield credit spread is negatively correlated to private equity performance. M&A volume and the FTSE World are positively correlated as expected. Buyout leverage and the FTSE Europe

have a reasonable strong correlation but not at a good significance level. It is remarkable that the FTSE All world is more related to European private equity performance than the FTSE Europe.

Correlation of variables with the US private equity index at time t				
Variables	Correlation	Adj R^2	F-value	Significance alpha
High yield credit spread	-0,83	0,69	29,21	0.001
High yield	-0,10	0,01	0,16	n.s.
BAA bond yield	0,12	0,01	0,22	n.s.
FED rate	0,49	0,24	5,02	0.05
Industrial production	0,46	0,21	3,99	0.1
GDP growth	-0,07	0,00	0,07	n.s.
M&A volume	0,64	0,40	8,83	0.025
IPO volume	0,21	0,04	0,60	n.s.
S&P 500	0,65	0,43	11,98	0.01
FTSE USA	0,74	0,54	11,84	0.01
FTSE All World	0,59	0,34	5,73	0.05
Buyout leverage	0,50	0,25	5,30	0.05
Fundraising	0,32	0,10	1,74	n.s.
P/E ratio S&P 500	-0,57	0,33	7,82	0.025
Liquidity premium	-0,26	0,07	0,93	n.s.

Figure 35 One-factor regression analysis US

In the US there are more significant macroeconomic variables that determine private equity performance. Especially high yield credit spread is strongly related to private equity performance. The correlation is -0.83 with an alpha of 0.001. The price / earnings ratio of the S&P is also strongly correlated with an alpha of 0.025. All other significant variables have signs that are in the line with expectations. For example stock market indices (S&P 500, FTSE USA and the FTSE All world) are reasonable strongly correlated as expected. Buyout leverage is more correlated than in Europe.

The figures below give an example of the relationship between the S&P 500 and the private equity index. The first figure gives the private equity index and the first derivative of the S&P 500 (also used in the regression analysis). The second one presents both the S&P 500 and the US private equity index as stock indices (in absolute values and not in relative returns).

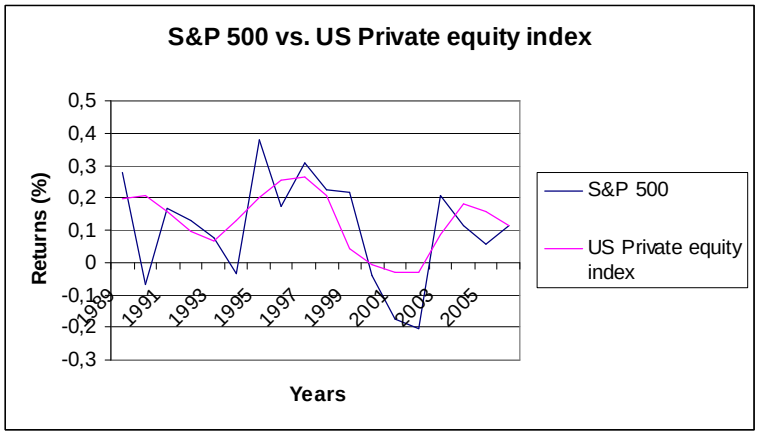


Figure 36 S&P 500 vs. US Private equity index (relative)

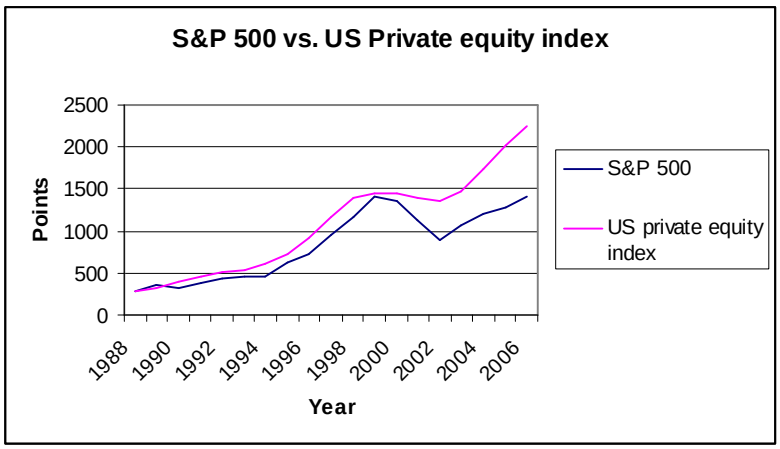


Figure 37 S&P 500 vs. US Private equity index (absolute)

This figure indicates that US private equity has outperformed the S&P 500 over the long term. Although this research is not aimed at finding alpha or risk adjusted returns of private equity compared to stock indices, it is a nice additional observation.

In the case of Europe there are not a lot of complete macroeconomic variable sequences for the European analysis. For example, the industrial production numbers for entire Europe are only given from 1998, which is too short for a reasonable analysis. Europe did not have one single "government" interest rate, like the US has for a very long period. European countries did not have the same currency for a long time. The European Union is nowadays working on financial and economic integration of all member countries. The effects of these efforts are emerging at this moment. In 1986, these developments were not prevalent. All these matters can distort a unanimous private equity performance and especially the assumptions behind this research. It also makes it hard to analyse the private equity index with non-existing parameters (like one industrial production sequence).

It must be stated that the correlations found in this research are based on regression analysis with unequal amount of observation points. For example the correlation of the high yield credit spread is based on 15 observations and the correlation of the S&P 500 is based on 20 observations in the US situation. This depends on the availability of historical data. This could mean that certain historical events cannot be incorporated by the certain macroeconomic variables because of the lack of data.
An analysis of all parameters and the private equity index by eye indicates that private equity performance tends to be more cyclical in the second half of the time horizon compared to the first half of the analysed period (this holds for both Europe and the US).

8.2 Comparison regression results with literature

The results of the one-factor regressions are hard to compare with literature. This research method differs significantly from other research. A lot of articles present all kinds of statistical information but do not reveal "practical" information such as correlations or adjusted R^2 on macroeconomic variables (Phalippou & Zollo (2005)). Sometimes articles present combined statistical output (for example macroeconomic variables with microeconomic variables (Ljungqvist & Richardson (2003)) such as fund size and quality of the General Partner), which is hard to compare with results in this research.

Most research is better able to relate variables to private equity performance. More precise information is debit to that fact. The signs of the significant variables in this research do show the same direction as reported in other articles. This gives confidence in the chosen research methodology.

8.3 Forecasting regression analysis

The goal of this research is to construct a model that is able to forecast private equity performance. This model should be constructed according the quadrant model philosophy at AEGON Asset Management. For this purpose forecasting regression analysis is used. First a forecasting one-factor regression analysis will determine what macroeconomic variables are able to forecast private equity performance within a significant range (8.3.1). After that the resulting variables will be used to construct the underlying structure for the quadrant model (8.3.2). This is partly based on a multiple factor forecasting regression analysis.

