EVCA

Risk Measurement Guidelines
January 2013

CREATING LASTING VALUE

EVCA
EUROPEAN PRIVATE EQUITY AND
VENTURE CAPITAL ASSOCIATION

Contents

Introduction

Investors in private equity and venture capital limited partnership investment vehicles have developed various approaches for the risk measurement of their portfolio of holdings. As with previously developed Professional Standards, EVCA believes that different stakeholders in the asset class will benefit from guidance based on current best practices among investors in the field of private equity and venture capital risk measurement. This guidance will help investors to increase their exposure to the asset class by developing sound risk measurement practices and will also inform discussions on risk measurement with regulators, boards of trustees and other stakeholders.

These Guidelines set out recommendations intended to represent current best practices to measure the value at risk of investing in private equity and venture capital funds. The term "private equity" is used in these Guidelines in a broad sense to include investments in limited partnerships which in turn invest in early-stage ventures, management buyouts, management buy-ins and similar transactions and in growth and development capital.

These Guidelines are intended for investors (banks, insurance companies, pension funds, fund of funds etc.), which act as limited partners in private equity funds. The focus of these Guidelines is the measurement of risks for investments through closed-ended funds with a finite life structured as limited partnerships, which is the dominant and most relevant vehicle for institutional investing in private equity. To the extent other structures recreate the major features of limited partnerships these Guidelines are relevant as well. Private equity funds structured as limited partnerships are difficult to model and to integrate into the framework of traditional risk measures and of existing regulation. As a consequence, regulated institutional investors have so far been predominantly applying "standard" or "simple" approaches when determining the regulatory capital for such assets. These coarse approaches could potentially miss significant risks, and in many other situations they overstate risks, leading to a suboptimal under-allocation to private equity.

New regulation recognises that IT plays an important role in modelling risks and enabling risk management. The resulting higher standards of operational risk management and increased complexity of modelling may challenge a reliance on spread sheets. Therefore, implementing the approaches described in the Guidelines may require significant IT development[1].

The Guidelines recognise that each portfolio of holdings of private equity funds has specific characteristics. Therefore they do not aim to calibrate their models by using one-size-fits-all parameters. The Guidelines aim to help users identify their own exposure to the different risks that need to be taken into consideration and how these risks should be measured. Risk management by definition deals with volatile environments and consequently there cannot be a "standard model" for all investors. The Guidelines are therefore principle-based, i.e. they aim to provide a conceptual basis instead of a list of detailed rules or parameters to calibrate internal models. Internal models are developed by investors, often with the aim of determining the Value at Risk (VaR), which is one of the most important measures for financial risks, with concepts similar to VaR being used in many parts of financial regulation.

All sections should be read as follows: Recommendations are set out in bold in a blue box. Further explanations, illustrations, background material, context and commentary to assist in the interpretation of the recommendations, are set out in normal type. An Appendix provides guidance on the application.

Adoption of the Guidelines is voluntary. The Guidelines were drafted by a working group of private equity risk measurement practitioners in dialogue with its academic board, and document the views and methods that have found broad acceptance.

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1 Recent discussions around Solvency II reflect an increase in IT requirements to comply with forthcoming regulation. For example, the European Insurance and Occupational Pensions Authority (EIOPA) captures in its final report on Public Consultations No. 11/009 and 11/011 on the Proposal for the Reporting and Disclosure Requirements such issues. (see: https://eiopa.europa.eu/consultations/consultation-papers/2011-closed-consultations/november-2011/draft-proposal-on-quantitative-reporting-templates-and-draft-proposal-for-guidelines-on-narrative-public-disclosure-supervisory-reporting-predefined-events-and-processes-for-reporting-disclosure/index.html)

1 Key Objectives of Private Equity Risk Measurement

Understanding and accurately measuring the risks of investments in private equity should be undertaken for effective risk management, investment decisions and internal capital allocation.

Interests in private equity funds involve investment in an illiquid asset class and hence have specific characteristics that make it difficult to measure value at risk (VaR) in a way similar to tradable assets. Nevertheless, and despite conceptual challenges, all industry stakeholders increasingly view a proper measurement of private equity risks as necessary.

Historically, the majority of investors have taken relatively simplistic approaches to measuring and reporting the risks of investing in private equity. However, with growing exposure to private equity, it has become more important to fully understand and correctly quantify the risks of investing in this asset class in order to strengthen risk management capacities.

It is also important that risk measurement used for investment decisions and internal capital allocation is of a high quality as this reinforces sound corporate governance by which investment policies are implemented to take account of both their expected returns and their risks.

Exhibit 1: The Importance of Risk Measurement in Private Equity: The Experience from the Global Financial Crisis 2008 – 2009

The collapse of Lehman Brothers in the autumn of 2008, the largest bankruptcy in history, resulted in the deepest global recession for at least three generations. As market participants became extremely risk averse, financial markets for risky assets shut, while yields on safe assets fell to record lows. Investors' cash flow models were generally not designed to cope with this tail risk, and many long-term asset allocators found themselves short of liquidity as distributions from private equity funds dried up at the same time asmargin calls increased and redemptions were suspended by hedge funds and similar vehicles.

Confronted with significant unfunded outstanding commitments and an acute shortage of liquidity, many private equity investors sought to sell stakes in private equity funds in the secondary market. However, given the huge macroeconomic uncertainty, the profound lack of liquidity and the massive degree of risk aversion, there were few buyers. As net asset values (NAVs) were only gradually adjusted in line with the rapidly deteriorating operating performance of underlying portfolio companies and the decline in public markets, there was a wide gap between sellers' and buyers' price expectations. In the first half of the year, this gap proved unbridgeable for many portfolios, causing a steep fall in the volume of secondary transactions.

While institutions seeking to liquidate (parts of) their private equity holdings included a wide range of investors, US university endowments are reported to have been particularly keen in reducing their exposure, which in individual cases accounted for more than 20% of their total assets under management (AUM). A case that has attracted particular attention and has been intensively followed in the media is the Harvard Management Corporation (HMC), which manages the endowment of Harvard University[2]. In mid-2008, the endowment's AUM stood at USD 36.9 billion, making it the biggest endowment of any university. At that point in time, private equity represented 13% of HMC's total portfolio, a relatively moderate share compared with other large endowments. However, HMC's total exposure to illiquid asset classes was far larger, with investments in real assets (real estate, infrastructure, timberland, oil & gas) accounting for more than 30%.

2 The following discussion is based on various media reports that are deemed to be trustworthy.

Exhibit 1

Prior to the financial crisis, HMC contributed as much as USD 1.2 billion per year to Harvard's budget, accounting for more than one-third of the university's total annual operating income, nearly equivalent to the contributions from tuition and sponsored research combined. Thus, the university came to rely on HMC in its planning for hiring, expansions and new facilities. This reliance was predicated on the assumption of steady cash flows from "harvested" private investments. However, while this assumption was based on historical observations, it proved fundamentally wrong in 2008 – 09 when exit markets shut amid deepening financial stress.

Making matters even worse, HMC had a substantial amount of unfunded commitments, which under normal market conditions would have been funded with distributions. However, during the crisis distributions dried up, and with cash reserves being negative – implying that the endowment overall had been leveraged – HMC was forced to liquidate assets to avoid defaulting on its previous commitments to private equity funds as well as other investments it could not easily get out of. In the end, HMC decided to liquidate some equity and fixed income investments in what turned out to be the worst possible time. In need of additional liquidity, HMC decided to put USD 1.5 billion of fund investments with unfunded commitments up for sale at a time when secondary private equity funds were on average bidding 50 – 60 % of NAV of private equity assets. With the liquidity crisis sending shock waves through the university, HMC also issued debt in the capital markets of more than USD 1 billion in another effort to raise liquidity.

HMC was not unique. As Ang and Kjaer report[3], CalPERS, the largest US pension fund, lost USD 70 billion during the market turmoil in 2008 – 09. Referring to an article in The Wall Street Journal[4], Ang and Kjaer attribute these losses to the sale of public equity holdings to raise cash so that CalPERS could meet its obligations to private equity and real estate investments. While CalPERS' equity weight was 60% at June 30, 2007, it shrank to 52% by June 30, 2008 and to 44% by June 30, 2009 - missing, to a significant degree, the substantial subsequent rebound in public equity markets. The experience led CalPERS to adopt a new asset allocation framework using risk factors[5]. This new framework became effective in July 2011.

1.1 Differentiation between due diligence, monitoring and risk management

Due diligence covers all activities associated with evaluating an investment proposal and has historically been seen as the major risk management tool in the private equity industry. However, within the overall risk management apparatus due diligence is simply one tool with a specific focus. Monitoring is an important part of information gathering that enables investors to conduct risk management in the first place.

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3 Ang, Andrew, and Knut N. Kjaer, Investing for the Long Run, November 2011. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1958258
4 Karmin, C., and J.S. Lublin, "Calpers Sells Stock amid Rout to Raise Cash for Obligations," Wall Street Journal, October 25, 2008.
5 International Monetary Fund, Global Financial Stability Report. September 2011, p. 19.

