On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula

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Table of Contents

Introduction ............................................................................................................. 5

Executive summary ................................................................................................. 9

1. The Measure of Private Equity Risk in the Solvency II Standard Formula ................................................................. 13
   1.1. The Modular Structure of Risks Taken by Solvency II ......................... 14
   1.2. The Measure of Risks Chosen by Solvency II and the Correlation Coefficients ............................................................................. 16
   1.3. Assessment of Private Equity Risk according to Solvency II ............ 18

2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula ......................................................... 23
   2.1. The Drawbacks of the LPX50 as a Benchmark for Private Equity .......... 24
   2.2. The Definition of a Performance Measure of a Listed Stock Comparable to that of Private Equity .............................................................. 26
   2.3. The Sample of Private Equity Funds .............................................................. 30
   2.4. Study of the Correlation of the Performance of a Portfolio of Private Equity and that of Listed Shares .............................................................. 32

Conclusion .............................................................................................................. 39

Appendices ............................................................................................................. 43

References .............................................................................................................. 49

Acronyms ................................................................................................................ 51

About EDHEC Financial Analysis and Accounting Research Centre ................. 53

About AFIC ............................................................................................................. 55

Foreword

The study it is our pleasure to present to you here was carried out by the EDHEC Financial Analysis and Accounting Research Centre and is sponsored by the Association Française des Investisseurs en Capital (AFIC). This study is an integral part of our innovative approach to research, an approach in which research is produced for business, and this in an attempt to favour a dynamic that puts business at the heart of the researcher’s work.

Since it was founded in 2006 the EDHEC Financial Analysis and Accounting Research Centre has underlined the importance of its work on Solvency II and IFRS in the insurance industry. We believe that the implementation of this new risk-based regulatory framework will constitute major progress in the perception and measurement of risks compared to existing systems. Therefore, there would be several effects on the daily management of insurance companies, on asset management, liability management, asset/liability management, as well as on hedging, the products offered to policyholders (guarantees and options), shareholders’ equity, and equity equivalents (subordinated debt), governance (through capital add-on). Indirectly it will also have effects on the financing of the economy, health, retirement, real estate, and also through liability on many sectors of activity (construction, medicine).

This study calls into question the method and the data used by the European regulator to measure the risk of private equity investments, in particular the correlation coefficient of performance of private equity and that of listed equities. The drawing-up of Solvency II prudential rules has become a matter of major concern for the private equity sector since the current measure for private equity risk, used by the European regulator, is likely to dissuade insurers from investing in this asset class. As an example, in the French market, in 2007, the total investments in private equity represented €22bn in the balance sheet of insurance companies (FFSA 2008). They finance 21% of the funds raised (AFIC); thus becoming the leading national investors in unlisted stocks.

Furthermore, we propose to study an alternative method to calculate performance and we show through simulations the impact of the level of the correlation coefficient (representing diversification in investments) not only on the capital requirement for equity risk but also on the marginal cost of the capital requirement as a consequence of asset reallocation between listed equities and private equity.

I would like to thank the team of Peter O’Kelly and Laurent Ringelstein for their role in the production of this document.

Finally, this study would not have been possible without the support of our partner AFIC, to whom we would like to express our warmest gratitude. The success of this partnership demonstrates yet again the advantages of close cooperation between the business and academic worlds.

Philippe Foulquier PhD,
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Introduction
Introduction

The drawing-up of the Solvency II prudential rules has become a major concern for the private equity industry. The capital requirements for private equity risk could turn out to be, from 2012, sufficiently binding to lead many European insurers to reduce appreciably their asset allocation to non-listed stocks. As an example, in the French market, in 2007, the total investments in private equity represented €22bn in the balance sheet of insurance companies (FFSA 2008). Insurance companies finance 21% of the funds raised (AFIC); thus becoming the leading national investors in non-listed stocks.

The new European regulatory framework Solvency II constitutes a true break with current Solvency I practices since it evolves from an "off-the-rack" system built on minimalist rules to a "custom-made" system adapted to the specificities of each company. To achieve this, the scope of the risks has been expanded and their assessment refined (distribution, correlation, diversification, extreme risks, etc.).