8.3.1 Forecasting one-factor regression analysis

The variable y_{t+1} represents the future returns of the private equity index (one year ahead). The macroeconomic variable that is used to explain the private equity performance is represented by $x_{i,t}$. The forecasting one-factor regression equation: $y_{t+1} = b_0 + b_i x_{i,t} + e_{t+1}$

The figures below present the forecasting one-factor regression results for both Europe and the US.

Correlation of variables with the European private equity index at time t+1				
Variables	Correlation	Adj R^2	F-value	Significance alpha
High yield credit spread	-0,48	0,23	3,57	0.1
High yield	-0,12	0,01	0,24	n.s.
BAA bond yield	0,10	0,01	0,16	n.s.
M&A volume	0,54	0,29	5,34	0.05
IPO volume	-0,26	0,07	0,87	n.s.
FTSE Europe	0,22	0,05	0,81	n.s.
FTSE world	0,55	0,30	4,34	0.1
Buyout leverage	0,31	0,10	1,76	n.s.
Buyout fundraising	0,20	0,04	0,70	n.s.

Figure 38 One-factor forecasting regression analysis Europe

As one can see the significant macroeconomic variables of the forecasting one-factor regression analysis are the same variables that emerged in the ordinary regression analysis of private equity performance, albeit less significant. European private equity performance can be forecasted based on high yield credit spreads, M&A volume and the FTSE World. The confidence level of the three parameters is always larger than 90% (1-alpha).

Correlation of variables with the US private equity index at time t+1				
Variables	Correlation	Adj R^2	F-value	Significance alpha
High yield credit spread	-0,58	0,34	6,11	0.05
High yield	-0,13	0,02	0,26	n.s.
BAA bond yield	0,18	0,03	0,52	n.s.
FED rate	0,31	0,09	1,66	n.s.
Industrial production	0,31	0,10	1,72	n.s.
GDP growth	0,00	0,00	0,00	n.s.
M&A volume	0,48	0,23	3,92	0.05
IPO volume	0,07	0,00	0,06	n.s.
S&P 500	0,48	0,23	4,73	0.05
FTSE USA	0,49	0,52	9,60	0.025
FTSE All World	0,41	0,17	2,07	n.s.
Buyout leverage	0,44	0,19	3,74	0.05
Fundraising	0,06	0,00	0,06	n.s.
P/E ratio S&P 500	-0,70	0,49	15,55	0.01
Liquidity premium	0,16	0,03	0,33	n.s.

Figure 39 One-factor forecasting regression analysis US

The price / earnings ratio of the S&P 500 seems to be a strong indicator of future private equity performance with a negative correlation of -0.70 at a 99% confidence level. The FTSE USA and the high yield credit spread are also strong indicators for future (one year ahead) private equity performance. Almost all macroeconomic variables have decreasing significance when compared to the non-forecasting one-factor regression analysis. Some even became non-significant in the forecasting regression analysis. The results from this analysis will be used in the next section.

8.3.2 Forecasting (multiple factor) regression analysis per quadrant

The quadrant modelling philosophy uses 4 quadrants with quadrant-specific variables. For example the valuation quadrant uses valuation-based variables and the sentiment quadrant only sentiment-related variables. Below the macroeconomic variables are grouped per quadrant for both Europe and the US. This grouping is based on other quadrant models and the previous (qualitative) private equity quadrant model. Each quadrant only represents the significant macroeconomic variables.

Europe Macro quadrant

- High yield credit spread
- European M&A volume

Europe sentiment quadrant

- FTSE World

Europe does not have a valuation quadrant because of the lack of enough explanatory variables.

US Macro quadrant

- High yield credit spread
- M&A volume

US Valuation quadrant

- P/E ratio S&P 500

US Sentiment quadrant

- FTSE USA
- S&P 500
- Buyout leverage

Variables that are in the same quadrant should be combined in one regression analysis. This enables each quadrant to have its own forecasting value. To avoid multicollinearity all concerned macroeconomic variables are analysed. For Europe this concerns the macro quadrant and for the US both the macro and the sentiment quadrant.
An absolute correlation value which is higher than 0.60, is a statistically critical value (Verschuuren (2002)). This means that if two parameters have an equal or larger correlation than 0.60 (absolute value) they are not used simultaneously in one multiple regression analysis.
European M&A volume and high yield credit spread are -0.53 correlated. US M&A volume and high yield credit spread are -0.84 correlated. The FTSE USA and the S&P 500 are 0.97 correlated. FTSE USA is 0.58 correlated with buyout leverage, the S&P 500 is 0.50 correlated with buyout leverage.
For Europe this means that European M&A volume and high yield credit spread can be used in multiple regression analysis. There still needs to be determined whether the adjusted R^2 is higher than each of the single variables. In the US the high yield credit spreads will be used solely in the macro quadrant since the correlation with US M&A volume is too high. High yield credit spread has the highest single factor explanatory power when compared to US M&A volume. The FTSE USA is too correlated with the S&P 500 for a valid multiple regression analysis. Since the FTSE USA has a higher single factor explanatory power when compared to the S&P 500 this variable will be used in combination with the buyout leverage in the sentiment quadrant. There still needs to be determined whether the adjusted R^2 is higher than each of the single variables.

Multiple factor regression works comparable to one-factor regression analysis. Only the future private equity performance y_{t+1} (one year ahead) is than explained by more than one parameter $x_{i,t}$: $y_{t+1} = b_0 + b_1 x_{1,t} + b_2 x_{2,t} + ... + b_i x_{i,t} + e_{t+1}$

The figures below present the multiple regression results for both Europe and the US.

Multiple factor regression analysis (US)			
Variables	adj R^2	F-value	Significance alpha
FTSE USA & Buyout leverage	0,42	4,57	0.05

Figure 40 Multiple-factor forecasting regression analysis US

Since the FTSE USA has a larger adjusted R^2 (0.52) as a single variable (which is also more significant) than in the multiple regression and therefore the US sentiment quadrant will only consist of the FTSE USA as forecasting variable. The FTSE USA has a larger explanatory power than the buyout leverage if observed as single variables.

Multiple factor regression analysis (Europe)			
Variables	adj R^2	F-value	Significance alpha
High yield credit spread & M&A volume	0,19	2,54	n.s.

Figure 41 Multiple-factor forecasting regression analysis Europe

Since M&A volume in Europe has a larger adjusted R^2 (0.29) as a single variable (and is significant as well) than in the multiple regression and therefore the European macro quadrant will only consist of the M&A volume as forecasting variable. The M&A volume has a larger explanatory power than the high yield credit spreads as single variables.

By excluding the variables from the multiple regressions all quadrants of both Europe and the US are left with one variable. The regression coefficients and other regression data can be found in Appendix A.3. Chapter 9 will describe how the results of the forecasting regression analysis are used in the further construction of the quadrant model.