Exhibit 2: Differentiation between due diligence, monitoring and risk management

Due diligence	Monitoring	Risk management
Focus on individual transaction	Focus on individual transaction	Focus on portfolio of funds
One-off with detailed analysis of individual fund proposal	Frequently executed	Frequently executed with coverage of entire portfolio of funds
Mainly pre-investment for investment decision making	On-going activity (pre- and post-investment)	On-going activity (pre- and post-investment)
Purpose is accepting or rejecting of investment proposal	Purpose is monitoring of the development of an individual fundand addressing potential issues in dialogue with the GP and other LPs	Purpose is monitoring of the development of the managed portfolio of funds and quantification of financial risks
Conservative bias with stringent cut-off criteria	Information gathering	Unbiased (i.e. fair) assessment of the portfolio of funds' status
Focus on achieving high performance for individual investment proposal, i.e. capital risk	Focus on protecting investment in fund	Coverage of all relevant risks for portfolio of funds, notably funding and liquidity risk

1.2 Risk measurement criteria

A risk model for portfolios of private equity funds has to fulfil the following criteria. It should be:

1. Complete
2. Unbiased
3. Monotonic
4. Observable
5. Reconcilable
6. Interrelated

The primary avenue for institutional investing in private equity is the limited partnership of 10-12 years duration, usually comprising a group of institutional investors (limited partners) and the fund manager (general partner). Investors become limited partners in a private equity fund by committing a specified amount of capital to the fund, which entitles them to a proportional share of interest in the partnership. The fund manager draws from this capital pool to fund the acquisition of stakes (often controlling) in a number of portfolio companies over the course of the fund's investment period. Even though fund managers do not call down all commitments at once, the commitments are binding for the duration of the partnership.

The fund manager seeks to increase the value of the portfolio companies through long-term active management and exits these investments at a time deemed appropriate. The proceeds from divestitures are distributed to the limited partners.

Risk measures aim to assess the degree of uncertainty about fund returns and liquidity events. The basis of a proper measurement of risks is an unbiased modelling of a portfolio of private equity funds. Even a conservative bias should be avoided as this makes it more difficult to pick up an early warning signal.

For this purpose, a risk model for portfolios of private equity funds has to fulfil the criteria below.

- **"Complete"** all relevant components that comprise a fund need to be reflected in a proper risk measurement.

- **"Unbiased"** for the entire population of funds at the same stage of their lifetime, the weighted average net present value (NPV) needs to be 0. In other words, risk measures should eliminate a systematic J-curve[6].

- **"Monotonic"** all other things being equal, for a fund A that is younger than fund B, the range for the projected outcome of IRR or multiple for fund A should be larger than that for fund B.

- **"Observable"** a condition for back-testing a risk model. For instance, publicly quoted asset prices are observable in the sense that it is possible to transact at such a price, but for illiquid asset observable prices do not exist. Liquidity events, however, are observable and thus a model can be tested against a fund's cash flows.

- **"Reconcilable"** every specific outcome (e.g. IRR or multiple) for a fund needs to be a result of an individual cash flow scenario of the fund's inflows and outflows.

- **"Interrelated"** the risks related with one fund cannot be determined in isolation. For example, risk stemming from over-committing or risk mitigation from diversification over portfolios of funds, have to be factored into the risk measurement.

1.3 Probability of default (PD) / loss given default (LGD) or value at risk (VaR)?

An investment in private equity funds has debt and equity characteristics but both the standard credit and market models are difficult to apply. Generally, PE/VC fund assets, with their low liquidity, require, in the eyes of many industry practitioners, risk analysis closer to that which accompanies the assessment of default risk, rather than a market risk paradigm. Rating-like approaches for evaluating the risks of private equity funds, for example where they are grouped into categories associated with growth expectations, are widely used in the industry and were also endorsed by the Basel Committee[7].

A number of practitioners and researchers have tried to apply existing credit portfolio models to private equity[8]. However, credit risk models only reflect downside risk while the significant upside of fund investments is ignored. Aggregating just the probability of default (PD)/loss given default (LGD) figures for individual funds, even when factoring in diversification benefits resulting from correlations between individual funds defaulting, will produce overall risk weights for portfolios of funds that are excessive. Diversified portfolios of funds are significantly less risky than every individual fund as the upside of well performing funds compensate for the losses from "defaulting" funds[9]. Indeed, the Basel Committee has long accepted that unrecognised and unrealised gains (or latent revaluation gains) on equity investments can act as a buffer against losses[10].

It does not make sense to allocate economic capital to individual private equity funds as this violates the interrelatedness criterion. Consequently, the Guidelines focus on a value at risk VaR approach to risk measurement for portfolios of private equity funds.

> ### Exhibit 3: Definition of Value at Risk (VaR)
>
> For a given portfolio of funds, probability and time horizon, the VaR at time t_0 is defined as loss on the portfolio over a given time horizon $[t_0, t_1]$ and for a given confidence level $\alpha, 0 \leq a \leq 1$ (assuming normal economic conditions and no changes in the composition of the portfolio of funds).

6 See Section 10 Glossary
7 See BIS (2001)
8 See, for example, Bongaerts & Charlier (2008) and Krohmer & Man (2007)
9 See Weidig & Mathonet (2004)
10 See BIS (2001)

2 Determining the Exposure at Risk

The appropriate exposure for the purpose of measuring risk is the limited partner's share in the private equity fund itself.

Risk models for private equity fund investments should account for the specific characteristics of investing in closed-ended funds with a finite life and appropriately apply the estimated risk to the exposure at risk. A complete model for a fund not only has to capture the value of its portfolio companies but also its undrawn commitments, its future management fees and the fund manager's value added (or lost).

The exposure at risk comprises mainly the undrawn commitments, plus the net asset value (NAV) of the fund that is indicative of the amount that could be distributed to investors. It is a matter of judgment whether the risk applied to the undrawn commitments is similar to that applied to the NAV of the fund. Differences in treatment could relate, for example, to specific legal clauses or degree of control over the fund manager that would establish a different risk profile for undrawn commitments.

3 Overview of Main Risks to be Considered

Limited partners face a number of risks that can impact the value of their investments. At a minimum, the following risks should be considered for effective risk measurement:

I. **Funding risk**: The unpredictable timing of cash flows poses funding risks to investors. Commitments are contractually binding and defaulting on payments results in the loss of private equity partnership interests.

II. **Liquidity risk**: The illiquidity of private equity partnership interests exposes investors to asset liquidity risk associated with selling in the secondary market at a discount on the reported NAV.

III. **Market risk**: The fluctuation of the market has an impact on the value of the investments held in the portfolio.

IV. **Capital risk**: The realisation value of private equity investments can be affected by numerous factors, including (but not limited to) the quality of the fund manager, equity market exposure, interest rates and foreign exchange.

There is a clear case for private equity risk management – in particular, liquidity risk – for over-commitments. Over-committing investors sign more commitments in aggregate than they have resources available. The purpose of over-committing is to maximise investments in private equity but is also associated with higher risk of not having sufficient cash available when funds call for capital. It is uncontroversial that proper risk management needs to be put in place in such situations.

However, it is often argued that certain large institutional investors have more than sufficient liquidity so they do not need to spend time and effort on private equity risk management. Clearly, such investors are not exposed to liquidity risks; however, they are still exposed to the risk of not meeting the target return for the resources dedicated to private equity. Therefore, this view needs to be challenged, especially with regard to capital risk. One could argue that in a large investor's portfolio, undrawn commitments are "lent" to other activities where they do not achieve a private equity-like return, but they have as such not been cancelled and thus carry opportunity costs, particularly if they are not invested in higher yielding and less liquid assets. Where this is the case, premature and unplanned liquidations of such positions will, on the other hand, usually depress returns and need to be reflected; otherwise the associated costs are over-looked. Even if they do not over-commit, investors with a marginal allocation have to "over-allocate" to private equity as they otherwise will not make an adequate return on the resources dedicated to the asset class.

The case of risk management is also uncontroversial for investors that are taking a high exposure to private equity specifically or in the context of an overall allocation to illiquid assets in general, e.g. real estate and infrastructure as in the endowment model of investment management[11].

As a consequence, limited partners face a number of risks that can impact the value of their investments. In the following, a selection of risks is introduced and discussed to enable a more structured approach for minimising an abstract exposure and understanding risk in favour of more informed decision-making and risk management.

I. Funding risk

The unpredictable timing of cash flows over the life of a fund poses funding risk for the limited partner. Fund managers call most or all of the committed capital over the investment period of the fund. Limited partners then have to meet their commitments within a fixed short notice period. Because commitments are contractually binding, a limited partner who cannot meet his obligations is forced to default on payments and lose a substantial portion of his share in the partnership. In practice, however, negotiations can occur between the limited partner and the fund manager to adapt the size of the fund and/or the capital call requirement.

II. Liquidity risk

Limited partners can sell their stakes in private equity partnerships to fund their outstanding commitments. However, the secondary market for private equity investments is relatively small and highly inefficient.

The characteristics of the secondary market expose investors to asset liquidity risk. Moreover, secondary market prices are often influenced by factors beyond the fair value of the partnership, which often means prices are discounted. For instance, investors selling from a distressed position often have to accept discounts to reported NAV.