After the European Parliament vote of 22 April 2009 and the adoption of European Directive Solvency II (level 1) by ECOFIN, the European Commission is expected to adopt in November 2011 the so-called level-two implementing measures, which are currently being drawn up. These measures will be first tested from August to October 2010 through the impact study QIS 5. The Directive is now expected to come into force by November 2012.

The calibration of the Solvency II models, which are meant to determine the capital requirements of those in the insurance industry, affects asset management, liability management, asset/liability management, hedging management, the products offered to policyholders (guarantees and options), shareholders’ equity, and equity equivalents (junior debt), governance (capital add-ons), and so on. Indirectly, these new prudential rules will also have effects on the financing of the economy – due to their pressure on investments in listed and non-listed stocks – of health, of retirement, of real estate, and also on policyholders and, through liability, on many sectors of activity (construction, medicine), as well as on private equity.

This publication studies the calibration of private equity risk in the Solvency II standard formula by analysing the correlation of listed share performance, measured through an MSCI index (Europe or the United States, depending on the region we consider in our study) and private equity performance. The point, in other words, is to ascertain whether the coefficient of correlation of 0.75 taken by CEIOPS in QIS 4 (CEIOPS 2008), in consultation paper 69 (CEIOPS 2009a), and in the final advice of 29 January 2010 (CEIOPS 2010a) is or is not suitable.

To estimate the correlation of these two asset types, this publication proposes an alternative approach to the one proposed by the CEIOPS: the benchmark index LPX50 chosen by the CEIOPS is replaced by a benchmark that is more representative of insurance portfolios invested in private equity, incorporating the different classes and geographic regions of private equity. In fact, the LPX50, an index of listed private equity firms, by design, is distorted by the idiosyncratic risk of the firms that make up the index.
Introduction

To do this, as there is no private equity benchmark and it is impossible to determine the annual return on private equity to compare it with an index of listed shares and thus to determine the performance of a fund, we have turned to academic works done on this subject and studied the practices of private equity managers. We will likewise determine the aggregated and annualised internal rates of return for different vintage years of the private equity funds. This index and the equivalent investment in an MSCI index (representative of the investment zone under consideration) associated with the same portfolio structure (different vintage years, cash flows) as that taken in the private equity benchmark are compared. The correlation of the two benchmarks is then measured.

The first part of the publication is devoted to analysing the regulators’ choice of the private equity measure (Value at Risk) since it generated the use of controversial correlation matrices which are at the heart of our debate. The second part shows the drawbacks of choosing the LPX50 index as a reference for private equity and proposes another solution, which is more representative of the non-listed stock investments of European insurers. The correlation of the listed stocks’ performance and that of non-listed stocks is then determined based on this new solution.
Introduction
Executive Summary
Executive Summary

With the support of the CEIOPS, the European Commission is putting in place a new regulatory framework, known as Solvency II, for the European insurance industry. After the European Parliament vote of 22 April 2009 and the adoption of European Directive Solvency II (level 1) by ECOFIN, the European Commission is expected to adopt in November 2011 the so-called level-two implementing measures, which are currently being drawn up. The Directive is now expected to come into force by November 2012. Under the pressure of these future prudential rules, insurance companies are getting ready to adapt themselves for a profound change.

The calculation of the SCR is done from a modular structure of risks measured in accordance with a 99.5% Value at Risk (VaR) over a one-year horizon from the aggregate of the six risk modules, themselves broken down into sub-modules. In general, a shock is associated with each type of risk. The aggregation of these shocks, in accordance with correlation matrices that reveal the dependence and diversification of risks, results in the solvency capital requirement.

The Solvency II risk-based approach is a breakthrough in the perception and measurement of risks compared to the existing system, Solvency I. Yet, the standard formula calibrations and correlation should not be taken lightly. Their effects are several, on policyholders and daily management of insurance companies (asset management, liability management, asset/liability management, hedging, the products offered to policyholders (guarantees and options), shareholders’ equity, and equity equivalents, governance) as well as on the financing of health, retirement, and the economy in general.

The drawing-up of the Solvency II prudential rules has become a major concern for the private equity industry. The capital requirements for private equity risk could, from 2012, turn out to be sufficiently binding to lead many European insurers to reduce appreciably their asset allocation to unlisted stocks or even to stop these investments. As an example, in the French market, in 2007, the total investments in private equity represented €22bn in the balance sheet of insurance companies (FFSA 2008). They finance 21% of the funds raised (AFIC); thus becoming the leading national investors in unlisted stocks.