8.4 Out of sample back-testing

The low amount of data points does not facilitate an out of sample analysis of the private equity index and the macroeconomic parameters. Especially some of the macroeconomic parameter sequences are not consisting of many observations. For example the high yield credit spread sequence consists of 15 observations. This means that for the goal of this research, the development of a private equity performance forecasting model, it is not possible to do a back-test for validity of the forecasting model. The first regression analysis gives an indication of interdependency between the macroeconomic parameters and the private equity index. The forecasting regression analysis gives an indication of the forecasting power of macroeconomic variables. It is up to the end user to determine whether the results of both regression analyses, and its forecasting power, can be considered valid.

Chapter 9: Quadrant model

Final goal of this research is the development of the quadrant model for private equity. This quadrant model will have the same structure as the currently used quadrant models described in the chapter 1. The first section will describe the calculation factors for the model based on the regression results from the previous chapter. It will also describe the frequent input of updated market data. The second section will describe the output of the model; the quadrant methodology is based on scores and not on direct regression results. The last section will describe how AEGON will use this model. This section discusses the usage frequency and the future improvements to the quadrant model.

9.1 Input

The input of the quadrant model will be based on the selected variables from the section 8.3. AEGON Asset Management produces quarterly and yearly reports for its customers and for internal use. These reports describe market expectations for future periods based on quadrant model outputs. It is expected that AEGON will use this model every (half) year to give a forecast on private equity performance for the next half year.

The coefficients from the regression analysis will be inserted in the quadrant model. For instance if the FTSE USA increases in value this (half) year, this relative increase is multiplied by its coefficient from the multiple factor regression analysis. Subsequently the intercept coefficient is added and a certain outcome is the result of this calculation. This outcome is the forecast of the sentiment quadrant for private equity performance for next (half) year. The same holds for other quadrants. Updated market information will be used as input for the model.

9.2 Output

The output of the model will not be given in regression results but in scores. Every quadrant will have scores ranging from -2 to +2 (very poor to very good). The outcomes of the regression results have to be ranked from very poor to very good.

Below the quadrant model with stylised scores for private equity is shown:

Macro quadrant			**Valuation quadrant**		
High yield credit spread			P/E ratio S&P 500		
Score	+	1.5	Score	--	1
Sentiment quadrant			**Technical quadrant**		
FTSE USA			Not applicable		
			Period		
Score	+	1.5	January 2007 to June 2007		

Figure 42 Quadrant model for US private equity

Europe has a comparable quadrant model it is only based on the macro and the sentiment quadrant (with respectively European M&A volume and the FTSE All world as explaining factors).

Currently it is discussed at AEGON what score is applicable for a certain outcome of the regressions. It is expected that the benchmark for AEGON's private equity results will be used for 0-score (FTSE All world + 300 base points risk premium on a 10 year rolling horizon). At this moment the scores are not identified but the regression results make it possible to relate private equity performance quantitatively to scores and construct the quadrant model: the goal of this research.

9.3 Quadrant model in practice

The quadrant model will be used once or twice a year to forecast private equity performance. This forecast information will be used in the macroeconomic reports produced by AEGON. It gives a rough indication how private equity markets are developing.
The quadrant model and the underlying regressions are far from perfect. As with other quadrant models this model is subjected to continuous developments. As will be described in the recommendations a lot of improvements can be made to the research methodology, the regression analysis and the final model.

Chapter 10: Conclusions

Reflecting on the research objectives and the research results interesting conclusions can be drawn upon this research. First it can be stated that researching private equity performance is a challenging task, the information availability at AEGON forced alternative research methods. This can be seen as an ironical fact, using alternative research methods for private equity, an alternative asset class. The conclusions focus first on the research method and subsequently on the research results.

The used research method, based on the estimation model for creating a benchmark or an index for private equity performance, has been developed because other research methods appeared even more inaccurate. The availability of information constrained this research at various stages. The use of assumptions was unavoidable for this research to generate the desired private equity performance index. The results of the regression analysis should be handled with care because of all (potential) biases (algorithm bias, objective function bias and data bias) and assumptions.

The private equity index for Europe seems hard to relate to macroeconomic drivers. Europe has a long history of less integrated countries with different economies. The index and its underlying assumptions are possibly harder to state for Europe compared to the US. Long-term parameter sequences (such as industrial production) are also hard to gather for Europe. Above-mentioned issues make researching private equity performance in Europe more difficult than compared to the US.

The results of the (forecasting) regression analysis for both Europe and the US (given the issues of the private equity index) are in line with expectations. The coefficients of the selected parameters have the expected signs (if compared with literature and the previous quadrant model).

Comparison of the research results with literature is difficult. Most articles do not present easy to compare statistical information. Often literature presents combined statistical information, which is hard to relate to this research.

Verifying regression results with out of sample back-testing is difficult. The low number of observations, based on a self-constructed private equity index, makes it hard to back-test the results. The private equity index itself contains numbers that are not easy to verify as well. The index is unique and can only be verified after a few years, when performance is clearer over several years. Therefore the research results should be handled with care and it depends on the end-user whether he bases conclusions upon it.

The quadrant model can be built based on the results of the regression analysis. After discussions with portfolio managers at AEGON the scores will be determined and the selected factors will be incorporated in the quadrant model. This will be done after completion of this thesis.

An advantage of the constructed estimation model is that it is very flexible and can adapt to newly available information. If more information regarding cash flow patterns etc. becomes available the model can incorporate this by adjusting the fixed parameters and the results of the model are expected to be more reliable.

To summarise, it can be concluded that European and US private equity performance can be forecasted with this research method. The results of the (forecasting) regression analysis and therefore the quadrant model should be handled with care. The availability of more information and improvements to the estimation model (algorithm included) will increase the

reliability of the private equity index and thus the forecasting regression results and ultimately the quadrant model.

Chapter 11: Recommendations

The research method used in this research is initially created to cope with the availability of detailed performance data. This chapter will discuss recommendations for further research in two separate sections. The first section will shortly describe the "what if" situation, the situation where all desired information is available for research. The second section will discuss further research recommendations in the current situation where private equity performance information is scarce.

11.1 "*What if*" situation

In the situation where all desired information is available, or more detailed information than AEGON has at this moment, other research methods would have been used. If cash flow data of large groups of individual funds was available, a more precise relationship could be determined between macroeconomic variables and private equity performance. The availability of detailed information on portfolio company performance and capital structure changes of the underlying companies could further improve the quality and scope of the research. The used research method would then be equal to current research methods in literature. More information, in terms of detailed fund cash flow data or even detailed underlying company data, would lead to a more empirically structured research. Empirical research is preferred above the currently used assumptions based estimation method.
Ergo, more information would facilitate better research methods with more precise empirical results.
Is AEGON able to get more information on private equity performance? For AEGON it is possible to get better information from the large commercial data providers. It is very important to realise that more data from these databases will improve the research results but for AEGON the extra costs of using commercial databases and further research are not expected to outweigh the additional research improvements. AEGON will use the results of this research purely to forecast private equity performance and to gain a better understanding of this asset class. The quadrant model developed in this research will only be used once or twice a year and that will not be sufficient to justify large investments in commercial databases.