III. Market risk

As an illiquid asset class, the treatment of market risk in private equity poses conceptual challenges. The key is to define value and how market fluctuation has an impact on this. There are two principal methods for valuing an asset. The first is its current market valuation, or an estimate of what that might be. The second is the present value of the estimated future cash flows from that asset. Normally, liquidity and arbitrage in the market force these two alternative methods of valuation into close alignment; lack of liquidity and other market dysfunctionalities cause these two alternative approaches to diverge, occasionally sharply, and this is most clearly observed in secondary private equity transactions.

Fair value estimates in private equity are based on the concept of an "orderly transaction", which assumes that: buyers and sellers are not acting under any compulsion to engage in the transaction; both parties have reasonable knowledge of relevant facts; and they have the ability to perform sufficient due diligence to make an orderly investment decision. Assessing the limited partner's ability to conduct an orderly transaction is key to ensuring market risk is properly accounted for in a funding test on such an illiquid asset class.

Where the limited partner is able to conduct an orderly transaction, a sale will be accepted if the price exceeds the present value of the estimated future cash flows. Discounts observed in the secondary markets are rarely caused by deterioration in the fund's value but often rather reflect the inability of some limited partners to execute an orderly transaction as they lack the necessary liquidity.

IV. Capital risk

In addition to the risk of losing invested capital due to liquidity constraints, private equity investors face the long-term risk of not recovering the value of their invested capital at realisation. This long-term capital risk can be affected by a number of factors, namely:

> **Manager quality**: The ability of managers to create value and extract cash from investee companies varies greatly across the industry. Therefore, good manager selection is of paramount importance for private equity investors. It is also important for investors to keep track of key personnel changes at the fund manager and other potential developments that can affect quality of management.

> **Equity market exposure**: Low equity valuations make it difficult for managers to exit at high prices. However, managers have full discretion as to the timing of divestments from investee companies within the life time of the fund and can wait for better or acceptable market conditions to exit their investments.

11 As pioneered by the Yale Endowment's CIO David Swensen, see Swensen (2000)

> **Interest rates and refinancing terms**: Private equity investments can be leveraged and private equity managers might need to refinance the maturing liabilities of investee companies. Substantial changes in interest rates can affect the value of investee companies and the distributed capital to investors.

> **Foreign exchange exposure**: The value of private equity investments can be affected by foreign exchange volatility where there is a mismatch between the reporting currency of the investor and the functional currencies of the fund.

4 Modelling Approaches

Limited partners can use a variety of models to assess the risk of their private equity investments. Therefore, it is important to exercise good judgment in selecting the most appropriate methodology for evaluating the risks of particular funds. Investors should consider all material risks, including general market risk and specific risk exposure.

Investors need to consider the following factors when selecting an appropriate methodology for specific portfolios:
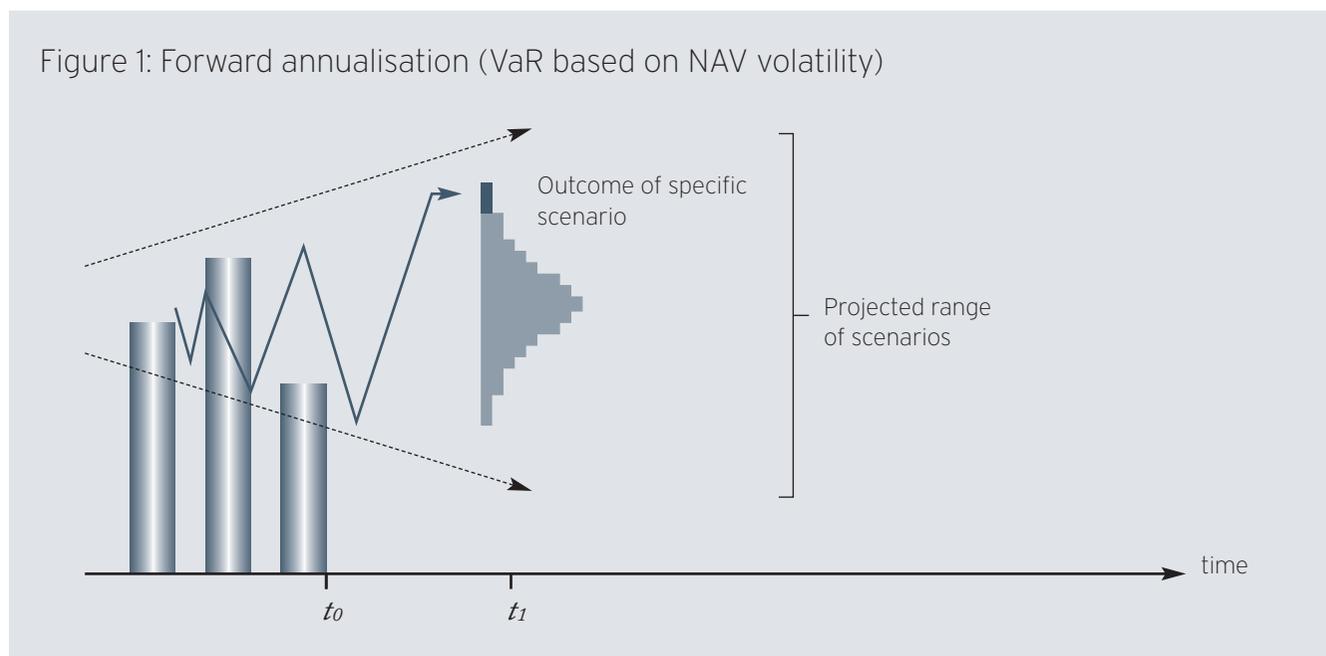
> The applicability of the methodology, given the nature of the industry and current market conditions

> The ability to reflect all relevant risks to which the fund may be exposed

> The quality and reliability of the data used in each methodology

> The comparability of funds or transaction data

> The stage in the lifecycle of the fund

The most widely used methodologies to measure the risk of private equity investments are based on the assessment of the volatility of net asset values (NAVs) and that of cash flows. Modelling inputs should include the fund's NAV, its undrawn commitments, the remaining life of the partnerships, the maturity of the portfolio, future management fees and suitable discount rates for discounting cash flows. The length of time over which the risk is measured and the level of risk should reflect the investment horizon and other contingencies that are idiosyncratic to a particular investor. For example, this could be measured by calibrating the risk with observed losses for interests in similar funds over a period of one year or longer and for a given confidence level. Regulated investors allocate capital based on the risk calculated in this way.

4.1 NAV-time series-based modelling approach

Net asset value (NAV)-time series-based methodologies assume that the risks of investments in private equity are mainly represented by the volatility of the fund's net asset value series. Such methodologies are likely to be appropriate for funds whose value derives mainly from the value of their existing underlying portfolio companies and for investors with a limited allocation to private equity.

NAV-time series-based modelling approaches aim to replicate the methodology used for publicly tradable assets and measure the volatility of the fund's NAV-time series. In principle, this is done by looking at – typically quarterly – value changes of the portfolio. Essentially, the idea is to replicate the daily price movements in public markets and then for the purpose of determining, say, a yearly VaR do a "forward annualisation" (see Figure 1).

Figure 1: Forward annualisation (VaR based on NAV volatility)

Outcome of specific scenario

Projected range of scenarios

time

t_0 t_1

The volatility is estimated by measuring the returns reported at different time intervals based on quoted indices or other private equity benchmarks available in the market. The measured volatility over the relevant period is then applied to the NAV of the fund or the portfolio. Currently, the investment industry's standard approach for measuring returns is to apply a chained Modified Dietz formula. Under this formula, the investor has an NAV at the start of every period. Over that period, investments draw down and distribute capital, then report another NAV at the end of the period. The return of this period (typically per quarter) is described through the following formula:

$$R_{t_1}^t = \frac{NAV_t - NAV_{t_1} - \sum_{t_1}^t Call + \sum_{t_1}^t Distribution}{NAV_{t_1} + \sum_{i>t_1}^{i \le t}\left(Call_i \times \left(1 - \frac{i - t_1}{t - t_1}\right)\right) - \sum_{i>t_1}^{i \le t}\left(Distribution_i \times \left(1 - \frac{i - t_1}{t - t_1}\right)\right)}$$

The market value of a portfolio is defined as:

$$MV_t = MV_{t-1} \times \left(1 + R_{t_1}^t\right)$$

The return of the first data point in the history is set to 0. This time series allows investors to estimate the volatility of a portfolio by taking the standard deviation of log return of the market values.

$$\log\left(\frac{MV_t}{MV_{t-1}}\right), t = 1, ..., n - 1$$

The yearly standard deviation can be derived from the standard deviation of the quarterly log-returns,

$$\sigma_{4t} = 2\sigma_t, t = 1, ..., n - 1$$

Because of the so-called appraisal value effect, NAVtime series tend to understate volatility. For measuring risks, in many cases it is necessary to apply statistical un-smoothing techniques to achieve more realistic results[12].