This publication studies the calibration of the correlation coefficient of private equity performance and that of listed equity. In the last impact study QIS 4 (QIS4 2008), the CEIOPS proposed a correlation coefficient of 0.75 which was maintained in the document CEIOPS-DOC-65/10 published in January 2010 (CEIOPS 2010b). The CEIOPS justified its choice by the study of the correlation of the LPX50 index and the MSCI World index which resulted in a coefficient of 83.59%. In the end, as the CEIOPS has chosen to deal with private equity, shares listed exclusively in emerging markets, hedge funds, and other alternative investments in one asset class, the correlation coefficient kept for these type of investments is 0.75.

As a first conclusion, this publication shows that the measure of private equity risk adopted by CEIOPS, a measure that relies on the LPX50, can be called into question. In fact, this index defined on the basis of
the stock prices of the fifty largest listed private equity firms in the world, poses an idiosyncratic risk that is added to the risk of investment in private equity. In other words, investing directly in listed firms involved primarily in private buyouts, such as Blackstone and Eurazeo, does not pose the same risks as investing in private equity funds or funds of funds. In order to correct this drawback, we propose to measure the correlation of private equity performance and that of listed equity by replacing the LPX 50 benchmark with the performance of private equity funds from the Thomson One database.

To reflect the make-up of the private equity portfolios of European insurers, our sample is made up of 1,120 liquidated and closed private equity funds, European and American, over the period of 1980 to 2009. These funds are divided into sixty-nine vintage years. Three quarters of the 1,120 funds are from the United States and 70% are venture funds.

Nonetheless, no longer using an index of publicly-traded shares, as the CEIOPS does, to measure the risk of investment in private equity and its correlation with an investment in an index of companies listed in EEA and OECD countries has the major drawback of making it impossible to apply classic approaches to the calculation of returns and to the measure of correlation of the two indices of listed firms. It is thus necessary to define another measure of performance that respects the very nature of private equity funds and can be compared to that of an investment in an index of listed firms.

The distribution flows from an investment in private equity can then be expressed in a manner equivalent to a sale of securities at the same dates. The comparison can be made by expressing the holding period of an investment in private equity through the equivalent of a purchase of listed shares over the same periods. In accordance with the practices of the private equity industry and academic approaches, we have calculated the internal rates of return (IRR) of private equity funds by vintage year, geographic zone, as well as the Public Market Equivalent Plus measure (PME +) for the listed equity market.

Given the modest sample size, it is customary to use the Kendall rank coefficient to measure correlation. For each of the four categories of private equity, the Kendall rank correlation coefficient of the private equity and the MSCI index is appreciably lower than 0.75 (buyout Europe: 0.54; buyout US: 0.44; venture Europe: 0.11; venture US: 0.21).

Furthermore, we have studied the correlation coefficient of insurance companies’ model portfolio of investments in private equity (the allocation estimation of AFIC is 10% in the United States and 90% in Europe, 10% in venture capital and 90% in buyout). The Kendall rank correlation coefficient of private equity and the MSCI is 0.30.

In conclusion, our study shows that private equity performance is significantly less correlated to that of listed equity markets than assumed in the 0.75 correlation coefficient selected by the CEIOPS.
Executive Summary
1. The Measure of Private Equity Risk in the Solvency II Standard Formula
1. The Measure of Private Equity Risk in the Solvency II Standard Formula

Analysing the choice of risk measurement made by CEIOPS is essential to our study, as it is the consequence of ongoing debate about the coefficients of correlation, including that for private equity and listed shares. As mentioned in the introduction, the issue is crucial as by its nature it is likely to affect the financing of the economy, and more specifically the financing of the non-listed sector. Indeed, the regulator’s current proposal (CEIOPS, 2010a) for modelling private equity risk is likely to encourage insurance companies to stop making investments in non-listed equity.