If one really wants to understand private equity performance, the commercial databases are even not good enough for providing detailed data. These databases do not exhibit information on the underlying companies, the performance of these companies and the changing capital structure of these companies. This data is only available at the private equity funds themselves and these funds are usually reluctant to provide this information.

11.2 Current situation

It is not expected that AEGON will invest in commercial private equity databases in the near future. In this situation AEGON could improve the current research results. The improvements of the research results can be made on two distinct research components: the available data and the estimation model.

If AEGON is able to acquire visual presentations of cash flow patterns of entire vintage years (and not the underlying data) this information could be used to make better assumptions on the investment paces and divestment paces of particular vintage years like in the article of Takahashi & Alexander (2002).

A better algorithm design can make the largest improvements in this research. This algorithm would generate more stable results based on different initial estimation parameter sequences. This could even imply that the objective function can be stated differently.
In this research the concept of one private equity index based on available historical performance information has been developed. Further research could improve this concept by using better a better estimation model and a better optimising algorithm. Two proposed improvements to the estimation model are given in section 7.9 to lower the amount of estimation parameters. Both improvements would require a different algorithm and it is expected that these improvements will generate more stable results.

If the current algorithm generates stable results and more (visual) information regarding pooled vintage year cash flows is available the resulting private equity index is more reliable. The results of the regression analysis and subsequently the results of the quadrant model would be more reliable.

Future research could also focus on residual analysis as described in section 7.8.2. This analysis could give better insights in the chosen research methodology and its assumptions.

The results for Europe are somewhat lagging US results. This research showed the difficulties of relating European private equity performance to macro-economic parameters. Further future research could focus more on European performance attribution. The availability of more information regarding European private equity performance is desirable for more extensive research.

Out of sample testing remains difficult with limited available information. In the current situation of limited information it is not expected that this problem can be solved.

To summarise: both the estimation model and the results can be improved. The estimation model gives better results with an improved algorithm and the results can be improved with more detailed (cash flow) information. Back-testing the results with this research approach remains difficult.

Chapter 12: Reflection

This chapter will give a personal perspective on this research project. I applied for this research project in May/June 2006. In this period I was very busy finalising my final exams. After a short holiday I started on August 15th on this project. Initially I started with the literature search and read a lot on private equity in general and private equity performance in particular. After a month and a half I processed all available literature on private equity performance and I knew what performance information I needed to do this research.

Sam Robinson of SVG Capital provided the desired information: private equity performance data, this was on the 4th of October. Then I realised that this information was not sufficient to do research with conventional methods. More information than this was not available for AEGON. The quest for alternative research methods had begun!

My first research attempt was to relate ΔIRR's (between different vintage years) to macroeconomic parameters. The idea behind this research method was that certain macroeconomic parameters only influence certain phases of the private equity lifecycle. I tried to relate the ΔIRR's with the ΔParameters exposed to other time periods related to certain phases of the private equity life cycle. This research method did not generate stable results when one compared the analysis for TVPI and IRR. It was also very hard to determine where phases (or cash flows) of certain vintage years are positioned exactly. The results were disappointing but the idea that private equity phases are important and that there is one economic environment affecting all vintage years stayed in my mind.

I realised that I had to mimic cash flow patterns to better relate macroeconomic parameters to private equity performance. Cash flow pattern analysis also highlighted in most literature studies. I constructed my own cash flow pattern simulation for this purpose. This took quite some time. At about half November I realised that my own cash flow pattern simulation model was not of much use. In other words, it was useless!

After a second literature search I rediscovered the article of Takahashi & Alexander (2002). This model gave me the opportunity to generate J-curves with different input parameters. With this model and the idea that there is one economic environment should facilitate private equity performance I adjusted this model. After a long period of building estimation models and algorithms to automatically find private equity indices I managed to build the final model. The algorithm used to find these indices appeared to have certain biases. In the end of this research I could not solve all biases. I believe that solving the algorithm issues is a research project in itself. The results of this research will become more reliable but I do not think that it will change a lot to the currently found regression relationships. These relationships appear quite sensible at the moment.

After 5 months of my internship I found out how to construct private equity indices for both Europe and the US. All kinds of problems emerged when I wanted to generate the private equity indices. What are your initial values, how to solve algorithm robustness issues etc? All these issues are (partly) solved in my evening hours from the moment I started working full-time for AEGON Asset Management from the 1st of February. The following months I have worked in the evening and weekends to write large parts of this thesis and execute estimation runs and gather research results. For everyone who is considering writing his thesis in evenings and in weekends: do not do this! It is more work than you can ever imagine!

After more than three months working in the evening hours I have written the thesis that is in front of you. This challenging research resulted in a long creative process with the quadrant model as final result. I have enjoyed finding creative solutions to seemingly unsolvable problems.

References

Bauer, M., Bilo, S. & Zimmerman, H. (2001) *Publicly traded private equity: an empirical investigation*, WWZ/Department of finance, working paper No.5/01

Brealey & Meyers (2003), *Principles of corporate finance*, 7th Edition, 2003, McGraw-Hill

Crouhy, Mark, Dalai (2000), *Risk management*, 1st Edition, 2000, McGraw-Hill

Diller, C. & Kaserer, C. (2005). *What drives cash flow based European private equity returns? – Fund inflows, skilled GP's and/or risk?* , RICAFE Working paper no. 015, February 2005

Fabozzi, F.J. & Modigliani, F. (2003). *Capital Markets, Institutions and instruments*, 3rd Edition, 2003, Pearson Education, Inc.