4.1.1 Advantages of using an NAV-time series-based model

NAV-time series-based methodologies are likely to be appropriate for funds whose value derives mainly from the value of their existing underlying portfolio companies and for investors with a limited allocation to private equity that are not exposed to significant liquidity risk. Such methods appear attractive, as quarterly or annual returns are thought to be easily comparable to public indices, for example for the purposes of testing correlations. In particular, using indices makes it possible to integrate the private equity portfolio in a broader market risk measurement framework together with real estate, public equity, etc. as indices for the other asset classes are researched elaborately. NAV-time series-based methodologies can often give a good approximation of the risks of mature funds and diversified portfolios of funds spread over several vintage years.

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12 See Geltner et al., 2003

4.1.2 Limitations and disadvantages of using an NAV-time series-based model

The NAV-time series-based models may look reasonably simple and are thought to be easy to implement. They can be appropriate for funds whose values derive mainly from the value of their existing underlying portfolio companies and where undrawn commitments can be ignored. However, such models have a number of limitations and disadvantages. In particular, they often violate the criteria for proper risk measurement:

> NAV-based models can be incomplete as they do not take into consideration a fund's future use of the undrawn commitments, the future management fees and the fund manager's value added (or value destroyed). This matters in particular for portfolios of young funds.

> Rather than being random movements, changes in the NAV often reflect the lifecycle characteristics of private equity funds, such as the J-curve. Whether the degree of NAV change exposes a limited partner to risk depends on whether this change is atypical for the fund's stage and atypical relative to its peer group. A model should filter out such systematic biases.

> The NAV often does not move in the same way as the value of the limited partner's interest in the fund. The concept of market risk at the portfolio company level can be problematic from the perspective of a fund's limited partners: a limited partner cannot initiate the sell-off a portfolio company; this is entirely within the control of the fund managers.

Consequently, the fund's value is derived from value changes in portfolio companies but does not necessarily move in the same proportion. In fact, it could be argued that the entire purpose of the fund is shielding fledgling portfolio companies or companies that are being restructured from disruptive market influences.

Disadvantages mainly relate to a number of technical complications that need to be addressed:

> The NAV-time series approach tries to project the fund's future development based on a relatively short history. For private equity funds the frequency at which the NAV is determined is limited and it is not possible for information to be more granular than quarterly. This gives limited data points with which to perform analysis, which creates a dilemma as trying to use the richest possible set of relevant data also leads to the possibility of distortion resulting from autocorrelation.

> In cases where significant commitments to new funds – with no portfolio companies and therefore no NAV – are added to a portfolio, the return calculation can give misleading signals, e.g. when there are far more capital calls than distributions, the value change will underestimate volatility. Comparable issues can occur for small NAVs compared to the size of the cash flows.

## 4.2 Cash flow-volatility-based modelling approach

Cash flow-based modelling methodologies can be used to measure various risks of investing in private equity funds. The method is based on cash flow projections, which are used to derive the net present value (NPV) of investments under different scenarios. Cash flows are discounted using appropriate risk-adjusted rates that quantify the risk inherent in the future cash flows.

Investors use a variety of models based on cash flow forecasts to assess the risks of their private equity investments. The simplest cash flow projections make assumptions about the levels of draw-downs and distributions over the lifetime of an average fund as observed historically, and apply this to the funds invested in to come up with an aggregate for the portfolio.

4.2.1 Basic approach

To calculate the VaR we need to determine the probability distribution for the valuation for a portfolio of funds at $t_1 > t_0$ (typically quarterly or annually). This is done by simulating a large number of samples for scenarios of fund cash flows over their full lifetime as opposed a time series analysis and then to annualise "backward" (see Figure 2).

Figure 2: Backward annualisation (VaR based on volatilities of cash flows)

Projected range of scenarios

Outcome of specific scenario

time

t_0 t_1 t_{max}
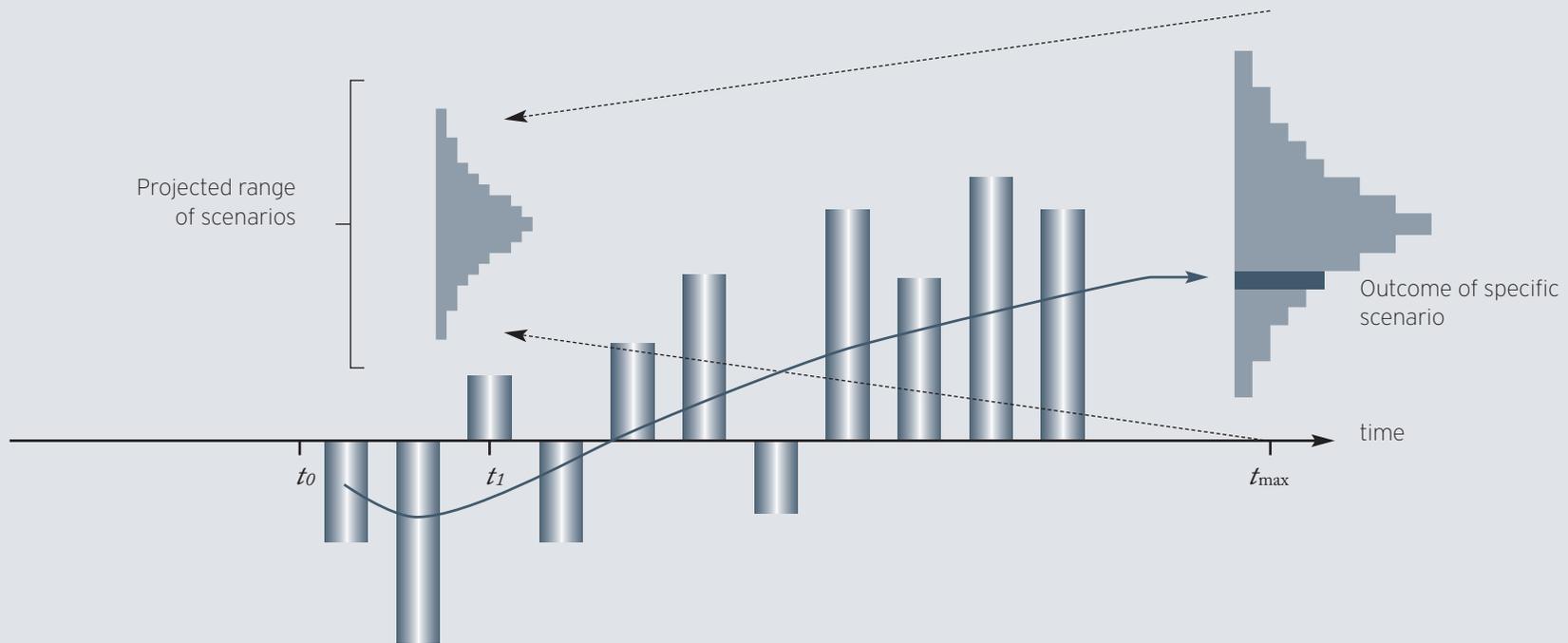
The procedure for a cash flow model-based VaR calculation is as follows:

Exhibit 4: Cash Flow Model-Based VaR Calculation

FOR i =1 TO simulation_sample_size DO

    FOR j=1 TO number_of_funds_in_portfolio DO

        Randomly generate new set of input parameters for fund j (e.g. lifetime, growth rates that are varied within historically observed / stressed ranges. Changes of parameters need to consider dependencies for funds (i.e. cannot be assumed as being independent));

        Generate cash flow projection for fund j over time interval $[t_0, t_j]$ (with t_j being the time of the last cash flow for fund j);

    END;

    Aggregate all number_of_funds_in_portfolio cash flow projections to sample i for cash flow of portfolio of funds over time interval $[t_0, t_{max}]$ (with t_{max} being the time of latest cash flow for the entire portfolio of funds);

    Apply suitable discount rate to determine the present value v_i of sample i for portfolio of funds;

    *** We have now the present value for the portfolio of funds for cash flows over time interval $[t_0, t_{max}]$, i.e. the portfolio's entire lifetime. However, we need to determine the present value of the portfolio at time $t_1 \leq t_{max}]$***

    Deduct present value for cash flow of portfolio of funds over time interval $[t_0, t_1]$;

    Save present value for the portfolio of funds at time t_1 for sample i ;

END;

Compile distribution function for all s samples;

Based on distribution function determine VaR for probability level α;

Exhibit 4

How can we calculate a portfolio's cash flow-based VaR by this backward annualisation technique? The following simplified examples describe two possible ways – there is no single "correct" approach to this.

(i) Time-series calculation: The first approach calculates the annual VaR based on the PV of one simulated cash flow series per fund over the entire lifetime (n periods) of this fund. The VaR for a given time period will be calculated based on the differences between the PV of two periods.

(ii) Fund growth calculation: The second approach begins by calculating the fair value of a fund at time t=0 based on m simulations of cash flow series over the entire lifetime (n periods) of this fund. For each scenario, the straight-line growth over its full lifetime and the resulting gain or loss per time period is calculated. The VaR for a given time period is derived from the projecting gains and losses under all scenarios starting from the fund's fair value at t=0.

Generally, it is important that the risk manager understands the assumption as well as the implications and shortcomings of the various possible methodologies and then chooses the one most appropriate for his objectives.