The objective of this section is to present CEIOPS’s approach to defining the regulatory capital requirements made of insurance companies. We will deal, in particular, with the modular structure of risks, with the choice of the perimeter and measure of risks, and with the adoption of different formulae (simplified standard, standard, internal model) defined by the European regulator. Its objective, then, is not simply to take into account the means and the complexity of insurance companies but also to encourage those in the business to develop a forward-looking and economically-grounded culture of risk. Subsequently, we will analyse how private equity risk was considered by CEIOPS in the context of the Solvency II framework.

1.1. The Modular Structure of Risks Chosen by Solvency II

For several years, the growing complexity and the increase in the number of risks faced by insurance companies have led to a determination to modify prudential rules; the objective is to offer a clearer picture of any company, especially in view of the risks it runs. Although the ends may not have been the same, the implementation of IFRS, Solvency II, Basel II, new rules for financial conglomerates, and MCEV (market consistent embedded value) (CFO Forum 2008) are all converging on this objective. With Solvency II, the European Union is seeking to come up with solvency requirements better suited to the risks borne by insurers and to encourage insurers to measure and control these risks better. By broadening the notion of risk and transferring analysis of their own risks to firms themselves, Solvency II is thus seeking to go from an “off-the-rack” system such as Solvency I, founded on minimalist rules, to a “tailor-made” system suited to the specificities of each firm.

Solvency II intends to take an operational approach to the exposure to risks—that is, an approach consistent with internal management models or economic capital—to foster development of these models and thus to encourage firms to manage their risks better. Solvency II spells out two levels of required capital. The first, MCR (minimum capital requirement), is the minimum beneath which supervisory intervention is systematic. The second, SCR (solvency capital requirement), is a capital target large enough to absorb any unusual shock. If the calibrations proposed by the European regulator are considered relevant by insurance companies, the means of calculating the SCR could be a new standard by which to improve internal management tools or to put in place an economic capital model (Foulquier 2008). The calculation of the SCR is done from a modular structure of risks measured in accordance with a 99.5% Value at Risk (VaR) over a one-year horizon from the aggregate of the six risk modules, themselves broken down into sub-modules.

5 - We will go over the measure of VaR risks in greater detail in this section.
1. The Measure of Private Equity Risk in the Solvency II Standard Formula

In general, a shock is associated with each type of risk. The aggregation of these shocks, in accordance with correlation matrices that reveal the dependence and diversification of risks, results in the solvency capital requirement.

The risks taken by Solvency II are the following:
1. operational risk arising from "inadequate or failed internal processes, people, systems, or external events" (QIS 4 2008);
2. life underwriting risk defined by the risks covered and those linked to the processes in the management of the business, segmented into seven risk sub-modules. Biometric risks (mortality risk, longevity risk, and disability–morbidity–sickness risk), expense risks (the impact of a change in the cost of managing policies), revision risks (non-life claims settled as annuities), lapse risks, and catastrophe risks (a pandemic, for example) are thus considered;
3. non-life underwriting risk (uncertainty having to do with the amount of claims to settle and the moment at which they are settled, with the volume of business, and with the premium rates) measured in accordance with a breakdown into twelve lines of business;
4. health underwriting risk (health guarantees and workers’ compensation);
5. market risk (arising from the market value or volatility of financial instruments);
6. counterparty risk (arising from losses resulting from an unexpected default or deterioration of a credit rating of counterparties or of providers of risk-mitigation instruments, as well as credit with any intermediaries).

The figure below shows this modular structure as proposed by CEIOPS in advance of the coming QIS 5.

Source: CP 72 CEIOPS (2009b)
1. The Measure of Private Equity Risk in the Solvency II Standard Formula

The SCR is thus defined from the sum of the capital charges for operational risk, for adjustments (future profit sharing, and deferred taxation), and for the basic solvency capital requirement (BSCR) resulting from the aggregation of the five other risk modules on the basis of a correlation matrix.

Now that we have described the modular structure, we turn, in the next section, to the measure of risk chosen by CEIOPS in the context of Solvency II.

1.2. The Measure of Risks Chosen by Solvency II and the Correlation Coefficients

As noted in section 1.1., the calibration chosen by Solvency II to determine the SCR is in accordance with a 99.5% VaR over a one-year horizon, which means that the SCR is capital that must be held by insurers to limit their likelihood of bankruptcy to once every two hundred years in a stable environment.