Fenn, G.W., Liang, N. & Prowse, S. (1995). *The economics of the private equity market*, Federal Reserve System, Dec 1995

Gompers, P.A. & Lerner, J. (1998). *What drives venture capital fundraising?*, working paper

Gompers, P.A. & Lerner, J. (2000). *Money chasing deals? The impact of fund inflows on private equity valuations*, Journal of financial economics, 2000, vol. 55

Gottschalg & Zipser (2006). *Money chasing deals and deals chasing money – The impact of supply and demand on buyout performance*, Working paper, June 2006

Groh, A. & Gottschalg, O. (2006). *The risk adjusted performance of US Buyouts*, Working paper, 2006

Hull, J.C. (1999). *Options, futures and other derivatives*, Pearson Higher Education, 4th edition

Ick, M.M. (2006), *Performance measurement and appraisal of private equity investments relative to public equity markets*, FINRISK working paper series, Jun 2006, no. 335

Jenkinson, T. (2006), *The development and performance of European private equity*, Working paper, 2006

Kaplan, S. & Schoar, A. (2003). *Private equity performance: returns persistence and capital*, NBER Working paper series, June 2003

Koren, M. & Szeidl, A. (2002). *Portfolio choice with illiquid assets*, CEPR Discussion Papers, no. 3795, Feb 2003

Ljungqvist, A. & Richardson, M. (2003a). *The cash flow, return and risk characteristics of private equity*, NBER Working Paper, 2003, no. 9454

Ljungqvist, A. & Richardson, M. (2003b). *The investment behavior of private equity fund managers*, RICAFE Working paper, Oct 2003, no. 005

Luenberger D.G. (1998). *Investment science*, Oxford University Press, New York

Markowitz, H. (1952). Portfolio selection, The journal of finance, March 1952, vol. 7, no. 1

Meredith, R., De Brito, N. & De Figueiredo, R. (2006). *Portfolio Management with illiquid investments*, Citigroup Alternative Investments Journal, June 2006

Nicholas, J.G. (1999), *Investing in hedge funds*, Bloomberg Press, Princeton

Phalippou, L. & Zollo, M. (2005). *What drives private equity fund performance?*, INSEAD Working paper series, Nov 2005

Schmidt, D. (2003). *Private equity-, stock- and mixed asset-portfolios: A bootstrap approach to determine performance characteristics, diversification benefits and optimal portfolio allocations*, Center for Financial Studies Working Paper, 2003, no. 2004/12

Schmidt, D., Nowak, E. & Knigge, A. (2004). *On the performance of private equity investments: does market timing matter?* , EFMA 2004 Basel Meetings Paper, Mar 2004

Schneeweis, T., Karavas, V.N. & Georgiev, G. (2002). *Alternative investments in the institutional portfolio*, Journal of Alternative Investments, 2000

Smit, T.J. (2002). *The economics of private equity*, oration Erasmus University Rotterdam, Nov 2002

Takahashi, D. & Alexander, S. (2002). *Illiquid alternative asset fund modeling*, Journal of Portfolio Management, Winter 2002, vol. 28, no. 2

Van der Wurf, F. & Mertens, G. (2001), *Public-to-private*, NIB Capital, March 2001

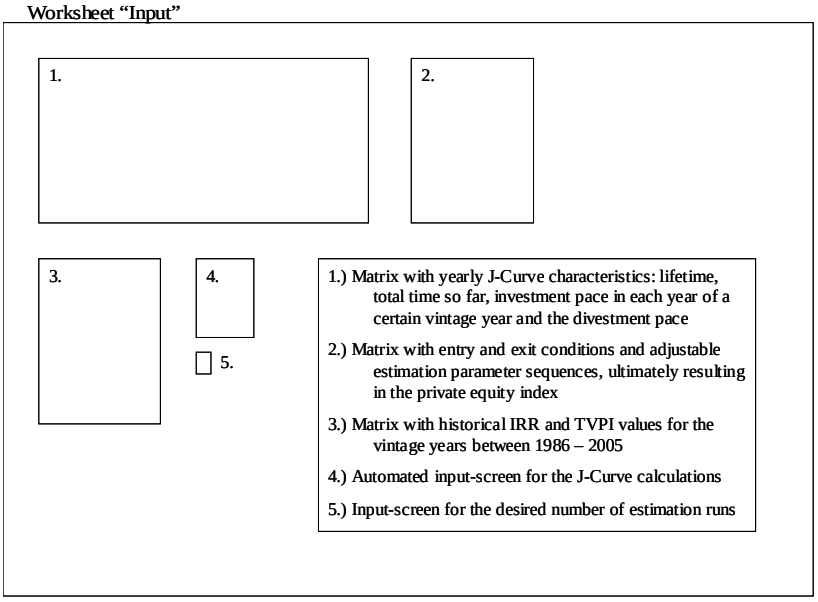
Verschuuren, T.P.F.J. (2002), *Risico en Rendement van Beleggingen*, AEGON scriptie, July 2002

Zimmermann, H., Bilo, S., Cristophers, H. & Degosciu, M. (2005). *Risk, returns, and biases of listed private equity portfolios*, WWZ/Department of Finance, Working paper no. 1/05, April 2005

Appendices

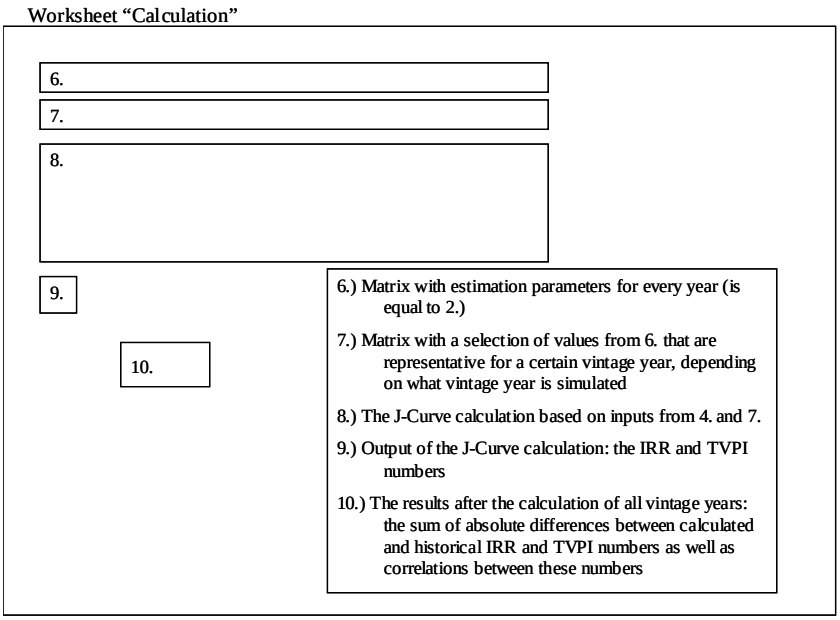
A.1 Algorithm in practice

This section will describe how the private equity index is calculated in practice. The Excel computer model consists of several worksheets with input and output fields and four VBA-subs or functions. This section describes all worksheets and VBA-functions in detail. Below the first worksheet is represented schematically. In the figure a short description is given for each field.



As indicated in the figure, most fields are meant for the fixed input parameters of the individual J-curve characteristics. Except for the yearly growth rates (estimation parameters) in field 2 all the inputs will remain fixed during the estimation runs with the algorithm. These inputs are based on assumptions regarding individual vintage years. More on this subject will be described the section 8.1. So every vintage year has own fixed parameters: lifetime (L_h), total time so far (TT_h) (for example a fund started in 2001 has 5 years as total time so far), the investment pace ($RC_{h,t}$) and a divestment pace (B_h). The yearly estimation parameters (G_t) are presented in field 2. Historical private equity performance (IRR_h^{Hist} and $TVPI_h^{Hist}$) is presented in field 3.