(a) Time-series calculation

A simplified example of the value at risk (VaR) calculation should give an indication of how the annualised VaR can be calculated: the proposed approach is one way of calculating the annualised VaR for a private equity portfolio.

In order to explain the annual VaR of a portfolio of limited partnership funds based on its projected cash flows, a highly simplified example is used. The starting point is a single fund with cash flows over 10 periods. The fund receives contributions over the first four years, i.e. during its investment period, and generates distributions thereafter. In total, the fund returns a multiple of 1.55 times the invested capital and an IRR of 6.0%.

	0	1	2	3	4	5	6	7	8	9	10	DPI	IRR
Cash Flows for 1 Fund													
Fund	-50	-20	-10	-15	-5	5	10	20	30	40	50	1.55	6.0%
Discount Rate													
NPV of fund 1	6.85	57.19	80.05	94.05	113.75	124.44	125.66	121.95	108.04	83.45	47.62		
Cash Flow Adjustment per period	-50.00	-72.50	-86.13	-105.43	-115.70	-116.49	-112.31	-97.93	-72.82	-36.47	11.71		
Annual NPV Fund 1	6.85	7.19	7.55	7.93	8.32	8.74	9.18	9.63	10.12	10.62	11.15		

Exhibit 4

As a first step, the net present value (NPV) of the fund will be calculated for each period until the end of its lifetime. In the example, a discount rate of 5% should be used as opportunity cost of the investor. In addition, it is necessary to adjust the NPV with the cash flows of the previous periods to derive the annual present value for each period. As the cash flows happened usually a few periods ago, the cash flows need to be compounded with the same interest rate. After adjusting the NPV by the cash flows, the annual NPV of each fund can be calculated based on its future cash flow projection and historic cash flow activity. The formula writes in general as follows:

$$NPV_k = \sum_{t=k}^{10} \frac{CF_t}{(1+r)^t} \pm \sum_{t=0}^{k} CF_t \times (1+r)^t$$

With k being the current period, CF the net cash flow of the period and r the interest rate/opportunity cost of the investor.

In a second step, the calculation needs to be performed for all funds of the limited partnership portfolio. Based on the cash flow information and projection for each fund, the annual NPV can be calculated. Based on the annual NPV of all funds, a cross-sectional distribution of the NPVs can be calculated and the 99th percentile can be derived. The VaR is calculated over the cross-section of the various annual NPVs of all funds of one period. To be able to calculate a VaR we need to use representative market data and be able to project the funds' future cash flows, which is explained in the next chapter.

The calculation methodology shows that the proposed backwards calculation derives an annual VaR measure for illiquid assets, as requested in the regulatory frameworks.

(b) Fund growth calculation

What we call here a "fund growth calculation" could be seen as an alternative approach. One difference is that there is not only one but a number of simulation paths for each fund over its remaining lifetime. In addition, the VaR is calculated based on the difference between the present values (PVs) of each simulation run and its current value.

Through the additional scenarios, the higher uncertainty that is implicitly included in the approach should also have an influence on the result of the distribution of the density function, which is expected to be broader than in the time-series calculation described before. Moreover, this in theory allows the calculation of a VaR for a portfolio comprising one fund only. Here, calculating the VaR requires the following steps:

(1)   For each fund in the sample, m cash flow scenarios over the fund's full lifetime n are generated;

Exhibit 4

(2) For each scenario i and a given discount rate, calculate PV_i;

(3) Calculate the average PV of all scenarios of one fund in order to derive the fair value of the fund at time $t=0$:

$$Avg(PV) = \frac{1}{m} \sum_{i=1}^{m} PV_i$$

(4) The period gain or loss for a given scenario i is derived by relating the difference between the fund's fair value and PV_i to the time period (depending on whether quarterly or annual VaR is to be calculated). This linear approach eliminates the fund's J-curve or other fund lifecycle-induced distortions:

$$gain / loss = \frac{Avg(PV) - PV_i}{n}$$

(5) Based on these results, the density function of the annual/quarterly gains and losses can be computed. This allows the calculation of the portfolio's VaR over the required period for a set confidence level.

To explain this approach, consider this simple example. Let us assume that we want to determine the VaR for year end (i.e. after one year) and for just one fund. For this one fund, we run three cash flow scenarios with a given discount rate, giving three PVs:

Scenario 1: fund's remaining expected lifetime 11 years, $PV_1 = 100 \text{ EUR}$

Scenario 2: fund's remaining expected lifetime 12.5 years, $PV_2 = 150 \text{ EUR}$

Scenario 3: fund's remaining expected lifetime 8.75 years, $PV_3 = -90 \text{ EUR}$

These three scenarios are based on different cash flow scenarios and, hence, reflect possible real outcomes of the fund. Assuming that they will materialise with equal probability, the fair value of the fund at time 0 by definition is the average of these scenarios:

$$\frac{150 \text{ EUR} + 100 \text{ EUR} - 90 \text{ EUR}}{3} = 53.33 \text{ EUR}$$

We calculate the risk of this fund based on these scenarios and the gain/loss over a given time period. Under scenario 1, the fund would gain a value of 4.2 EUR p.a. over its projected lifetime:

$$\frac{150 \text{ EUR} - 53.3 \text{ EUR}}{11 \text{ years}} = 4.24 \text{ EUR p.a.}$$

Exhibit 4

Under scenario 2, the gain is 7.73 EUR p.a. and under scenario 3, the fund would lose 16.38 EUR p.a.
Based on these results, the density function for the fund's valuation after one year can be determined:

> Should scenario 1 materialise, after one year the fund would be worth   53.33 EUR + 4.24 EUR = 57.57 EUR

> Should scenario 2 materialise, after one year the fund would be worth   53.33 EUR + 7.73 EUR = 61.07 EUR

> Should scenario 3 materialise, after one year the fund would be worth   53.33 EUR - 16.38 EUR = 36.95 EUR

Based on these valuations, the risk of losing any capital until the next year can be assessed.

Let us now discuss another example to compare the calculation method to the time-series calculation approach described before.

4.2.2 Approaches to cash flow-based models for private equity funds

Cash flow-based models for private equity funds can be non-probabilistic (i.e. deterministic) or probabilistic. Non-probabilistic models can be a solution in situations where too little data is available for a probabilistic approach. Such models require a limited number of parameters which – due to the lack of data – will be highly subjective. Because of these limitations, non-probabilistic models have to be robust and relatively simple. They do not produce ranges for the outcomes and therefore do not capture volatility of cash flows and can only be used to manage liquidity risk for very large, diversified portfolios of funds. Consequently, non-probabilistic models can also only be applied in very specific situations.

Practitioners tend to prefer models that are probabilistic because they show a range of potential outcomes. Probabilistic models base their forward-looking assumptions on historical data. This approach is, of course, based on the major assumption that historical data is representative. The more data that is available and the longer its history, the more likely it is that the dynamics of the market will be captured. The main question is how to adjust the historical cash flows to fit the development of a specific fund. Here, various approaches are possible. One way would be to compile a statistic of cash flows for each step in a fund's lifecycle and draw from this statistic independently for every cash flow. This of course assumes zero autocorrelation between consecutive cash flows, which might not always be justifiable[13]. Taking account of autocorrelation would be more convincing, but will make the model far more complicated and requires the introduction of other assumptions that would be difficult to justify as well.

It would be more consistent to collect total cash flow histories of a fund rather than splitting the history into the various distributions of cash flows for each time period. In the end, it comes down to whether such data is available and its quality. For investors just starting in an asset class and without access to large historical datasets, a non-probabilistic model may be the only feasible option.

Cash flow volatility-based models can be built using a "bottom-up" approach where the fund's risk is derived from the risk measurement of the individual investee companies, or through a "top-down" approach where the fund's risk is determined, for example, by comparing it to other funds. The comparison between funds is made on the basis of net returns to limited partners, while bottom-up approaches require that the fund's specific distribution waterfall[14] is factored in.

13 See Weidig (2002)
14 See Section 10 Glossary

In practice, the bottom-up approach is often impractical due to: the lack of appropriate information at the limited partner level; the large volume of data that has to be collected for large portfolios; and the complexity of specifying each cash flow position. A bottom-up approach is not necessarily superior to a top-down approach and in many cases it is simply not applicable (e.g. for very young funds). The choice between bottom-up and top-down also highly depends on the size of the portfolio of funds to be modelled.

4.2.3 Advantages, disadvantages and limitations

Cash flow-volatility-based modelling is particularly useful because it can incorporate information about undrawn commitments and possible re-use of distributions when evaluating the PV of private equity partnerships. When using the returns of mature funds to determine the risk profile for a portfolio of funds, issues related to limited data points, such as autocorrelation and de-smoothing, can largely be avoided.

One disadvantage is the assumption that funds will perform in the same way that funds have in the past. This approach provides a general idea of the average cash requirement for a portfolio of funds, but does not necessarily factor in the influence of changing market environments, different vintages, separation between different types of fund or other distinctive features of particular funds.

While such models in their basic form have clear limitations, especially during financial market crises, the portfolio's risk can be approximated by applying some sort of stress measurement to the distribution curves.