VaR is a measure of the likelihood of loss for a firm arising from future changes in risk factors. It is equal to the potential loss suffered by a firm, given a particular holding period (often one year) and at a likelihood of occurrence \( \alpha \). It is expressed:

\[
\text{VaR}_\alpha (X) = - \inf \{x : F_X(x) \geq \alpha \}.
\]

The estimation of the distribution of losses can be done with a historical method (observation of historical behaviour), a parametric method (estimate of the probability distribution of the risk factors), or with a Monte-Carlo method, parametric or not (several thousand random draws to determine the likelihood of each of the outcomes).

VaR may be a simple concept, easy to define and interpret, but it has often been the target of criticism, as it is not sub-additive, and it does not take into account the severity of ruin. In other word, VaR limits the view of the risk profile of the firm to a single point on the loss distribution; it provides no indication of the fatness of the tail. The fact that it is not sub-additive means that the overall VaR of a firm \( \text{Var}(X_1, \ldots, X_n) \) is not necessarily less than the sum of the VaR of each of its component parts \( \text{Var}(X_1) + \ldots + \text{Var}(X_n) \); and the solvency capital requirement, as it happens, is founded on a VaR amount.

The fact that the measure selected by the CEIOPS is not sub-additive constitutes an essential drawback regarding the issue of our study. This measure has forced the regulator to put in place highly debatable correlation matrices with the aim of allowing for diversification and correlation between risks.

In fact, in internal models, another risk measure derived from VaR is thus often favoured, as it possesses sub-additivity: TailVaR, also known as expected shortfall.
1. The Measure of Private Equity Risk in the Solvency II Standard Formula

conditional tail expectation, or conditional VaR. TailVaR of threshold \( \alpha \) is the conditional expectation of the random variable of an amount less than VaR of threshold \( \alpha \):

\[
\text{TailVaR}_\alpha (X) = TCE_\alpha (X) = E[X/X \geq \text{VaR}_\alpha (X)]
\]

Its advantage is that it takes into account the tails of the distribution and is a consistent risk measure in the sense of Artzner et al. (1999). Another criticism of VaR (which can likewise be levelled at TailVaR) is that these measures of risk often rely on an assumption of the normality of events conditionally on the past available information. Yet unusual events are greater in magnitude than the law of normality would have it (the fatness of the tails of the distribution, leptokurtosis phenomenon).

Finally, before applying this measure of risks, each insurance company must convert its statement of accounts into a statement drawn up in keeping with Solvency II standards. The latter statement relies on economic valuation of assets and liabilities consistent with fair value—in other words, at the amount for which they could be exchanged in a transaction concluded in normal market conditions, between willing and informed parties, and in accordance with three approaches (Escaffre, Foulquier, and Touron 2008), depending on the information available to do the valuation (from mark to market to mark to model). Thus, assets invested in private equity should be measured at fair value rather than at their acquisition value, as is the case in many national accounting standards.

The figure below compares the structure of the conventional statement of accounts and that of the economic statement of accounts under Solvency II:

To determine the economic value of technical provisions, the approach taken by Solvency II is that of current exit value (what would have to be paid to transfer contractual obligations). They are defined in keeping with two components: the best estimate and the risk margin. The best estimate is equal to "the probability weighted average of future cash flows, taking account of the time value of money, using the relevant risk-free interest rate term structure" (European Commission 2008, 13). It is calculated gross of reinsurance and securitisation and should take into account the entirety of flows covering the lifetime of obligations on the assumption of their being settled (future expenses, inflation, guarantees, options, policyholder behaviour, management decisions), discounted at a risk-free interest rate corresponding to each
1. The Measure of Private Equity Risk in the Solvency II Standard Formula

Term. The risk margin\(^7\) plays the role of an adjustment variable to take into account the possible gap between the average and the reality. It is the cost of the mobilisation of the solvency capital requirement (cost of capital method).

1.3. Assessment of Private Equity Risk according to Solvency II

As this section will show, private equity risk is measured:

- for one, through the impact of a fall of 55% in the value of private equity portfolios (CEIOPS 2010b), net of hedges and risk transfers\(^8\) over the net assets on an insurance company. A symmetric adjustment mechanism (article 106 of the Directive, Official Journal of the European Union, 2009) defined according to the index level at a given moment; plans to modulate the shock of 55% using an adjustment coefficient which varies from +10% to -10%. This adjustment mechanism aims to avoid, in particular, pro-cyclical effects, and
- for another, through its correlation with the risks of publicly traded shares.