The VBA-function SETYEAR (SY) puts the J-curve fixed parameters from field 1 of a predetermined single vintage year in field 4. The J-curve calculation uses this field as input to calculate the J-Curve and does not use field 1 directly. For example if the vintage year 1997 needs to be calculated, the function SY gets the fixed parameter values of 1997 from field 1 and puts them in field 4. After the function SY has set the fixed parameters in field 4 it will initiate another function: YEARLYINPUTFACTORS (YIF).



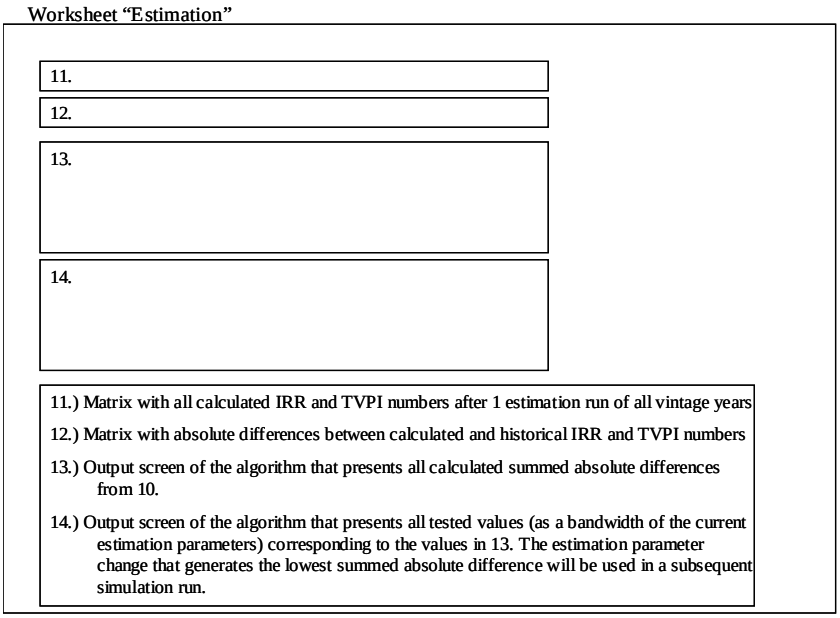
The function YIF uses the input from field 6 (which is a copy of field 2) to determine what section of the estimation parameter sequence (the initial sequence of the PE index) is representative for a certain vintage year, for example 1997. Thus the function puts the yearly estimation parameters from 1997 to 2006 in field 7 (if the life of that vintage year is set at 10 years).

At this moment the function SY has set all fixed parameters at field 4 and the specific estimation parameters in field 7 (with the function YIF). Field 8 immediately calculates automatically the corresponding IRR_h^{Calc} and $TVPI_h^{Calc}$ values in field 9. This process can be executed by clicking the button "Setyear" which is obviously connected to the VBA-function SY. Up to this moment this is a manual way to calculate the IRR and TVPI number of an individual vintage year.

The function VINTAGEYEARTEST (VYT) uses the function Setyear to repeat this process for all vintage years. The function VYT starts when the button "Vintage year test" is clicked. VYT begins setting field 4 and 7 for the conditions of the vintage year 1986, calculates the IRR_h^{Calc} and $TVPI_h^{Calc}$ and puts this result in the first column of field 11. This is repeated until 2006 and all columns of field 11 are filled with the calculated IRR_h^{Calc} and $TVPI_h^{Calc}$ numbers of each individual vintage year. So when fixed parameters are changed in field 1 and the function VYT simulates all vintage years the IRR_h^{Calc} and $TVPI_h^{Calc}$ numbers of corresponding vintage years will change. When the estimation parameters in field 2 are adjusted and the function VYT simulates all vintage years the IRR_h^{Calc} and $TVPI_h^{Calc}$ numbers of multiple vintage years will change. This is because these parameters affect more than one year.

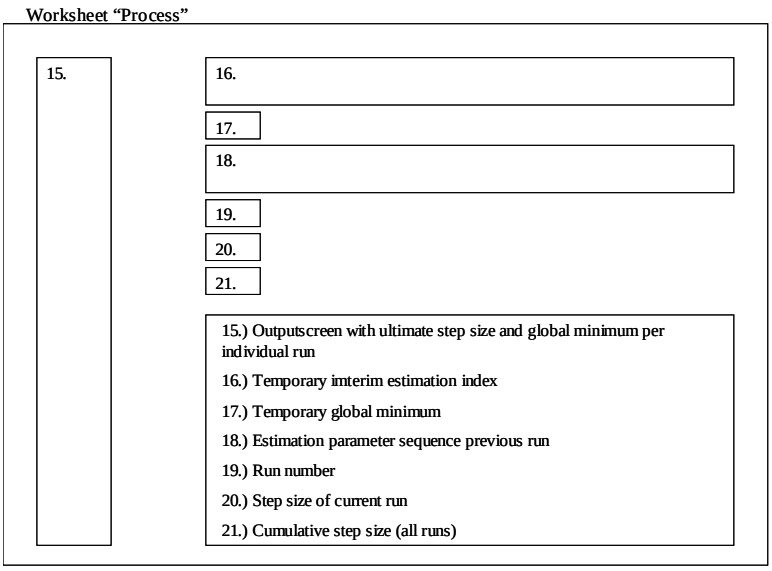
At this moment the function VYT is able to calculate the IRR_h^{Calc} and $TVPI_h^{Calc}$ numbers for each vintage year in one calculation run and presents the results in field 11. Fixed parameters can be set and the estimation parameters are still to be set manually. The idea behind this

model is to let the algorithm find a private equity index that drives private equity performance measured by the historical IRR_h^{Hist} and $TVPI_h^{Hist}$ numbers. When this is done manually it takes too much time and can be inaccurate.



In field 12, the squared differences are determined between the calculated IRR_h^{Calc} and $TVPI_h^{Calc}$ numbers from field 11 and the historical IRR_h^{Hist} and $TVPI_h^{Hist}$ numbers from field 3. This is calculated by the worksheet and not by a VBA-function. On field 10 these squared differences (=result of the objective function) are summed to one single number, the result of the objective function corresponding to the estimation parameter sequence from field 2 (and the fixed parameter setting from field 1) after using the function VYT.

So, by clicking the button "Vintage year test" with a given initial estimation parameter sequence the result of the objective function can be calculated at field 10. The lower this number is the more the calculated IRR_h^{Calc} and $TVPI_h^{Calc}$ sequence match with the historical IRR_h^{Hist} and $TVPI_h^{Hist}$ sequence. An iterative way to minimise the result of the objective function based on these sequences is executed with the VBA-function "MINABSDIFF" (MAD), which is the actual algorithm. The button "Find PE index!" initiates this VBA-function.