More elaborate projections draw more heavily from historical and market data, and are therefore more reliable than those based on assumptions. These projections incorporate data about particular fund managers, various market environments and differentiate between different types of investment strategies (e.g. venture, buyout). However, the technical complexity of developing and maintaining such a model can make it too cumbersome for investors with limited allocations to private equity.

4.3 Stress testing to overcome lack of data and data quality problems

In the environment of high uncertainty that characterises private equity, there are limits to the predictive value of historic data. While it is not possible to anticipate outcomes, it is nevertheless possible and meaningful to evaluate and quantify the impact of shocks that would materially change projections. For cash flow-based models of private equity funds and the associated portfolio models, a number of shocks should be applied for stress testing, for example:

> Lower IRRs or multiples than have historically been achieved by funds

> Longer lifetimes of funds

> Accelerated draw-downs

> Delayed repayments

> Higher volatility of cash flows

> Higher degree of dependency between funds

A stress testing process is important for prudent management, as it examines the "what if" scenarios necessary to detect vulnerabilities, and can help estimate shifts in the long-term economic environment.

4.4 Use of indices

As many investors do not have access to sufficient and reliable data sets necessary to achieve statistically significant results, they can use indices provided by external providers (such as Thomson One and Cambridge Associates). An index can be a suitable proxy for the risk of the portfolio of funds held if the composition of the index is representative of the institutional investor's portfolio composition and diversification.

4.5 Look-through requirement

For deciding for which model for funds to apply, limited partners have to look through to the fund's portfolio companies in order to assess whether the approach is appropriate for the portfolio's composition and whether the underlying assumptions still hold.

5 Addressing Funding Risk

Risks related to the liquidity required to fund capital calls can affect investors' ability to generate realisations from a private equity partnership or to conduct orderly transactions in the secondary market. Therefore, monitoring funding risk is central to effective risk management in private equity.
Where investors have multiple sources of liquidity to meet their capital calls, they should evaluate the availability of liquidity not only from within the private equity portfolio, but also across business lines, other asset classes and all legal entities of their organisation.

Limited partners do not need to reserve all committed capital in cash as distributions from existing investments and other sources of liquidity can be used to partially finance open commitments. However, they do need to monitor funding risk to ensure they will have enough resources to honour capital calls and to allow them to hold their private equity investments to maturity. Monitoring liquidity needs also enables limited partners to prevent cash shortages due to over-allocations or over-commitments.

Many investors estimate and plan their short-term liquidity needs through continuous dialogue with private equity managers. This approach helps smooth short-term cash management. However, it has limitations when estimating cash needs in the medium- to long-term, an estimation necessary for preventing over-commitment. In addition, this strategy may be suitable for an investor with only a handful of private equity investments in its portfolio, but it is more burdensome for investors with hundreds of private equity investments in their portfolios.

5.1 Preventing liquidity shortfalls

Limited partners have four sources of liquidity to meet capital calls: (1) distributions from private equity funds, (2) liquidity provided by other assets, (3) liquidity provided by external sources (e.g. borrowing), and (4) proceeds from the sale of private equity interests in the secondary market.

In a buoyant economy, proceeds from distributions are generally high and can be used to finance all or part of an investor's open commitments. However, when equity markets contract, private equity managers slow down exit activity significantly (but do not necessarily slow down investment activity), so investors have to find alternative ways to finance open commitments.

Funding tests help investors determine if their private equity portfolio will likely receive enough distributions to fund capital calls, and if not, how much is needed to fund short- and medium-term obligations. For this purpose stress tests should be applied. The outcomes of funding tests should be used in liquidity planning and to develop effective contingency plans. To this end, investors also need to consider the relative ease or difficulty with which they can mobilise cash resources from outside their private equity portfolio. For instance, investors with investments in liquid assets can mobilise cash more easily than investors with high proportions of illiquid investments. Contingency plans include slowing commitment activity or selling stakes in the secondary market. Effective liquidity monitoring can help investors arrange orderly sales in the secondary market, particularly if it gives investors time to sell at an acceptable price. Overall, a secondary sale in order to prevent liquidity shortfall implies two effects: it generates proceeds as well as releasing open commitments.

5.2 Limited partners facing liquidity shortfalls

If it is likely that a limited partner will not be able to finance its future capital calls, it needs to assess the risk of a distressed sale of a fund stake before its maturity. The limited partner needs to analyse for which funds in the overall portfolio future capital calls can still be honoured.

Limited partners need to bear in mind that distressed sales often command steep discounts. From a risk management perspective, liquidity shortfalls should be assessed conservatively, i.e. it should be assumed that exiting individual fund positions will not provide any liquidity in the short term.

6 The Impact of Diversification on Risk

The degree of diversification of an investor's portfolio influences the risk profile significantly and should be taken into account when measuring long-term risks for portfolios of funds. However, investors should also be aware that short- and medium-term cash flows can become highly correlated during market downturns.

Limited partners typically hold portfolios of funds that are generally diversified across managers, vintage years, strategies, industries, geographies and currencies. The continuous monitoring and management of diversification is an important component of their risk management framework. Experience shows that diversification over vintage years is one of the most effective ways of mitigating risks. Others are stages (e.g. buyouts, mezzanine, VC), geographies (e.g. Europe, North America, Asia) and industry sectors (e.g. ICT, life sciences).

Diversification reduces the long-term risk of a private equity portfolio and for large portfolios is expected to increase the median returns (although it also reduces the potential for extraordinary returns). However, experience obtained over several market cycles shows that cash flows tend to become highly correlated during market downturns. Therefore, even funds following different strategies or with exposure to different geographies can, in extreme situations, become subject to similar degrees of liquidity risk in the short- and medium-term. The impact of diversification also depends on the interaction between the private equity portfolio and other assets that to which an investor has exposure.

The use of correlation as a measure of dependence between the funds in a portfolio of funds has significant limitations. These include stale pricing and difficulty in measuring the risks of private equity funds as the principal limitations for using the NAV as a proxy for a private equity fund's price on the market. A number of modelling approaches can be applied:

> **Direct correlation modelling**: This type of modelling is based on observed funds' or co-investments' performance data, if available from either public or private sources.

> **Implied correlation modelling**: This approach is based on systemic factors (i.e. value drivers), which are usually mapped to each fund and/or underlying portfolio companies.

Alternatively, the relative dependence or independence of funds within a larger portfolio can be assessed through other tools, such as cluster analysis. Cluster analysis is a technique to classify similar objects into relatively homogenous groups and dissimilar objects into different groups. It can be used to analyse the degree to which a portfolio of private equity funds is "clogged", i.e. tends to form clusters of sub-portfolios that cannot be seen as independent any more. Funds that belong to the same cluster are should be modelled as moving in the same direction. When applying stress scenarios, portfolios of funds tend to get increasingly clogged. The portfolio construction process aims to assure a high degree of independence between returns by maximising dissimilarity between funds across a limited number of clearly identified diversification dimensions, such as vintage year, stage focus, industry focus and geographical focus.

7 Measuring Risks of Private Equity Co-Investments

Limited partnerships can sometimes co-invest directly in private equity portfolio companies alongside one or more general partners. Although there are plenty of similarities, the risk factors and risk assessment approaches for co-investments are typically different from the ones applied to private equity funds.

Co-investments: overview of main risks to be considered

Co-investments are generally subject to all the main risks that apply to investments in private equity funds[15], but they are also characterised by idiosyncratic risk factors.

All the following risks should be considered for effective risk measurement of co-investments:

I. Funding risk

Generally, there is no contractual or legal obligation to fund additional financing rounds in the case of co-investments. Consequently, funding risk is minimal or non-existent. Nevertheless, there is a degree of funding risk associated with equity injections, e.g. in the context of expansion programmes (e.g. buy and build strategies), to comply with debt covenants and, in worst case scenarios, to remain solvent (see paragraph IV below on capital risk).

II. Liquidity risk:

The secondary market for co-investments is arguably more illiquid than the funds secondary market. This exposes investors to a high degree of liquidity risk. This needs to be taken into account and measured.

III. Market risk:

Co-investments are typically valued at fair market value in line with the International Private Equity and Venture Capital Valuation Guidelines and could therefore be heavily influenced by market movements. Market risk is relevant both for unrealised value (i.e. when investments are held in the investor's balance sheet) and realised value (i.e. cash inflow in case of exit) of co-investments.

IV. Capital risk

Capital risk is defined as the risk of losing invested capital as a result of idiosyncratic factors impacting single co-investments. These idiosyncratic factors can be divided in two main categories:

a. **Capital structure, cash flow and default risk**: Balance sheet and cash flow risks are key risks for co-investments. In leveraged capital structures, weak cash flow and poor performance could lead to debt covenant breaches and, in a worst case scenario, to default and write-off of the investments.

b. **Operational risks**: Operational risks in the context of co-investments' risk measurement are defined as idiosyncratic factors that could impact portfolio companies' earnings and profitability. Operational risks of co-investments vary across sectors, geographies and portfolio companies' sizes but they typically include:

- Quality of a portfolio company's management
- Credibility and quality of management and board information and accounts
- Credibility and achievability of budget and business plan, including revenue growth, margin improvements and future cash flow generation
- Investors' level of influence in board and management decisions
- Supply risk, including reliance on specific suppliers, commodities and markets
- Demand risk, including reliance on specific clients, distribution channels and markets
- Compliance and regulatory risks
- Legal and contractual risks
- Environmental, social and governance risks
- Quality of relationship and alignment with general partners

V. Foreign exchange risk

FX risk should be also considered and should be analysed from two points of view:

a. Currency of investment
b. FX exposures in the portfolio company's balance sheet, income and cash flow statements

Base models to measure co-investment risk

Similarly to funds, private equity co-investments risks can be modelled using a variety of approaches and methodologies.