The algorithm MAD can run a number of times; this number can be set at field 5. At each run MAD calculates the result of the objective function at field 10 with the initial estimation parameter sequence by using the function VYT. The entire initial estimation parameter sequence is copied in field 18. The corresponding result of the objective function from field 10 is copied in the first line of field 15 and is represented in field 17. This is the initial run of the algorithm.
In the next run the algorithm calculates an adjusted estimation parameter sequence based on the initial estimation parameter sequence only with minor changes. The MAD function adjusts the estimation parameter sequence as follows. The algorithm calculates the result of the objective function for every individual estimation parameter G_t (for example 10%) and two surrounding values of this parameter (9% and 11%) based on an initial step size h = 1 (1 / h = 1%). Consequently the algorithm calculates for every individual estimation parameter which of the three values minimises the objective function most. The corresponding local minima are copied to field 14. If all combined local minimising values minimise the global minimum the combination of the related growth values is used as the next "initial" sequence of estimation parameters. The temporary global minimum is copied in field 17. The algorithm puts the potential next estimation parameter sequence in field 16. Only if the new temporary global minimum is smaller than the previous one the content of field 16 is copied to field 2 for the next run. If all combined local minimising values do not minimise the global minimum the step size is halved (the three values are now: 9.5%, 10%, 10.5%) with a maximum of h = 1024. The step size for each run is presented in field 20. In every run all estimation parameters are adjusted to minimise the objective function.

The result of the objective function corresponding to every individual adjusted estimation parameter G_t in field 14 is presented in field 13. There is one number in field 13 that generates the smallest result of the objective function. The corresponding adjusted estimation parameters from the bandwidth in field 14 are responsible for this smallest number. The MAD function adjusts this individual estimation parameter in field 2 and starts a new calculation run according to the number of runs at field 5. In this way the algorithm searches iteratively for estimation parameters that minimise the differences between the calculated and historical TVPI and IRR sequences most.

Once the algorithm has found the region of the (sub-) optimal solution the gains in each run become smaller and smaller. It is up to the end user to determine at what moment the (sub-) optimal solution is reached (depending on the number of predetermined runs or the ultimate differences in subsequent results of the objective function). Field 21 is a process field that helps putting the output of each run with possible several step size changes in field 14.

A.2 Divestment paces of estimation model II

Divestment paces estimation model II (Europe)											
Year	run1	run2	run3	run4	run5	run6	run7	run8	run9	run10	run11
1986	3,55	3	3,25	3,45	3,45	3,45	3,45	3,2	3,45	3,25	3,45
1987	2,25	2,25	2,25	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3
1988	3	2,75	2,75	3	3	3	2,7	2,7	2,7	2,7	2,7
1989	2,6	2,6	2,6	2,6	2,6	2,6	2,4	2,4	2,4	2,4	2,4
1990	2	2,1	2,1	2,1	2,1	2,1	2	2,1	2,1	2,1	2,1
1991	1,95	1,95	1,95	1,95	1,95	1,95	1,95	1,95	1,95	1,95	1,95
1992	2,05	2,25	2	2,05	2,05	2,05	2,05	2,05	2,05	2,05	2,05
1993	1,5	2,6	1,4	1,4	2	1,3	1,3	1,6	1,1	1,1	1,1
1994	2,5	2,25	2,9	2,5	2,1	2,2	2,2	2,2	2,2	2,2	2,2
1995	1	1,75	1,75	1,1	1,1	1,1	1,1	1,3	1,1	1,1	1,5
1996	1,55	1,6	1,8	1,55	1,55	1,55	1,55	1,55	1,4	1,4	1,3
1997	2,15	2,15	2,15	2,15	2,15	2,15	2,15	2,15	2,15	2,15	2
1998	2,2	2	2	2,2	2,2	2,2	2,2	2,2	2,2	2,2	2,1
1999	2	2,75	1,9	1,8	1,6	1,4	1,4	1,4	1,1	1,1	1,1
2000	1,5	2	2	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
2001	2	1,9	1,9	2	2	2	2	2	2,7	2,7	2,7
2002	2,5	2,25	2,25	2,25	2,25	2,25	2,25	2,25	2,6	2,6	2,6
2003	2,5	2,25	2,25	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5
2004	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5
2005	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5

Divestment paces estimation model II (US)											
Year	run 1	run 2	run 3	run 4	run 5	run 6	run 7	run 8	run 9	run 10	run 11
1986	4,85	3,5	3,2	3,2	3,2	3,8	3,8	3,8	3,8	3,8	3,8
1987	3,45	3,4	3,1	3,1	3,1	3,5	3,5	3,5	3,5	3,5	3,5
1988	3,3	3,3	3,3	3,3	2,8	2,8	2,8	2,8	2,8	2,8	2,8
1989	2,65	3,3	3,3	3,5	3,2	3,6	3,8	3,8	2,5	3,8	3,8
1990	2,95	2,95	3,1	3,1	3,1	3,1	3,1	3,1	3,1	2,9	2,9
1991	2,4	2	2	1,8	2	1,8	1,2	1,1	1,1	1,2	1,2
1992	1,7	1,7	2,2	2,2	2,2	2,2	2,2	2,6	2,6	2,4	2,4
1993	2,05	2,05	2,05	2,3	2,5	2,9	2,9	2,9	2,9	2,9	2,9
1994	2,65	2,65	2,4	2,4	2,4	2,4	2,9	3,1	3,1	2,9	2,9
1995	2,35	2,35	2,35	2,35	2,35	2,35	2,8	2,4	2,4	3,1	3,1
1996	3,2	3,2	3,2	3,2	3,2	3,2	3,4	3,4	3,4	3,4	3,4
1997	2,35	2,5	2,75	2,95	3,1	3,5	3,5	2,9	2,9	3,5	1,5
1998	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	1,7
1999	2,65	2,65	2,65	2,65	2,65	2,65	2,65	2,65	2,65	2,65	2,65
2000	1,3	2,3	2,3	2,3	2,2	2,5	2,5	2,5	2,3	2,5	2,5
2001	0,8	2	2	2	2	2	2	2	2	2	2
2002	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,25	2,25
2003	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5
2004	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5
2005	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5

A.3 Regression results

Correlation of variables with the European private equity index at time t

Variables	Correlation	Adj R^2	F-value	Significance F alpha	B^0	t-value B^0	Significance B^0 alpha	B^1	t-value B^1	Significance B^1 alpha
High yield credit spread	-0,46	0,21	3,45	0.01	0,40	2,80	0,010	-0,05	-1,86	0,050
High yield	0,08	0,01	0,09	n.s.	0,12	0,62	n.s	0,01	0,30	n.s.
BAA bond yield	0,05	0,09	1,17	n.s.	0,72	1,38	0,100	-0,07	-1,08	0,150
M&A volume	0,63	0,40	8,56	0.025	0,11	2,38	0,020	0,29	2,93	0,010
IPO volume	-0,01	0,00	0,00	n.s.	0,15	2,58	0,020	0,00	-0,03	n.s.
FTSE Europe	0,30	0,09	1,61	n.s.	0,14	2,75	0,010	0,33	1,27	0,150
FTSE world	0,56	0,32	5,09	0.05	0,12	2,28	0,025	0,68	2,26	0,025
Buyout leverage	0,26	0,07	1,20	n.s.	0,07	0,60	n.s.	0,04	1,10	0,150
Buyout fundraising	0,04	0,00	0,02	n.s.	0,18	3,32	0,003	0,01	0,15	n.s.