The model selection factors and the two main types of modelling methodologies described in Section 4 of this paper - the NAV-time series and cash flow projection-based modelling approaches - are also applicable to co-investments.

Additionally, the following two high-level risk modelling approaches can be adopted for co-investments:

I. Bottom-up approach

This approach can be adopted for measuring the risk of single co-investments and portfolios of co-investments.

The bottom-up approach entails detailed analysis, assessment and quantification of single co-investment funding, liquidity, market and capital risks. When measuring the risk of portfolios of co-investments, correlations across single portfolio companies will also need to be considered.

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15 Please refer to section 4 for more details.

II. Top-down approach

This approach can be adopted for measuring the risk of portfolios of co-investments only and entails a general assessment of portfolio funding, liquidity, market and capital risks.

Risk models for co-investments are generally characterised by material model risks due to relatively high reliance on subjective judgment when assessing the impact of more qualitative risk factors (e.g. quality of management, level of influence on board and management decision, etc).

8 Model Validation and Verification

The accuracy and robustness of risk management frameworks need to be reassessed regularly.

I. To be objective and unbiased, the verification and validation processes should be conducted independently. This can be done by independent qualified internal staff or through an external review prior to actual reliance on a model, and periodically thereafter.

II. For their risk measurement, limited partners should use several sources to be able to capture all relevant available market data. Sensitivity analysis, stress testing, qualitative assessment and judgment are appropriate ways of overcoming data scarcity and showing that results are still valid under more pessimistic conditions.

III. Knowledge gained from the monitoring of funds has to be incorporated in risk measurement. Judgment has to be structured and well documented. Models should not be based on the assumption that the limited partner has above-average selection skills.

IV. Market indices are important as one modelling input and as benchmarks for risk measurement but cannot be a substitute for a risk model that is specific to an institutional investor's portfolio of funds.

Risk measurement models should not be static and need to be improved continuously. They not only have to incorporate relevant past data but should also evolve with new information and adapt to a changing environment. Models should be regularly validated and verified. Limited partners need to ensure that choices of reference data and scenarios do not assume they have above-average selection skills.

Scarcity of data on the universe of private equity funds can be a major obstacle to precise risk measurement and to back-testing of models. For example, smaller private equity investment programmes will have good quality data only on their investee funds. Investors in the early stages of building up portfolios of private equity funds will face similar issues. In addition, where investors are exposed to venture capital investment in innovation, the past does not always provide a reliable yardstick for the future. In situations where there are significant difficulties in accessing good quality and representative data, assumptions and modelling choices, well documented judgment, stress testing and scenario analysis have to play a significant role.

Risk models use a variety of indices related to public markets as well as private equity market-specific ones. The mapping of the overall portfolio on the market indices has to be clearly defined. The (sub-)indices used to quantify shocks or volatility must be representative and consistent with the structure (notably diversification, quality, stage in the funds' lifecycle and the investor's funding liquidity test) of the (sub-)portfolios to be modelled. In the case of private equity market indices, the completeness and quality of the data needs to be taken into consideration.

9 Application Guidance

This section provides references to academic papers and publications by practitioners that give further guidance on the application of the principles and methodologies presented in the previous sections. Generally, research and development does not stand still and needs to keep abreast of changes in markets, asset management practices and regulation. Consequently this section requires continuous updates.

9.1 Estimating the volatility of the fund's portfolio using NAVs

Key issues

> Overcoming lack of market data
> Use of indices
> No more frequent than quarterly data available
> Un-smoothing of the "appraisal value effect"

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9.2 Projecting cash flows for funds

Key issues

> Estimating ranges for return multiples and lifetime for a fund
> Overcoming the lack of market data and using qualitative inputs
> Use of a model that projects cash flows for a fund over its (remaining) lifetime
> Use of a non-probabilistic or probabilistic fund model
> Applying a discount rate to sum up the present value for the fund

- Arthus, P. & Teïletche, J. (2004) Asset allocation and European private equity: A first approach using aggregated data. Brussels, EVCA.
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9.3 Determining a discount rate

Key issues

> The choice of a discount rate should be complementary to the risks modelled in the cash flow forecast:

- First implication: it is important that different sources of uncertainly are only reflected once. For instance, the impact of inflation and interest rate risks can be modelled as part of either the cash flow model or the discount rate, but shouldn't be modelled by both. Likewise, if the cash flow model takes care of the probability of success or failure of an individual company then the discount rate should not be higher than what could be expected to account for possible default events.
- Second implication: If the cash flow forecast uses historical data, the discount rate should reflect the same time frame.

> Discount rates can also be used to explore ranges of variation in the discounted cash flow (DCF) output for single cash flow forecasts. However, particular choices of discount rates should hold true for the entire duration of the cash flow forecast. If the intention is to stress test for punctuated losses or gains, one may need to use different discount rates over time. Otherwise, the model would assume constant gains or constant losses.

> The cash flow forecast and the discounting scheme need to be thought of as complementary components in a DCF framework. Together they should reflect – but not double-count – the risks inherent in private equity investing, as well as the difficulty of forecasting cash flows accurately.

> When using Monte-Carlo simulations, cash flows need to be simulated under the "risk-neutral" probability measure, to take proper account of the risk properties of the cash flows. It is a mistake to simulate cash flows using historic means and variances, and then still discount using a risk-free rate as this overstates the value.

- Arthus, P. & Teïletche, J. (2004) Asset allocation and European private equity: A first approach using aggregated data. Brussels, EVCA.
- Bauer, M., Bilo, S. & Zimmermann, H. (2001) Publicly Traded Private Equity; An Empirical Investigation. 2nd draft, Swiss Institute of Banking and Finance, Universität St. Gallen, Working Paper No. 5/01.
- Kaserer, C. & Diller, C. (2004) European Private Equity - A Cash Flow based Performance Analysis. Brussels, EVCA.

- Kerins, F., Kiholm Smith, J. and Smith, R. (2003) "Opportunity Cost of Capital for Venture Capital Investors and Entrepreneurs" working paper, February. http://leeds-faculty.colorado.edu/bhagat/EntrepreneursOpportunityCost.pdf
- Ljungqvist, A. & Richardson, M. (2003) The Cash Flow, Return and Risk Characteristics of Private Equity. Unpublished working paper, New York University, Finance Working Paper No. 03-001. Available from http://ssrn.com/abstract=369600. [Accessed 12 October 2004].
- Moskowitz, T. & Vissing-Jørgensen, A. (2002) The Returns to Entrepreneurial Investment: A Private Equity Premium Puzzle? American Economic Review, Vol. 92, No. 4, pp. 745-778.
- Weidig, T. & Mathonet, P.-Y. (2004) The Risk Profile of Private Equity. January. Available at http://ssrn.com/abstract=495482, [accessed 16 June 2008]
- Zimmermann, H. et al. (2004) The Risk and Return of Publicly Traded Private Equity. University of Basel, WWZ/Department of Finance, Working Paper No. 6/04.

9.4 Diversification in private equity investments

Key issues

> Risk factors impacting diversification of portfolios
> Measuring correlation and diversification
> Illiquidity, paucity and inconsistency of market data for private equity

- Bauer, M., Bilo, S. & Zimmermann, H. (2001) Publicly Traded Private Equity; An Empirical Investigation. 2nd draft, Swiss Institute of Banking and Finance, Universität St. Gallen, Working Paper No. 5/01.
- Mathonet, P.-Y. & Meyer, T. (2007) J Curve Exposure. John Wiley & Sons. Chichester.
- Weidig, T. & Mathonet, P.-Y. (2004) The Risk Profile of Private Equity. January. Available at http://ssrn.com/abstract=495482, [accessed 16 June 2008]

9.5 Monitoring of funding risk

Key issues

> Interrelatedness with a limited partner's other assets and liabilities
> Early identification of funding needs
> Need to stress test projections
> Contingency plans to address funding gaps

- Ang, A. (2010). Liquidating Harvard . 2010, Columbia CaseWorks 100312. http://www2.gsb.columbia.edu/faculty/aang/cases/Liquidating%20Harvard%20p1.pdf
- Robinson, D. T. and Sensoy, B. A. ,(2011). Cyclicality, Performance Measurement, and Cash Flow Liquidity in Private Equity. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1731603

9.6 Incorporation of qualitative data in risk models

Key issues

> Consistent incorporation of qualitative data
> Translating qualitative data into quantification
> Regular updates and monitoring of qualitative data
> Clear separation from due diligence processes

- BIS (2001) Working Paper on Risk Sensitive Approaches for Equity Exposures in the Banking Book for IRB Banks. Basel Committee on Banking Supervision. August. Available at http://www.bis.org/publ/bcbs_wp6.pdf?noframes=1, [accessed 1 July 2008]
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- Crouhy, M., Galai, D. & Mark, R. (2001) Prototype Risk Rating System. Journal of Banking and Finance. No 25.
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- Healy, B. (2001) Calpers Posts Fund's Record on Web Site – Money Managers Aghast that Pension Investor Shows Returns, Rankings. Boston Globe. August.
- Krahnen, J.P. & Weber, M. (2000) Generally Accepted Rating Principles: A Primer. To be published working paper.
- Meyer, T. & Mathonet, P.-Y. (2005) Beyond the J Curve. John Wiley & Sons. Chichester.
- Primack, D. (2011) The best private equity firm is... Fortune. Available at http://finance.fortune.cnn.com/2011/11/14/best-private-equity-firm/, [accessed 8 February 2012]

- Ruso, S. (2008) A Governance-focused Rating System for Closed-end Funds in Germany. Diplomarbeit. Swiss Banking Institute.
- Troche, C.J. (2003) Development of a Rating Instrument for Private Equity Funds. MBA Management Project Report, NIMBAS Graduate School of Management.

9.7 Accessible data on private equity

Key issues

> No complete and reliable historical public data available on private equity
> Few data providers
> Substantial variations between data providers
> Biases related to data collection process
> No data on emerging sectors in private equity (e.g. new markets, teams)

- Cornelius, P. (2011) International Investments in Private Equity: Asset Allocation, Markets, and Industry Structure Academic Press; 1 edition (January 3, 2011)
- Mathonet, P.-Y. & Meyer, T. (2007) J Curve Exposure. John Wiley & Sons. Chichester. Chapter 6

9.8 Further reading

Probability of default (PD) /loss given default (LGD) or value at risk (VaR)?

- BIS (2001) Working Paper on Risk Sensitive Approaches for Equity Exposures in the Banking Book for IRB Banks. Basel Committee on Banking Supervision. August. Available at http://www.bis.org/publ/bcbs_wp6.pdf?noframes=1, [accessed 1 July 2008]
- Bongaerts, D. & Charlier, E. (2008) Private Equity and Regulatory Capital. Tilburg University. Discussion Paper. No. 52. May.
- Krohmer, P. & Man, K.-S. (2007) Modeling Default Risk of Private Equity Funds – A Market-based Framework. Published in Krohmer, P. (2008) Essays in Financial Economics: Risk and Return of Private Equity. Inaugural-Dissertation. Matrikelnummer 2473635. Fachbereich Wirtschaftswissenschaften. Johann Wolfgang Goethe Universität. Frankfurt am Main. April.
- Weidig, T. & Mathonet, P.-Y. (2004) The Risk Profile of Private Equity. January. Available at http://ssrn.com/abstract=495482, [accessed 16 June 2008]

10   Glossary

Entries in the glossary marked with an asterix (*) are derived from the EVCA's Handbook of Professional Standards for the Private Equity and Venture Capital Industry (2012 Edition) in order to ensure consistency across all EVCA publications. The remaining glossary and definitions reflect the scope and objective discussed within the EVCA Risk Measurement Guidelines.

> **Asset liquidity risk**

Asset liquidity risk relates to the relative ease and promptness with which a financial instrument may be sold at a fair price when desired.

> **Commitment**

A limited partner's obligation to provide a certain amount of capital to a fund when the general partner requests capital.

> **Discounted cash flow (DCF)**

Discounted cash flow is a method of valuing an investment by estimating future cash flows and taking into consideration the time value of money.

> **Distressed or forced transaction**

A forced liquidation or distressed sale (i.e., a forced transaction) is not an orderly transaction and is not determinative of fair value. An entity applies judgment in determining whether a particular transaction is distressed or forced.

> **Distribution(s)***

All amounts returned by the fund to the LPs. This can be in cash, or in shares or securities (in the latter case known as "Distribution(s) in specie").

> **Distribution waterfall**

During the lifetime of a fund, liquidity events occur and distributions are made, based on a predetermined distribution waterfall, whereby limited partners typically receive a certain amount of the profit first before the general partners can receive their share.

> **Drawdown(s)***

LP commitments to a fund are drawn down as required over the life of the fund, to make investments and to pay the fees and expenses of the fund. When LPs are required to pay part of their commitment into the fund, the GP issues a drawdown notice. Drawdowns are sometimes referred to as "capital calls".

> **Fair value**

The fair value is the price at which an orderly transaction would take place between market participants at the reporting date (measurement date).

> **Fund or private equity fund***

A private equity or venture capital fund. A closed-ended limited partnership is a common structure used for such a fund, but other legal forms are also used e.g. FCPR, KG, SICAR, AB, BV and NV, etc.

> **Fund-of-funds**

Fund-of-funds is a generic term used in these Guidelines to refer to any designated pool of investment capital targeted at investment in underlying private equity funds.

> **Funding risk**

Funding risk relates to an investor's ability to meet its funding obligations when they are due without incurring unacceptable losses.

> **General partner (GP)***

GP is the term typically used to refer to the different entities and professionals within a private equity firm which source, analyse, negotiate and advise on potential transactions as well as invest and manage the fund. More specifically, it means the general partner of a limited partnership. The term GP may also be used to refer to the manager or investment adviser of a fund, depending on the fund structure.

> **Investee company**

The term investee company refers to a single business or group of businesses in which a fund is directly invested.

> **J-curve**

The J-curve refers to the fact that, in the initial years of a private equity fund, its cash flow and return performance will always be negative as drawdowns for investment and management fees significantly exceed any distributions to limited partners from generated income or capital gain. From the investors' perspective, this phenomenon results in a temporary accounting loss which, when graphically illustrated with the profits and positive cash flows in future years, produces a curve resembling the letter J.

A portfolio with many young funds will have a steep J-curve, while a more mature portfolio will have a less pronounced J-curve.

> **Limited partner (LP)***

An investor in a fund. More specifically, it means the limited partner in a limited partnership. LPs in a fund include sophisticated investors, experienced high net-worth individuals and entrepreneurs, sovereign wealth funds, endowment funds, foundations and family offices.

> **Limited partnership***

A legal structure commonly used by many private equity and venture capital funds. It is used especially when catering for broad categories of international investors and looking to make cross-border investments. The partnership is usually a fixed-life investment vehicle, and consists of a general partner (the GP/manager of the fund, which has unlimited liability) and limited partners (the LPs, which have limited liability and are not involved with the day-to-day operations of the fund).

> **Market participants**

Market participants are potential or actual willing buyers or willing sellers when neither is under any compulsion to buy or sell, both parties having reasonable knowledge of relevant facts and the ability to perform sufficient due diligence in order to be able to make orderly investment decisions related to the transaction.

> **Net asset value (NAV)**

The NAV of a fund is the amount estimated as being attributable to the investors in that fund on the basis of the fair value of the underlying investee companies and other assets and liabilities.

> **Net present value (NPV)**

The NPV of a fund is the discounted current value of the expected future cash inflows and outflows, calculated using an appropriate cost of capital.

> **Orderly transaction**

An orderly transaction is a transaction that assumes exposure to the market for a period prior to the date of the transaction to allow for marketing activities that are usual and customary for transactions involving such assets or liabilities.

> **Partnership Agreement**

The Partnership Agreement mainly covers terms, fees, structures and other items agreed between the limited partners and the general partner. It also determines the timing of distributions to the limited partner and how profits are divided among the limited partners and general partner.

> **Private equity***

Private equity provides funding in equity form from funds to acquire a majority or minority stake in portfolio companies in different stages of development across a wide range of industries. The term is widely used and encompasses venture capital (typically a minority stake invested in an early-stage or pre-profitable business), through to enterprise capital (a minority or majority stake invested in portfolio companies at critical points of their development). When majority stakes are acquired through enterprise capital investments, these are commonly referred to as "buyout" transactions.

> **Reporting date**

The date for which the risk measurement is being prepared. It is the same as the measurement date.

> **Secondary investments or secondaries***

These terms are typically used to refer to the transfer of an LP's contractual commitment and interest in an existing fund to another LP ("secondary fund investment"). In contrast, the term secondary (direct) sale is used to describe the sale by a fund of its interests in one or more portfolio companies to a fund managed by a different GP.

> **Stale pricing**

Stale pricing is a result of reported net asset values of a fund not incorporating all available information. Therefore, stale pricing leads to a time-lag between observable market valuations and valuations in private equity portfolios.

> **Undrawn commitment**

A significant part of a fund's commitments will not be needed immediately but only as investment opportunities arise. They remain with the limited partners and are called by the general partner over the agreed investment period as and when investment opportunities are identified. This capital is a fund's undrawn commitment.

> **Validation**

Validation is the process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model, and whether the logic followed by the model conforms to economic and mathematical principles.

> **Venture capital***

Funding typically provided in equity form to companies in early stages of their life cycles, i.e. seed, early-stage, development, or expansion. Historically the term was used to refer generally to all private equity investments, which is why many private equity associations refer only to venture capital in their name.

> **Verification**

Verification refers to the process of determining whether the output from the model conforms to actual experiences in the real world.

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