Correlation of variables with the US private equity index at time t

Variables	Correlation	Adj R^2	F-value	Significance F alpha	B^0	t-value B^0	Significance B^0 alpha	B^1	t-value B^1	Significance B^1 alpha
High yield credit spread	-0,83	0,69	29,21	0.001	0,33	7,79	0,001	-0,04	-5,40	0,001
High yield	-0,10	0,01	0,16	n.s.	0,16	1,78	0,050	0,00	-0,41	n.s.
BAA bond yield	0,12	0,01	0,22	n.s.	0,05	0,31	n.s.	0,01	0,47	n.s.
FED rate	0,49	0,24	5,02	0.05	0,03	0,65	n.s.	0,02	2,24	0,020
Industrial production	0,46	0,21	3,99	0.1	0,09	2,85	0,010	1,53	2,00	0,050
GDP growth	-0,07	0,00	0,07	n.s.	0,15	1,66	0,100	-0,01	-0,27	n.s.
M&A volume	0,64	0,40	8,83	0.025	0,08	3,69	0,001	0,16	2,97	0,010
IPO volume	0,21	0,04	0,60	n.s.	0,11	4,12	0,001	0,04	0,77	0,250
S&P 500	0,65	0,43	11,98	0.01	0,09	4,29	0,001	0,37	3,46	0,003
FTSE USA	0,74	0,54	11,84	0.01	0,08	3,39	0,003	0,33	3,44	0,005
FTSE All World	0,59	0,34	5,73	0.05	0,09	3,21	0,005	0,37	2,39	0,020
Buyout leverage	0,50	0,25	5,30	0.05	0,03	0,61	n.s.	0,04	2,30	0,020
Fundraising	0,32	0,10	1,74	n.s.	0,11	4,29	0,001	0,09	1,32	0,150
P/E ratio S&P 500	-0,57	0,33	7,82	0.025	0,34	4,34	0,001	-0,01	-2,80	0,010
Liquidity premium	-0,26	0,07	0,93	n.s.	0,14	3,65	0,003	-0,02	-0,97	0,200

Correlation of variables with the European private equity index at time t+1 (forecasting regression)

Variables	Correlation	Adj R^2	F-value	Significance F alpha	B^0	t-value B^0	Significance B^0 alpha	B^1	t-value B^1	Significance B^1 alpha
High yield credit spread	-0,48	0,23	3,57	0.1	0,42	2,96	0,010	-0,05	-1,89	0,050
High yield	-0,12	0,01	0,24	n.s.	0,27	1,36	0,100	-0,01	-0,49	n.s.
BAA bond yield	0,10	0,01	0,16	n.s.	0,06	0,19	n.s.	0,01	0,40	n.s.
M&A volume	0,54	0,29	5,34	0.05	0,10	2,02	0,050	0,26	2,31	0,020
IPO volume	-0,26	0,07	0,87	n.s.	0,19	3,33	0,005	-0,03	-0,93	0,200
FTSE Europe	0,22	0,05	0,81	n.s.	0,15	2,95	0,005	0,25	0,90	0,200
FTSE world	0,55	0,30	4,34	0.1	0,15	2,92	0,010	0,62	2,08	0,050
Buyout leverage	0,31	0,10	1,76	n.s.	0,08	0,96	0,200	0,08	1,33	0,100
Buyout fundraising	0,20	0,04	0,70	n.s.	0,15	2,96	0,005	0,03	0,84	0,250

Correlation of variables with the US private equity index at time t+1 (forecasting regression)

Variables	Correlation	Adj R^2	F-value	Significance F alpha	B^0	t-value B^0	Significance B^0 alpha	B^1	t-value B^1	Significance B^1 alpha
High yield credit spread	-0,58	0,34	6,11	0.05	0,27	4,05	0,001	-0,03	-2,47	0,020
High yield	-0,13	0,02	0,26	n.s.	0,17	1,84	0,050	0,00	-0,51	n.s.
BAA bond yield	0,18	0,03	0,52	n.s.	0,03	0,18	n.s.	0,01	0,72	0,250
FED rate	0,31	0,09	1,66	n.s.	0,07	1,46	0,100	0,01	1,29	0,150
Industrial production	0,31	0,10	1,72	n.s.	0,10	3,13	0,005	1,02	1,31	0,150
GDP growth	0,00	0,00	0,00	n.s.	0,12	1,31	0,150	0,00	0,02	n.s.
M&A volume	0,48	0,23	3,92	0.05	0,09	3,47	0,003	0,12	1,98	0,050
IPO volume	0,07	0,00	0,06	n.s.	0,11	3,96	0,001	0,01	0,24	n.s.
S&P 500	0,48	0,23	4,73	0.05	0,10	4,07	0,001	0,27	2,18	0,025
FTSE USA	0,49	0,52	9,60	0.025	0,08	3,22	0,010	0,34	3,10	0,010
FTSE All World	0,41	0,17	2,07	n.s.	0,10	3,02	0,010	0,27	1,44	0,100
Buyout leverage	0,44	0,19	3,74	0.05	0,06	1,71	0,100	0,02	1,93	0,050
Fundraising	0,06	0,00	0,06	n.s.	0,12	4,98	0,001	0,02	0,24	n.s.
P/E ratio S&P 500	-0,70	0,49	15,55	0.01	0,37	5,84	0,001	-0,01	-3,94	0,001
Liquidity premium	0,16	0,03	0,33	n.s.	0,09	2,05	0,050	0,01	0,57	n.s.

Multiple factor regression analysis (US)									
Variables	adj R^2	F-value	Significance alpha	B^o	t-value B^o	Significance B^o alpha	B^n	t-value B^n	Significance B^n alpha
Buyout leverage &							0,11	2,23	0.05
FTSE USA	0,42	4,57	0.05	-0,12	-1,24	n.s.	0,05	0,36	n.s.

Multiple factor regression analysis (Europe)									
Variables	adj R^2	F-value	Significance alpha	B^o	t-value B^o	Significance B^o alpha	B^n	t-value B^n	Significance B^n alpha
High yield credit spread &							-0,03	-1,00	n.s.
M&A volume	0,19	2,54	n.s.	0,29	1,61	0,15	0,16	0,26	n.s.