As the figure Solvency II modular approach to risks (section I.1.) shows, private equity risk falls into the equity risk sub-module in the market risk module (noted SCR Mkt by CEIOPS), itself correlated to other risks: life underwriting (SCR Life), non-life (SCR NL), health (SCR health), and counterparty (SCR def), in keeping with the Corr SCR\(_{r,c}\) matrix below:

<table>
<thead>
<tr>
<th>Corr SCR(_{r,c})</th>
<th>SCR Mkt</th>
<th>SCR def</th>
<th>SCR life</th>
<th>SCR health</th>
<th>SCR NL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR Mkt</td>
<td>1</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>SCR def</td>
<td>0.25</td>
<td>1</td>
<td>0.25</td>
<td>0.25</td>
<td>0.5</td>
</tr>
<tr>
<td>SCR life</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td>0.25</td>
<td>0</td>
</tr>
<tr>
<td>SCR health</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td>0.25</td>
</tr>
<tr>
<td>SCR NL</td>
<td>0.25</td>
<td>0.5</td>
<td>0</td>
<td>0.25</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: QIS4

1.3.1. Application of a Downwards Shock of 55% to Investments in Private Equity

According to the approach taken by CEIOPS, market risks arise from the level and volatility of the value of financial instruments. They are measured by analysing the impact of changes in four financial variables (interest rates, equity prices, real estate prices, and the level of exchange rates) in six risk sub-modules:

- Interest rate risk, measured by the impact on the net asset value (\(\Delta\)NAV) of the change in the term structure of the risk free rates or of the volatility of risk free rates on the company’s accounts (investments in fixed-rate instruments, interest-rate products, insurance liabilities, and debts) and future liability flows (in correlation with the change to the rate at which they are discounted).
- Equity risk, measured through 1) the idiosyncratic risk linked to inadequate diversification, dealt with in the concentration risk sub-module, 2) systemic risk, which cannot be mitigated by diversification and is thus correlated to the market. It is sensitive to the cycles of the economy, to taxation, to interest rates, to inflation, and so on.
- Property risk makes it possible to calculate the capital charge for possible price changes in real estate markets.
- Currency risk, measured by the change in net asset value (\(\Delta\)NAV) as a result of the greater cost in capital of a rise or fall in the value of all other currencies.

7 - The risk margin is calculated per line of business, net of reinsurance, in the following way: i) calculation of the annual capital required per line of business (not including market risks which are already part of the best estimate), ii) calculation of the cost of mobilisation by multiplying the annual required capital by a cost of capital of 6%, iii) discounting of cash flows at the risk-free rate.

8 - Hedging instruments are allowed only when average protection is afforded over the next year. For example, where an equity option provides protection for the next six months, the determination of the capital requirement should be done assuming that the option covers only half of the current exposure. In addition, hedging programmes other than those in force at the balance sheet date, rolling hedging programmes, for example, are not included.
1. The Measure of Private Equity Risk in the Solvency II Standard Formula

- Spread risk, for the magnitude and volatility of spreads (movements of the yield curve) with respect to the term structure of the risk-free rates. The capital required is measured through the change in net asset value resulting from the more adverse of a rise or fall in credit spreads for each of the relevant assets (bonds, credit structured products, credit derivatives). The shocks are a function of the modified duration and the credit risk rating of those assets.

- Concentration risk, which reflects the risk of additional volatility inherent to portfolios of concentrated assets and the additional risk of falls in value arising from default of an issuer. For the sake of simplicity, QIS 4 restricted the bounds of this sub-module to counterparty risks and thus excludes other forms of concentration risk such as geographic or sector concentration.

These risk sub-modules are aggregated to obtain the solvency capital requirement for the market risk module. The correlation matrix defined in QIS 4 to aggregate the risks is the following:

<table>
<thead>
<tr>
<th>Corr SCR market</th>
<th>Mkt interest</th>
<th>Mkt equity</th>
<th>Mkt property</th>
<th>Mkt fx</th>
<th>Mkt spread</th>
<th>Mkt conc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mkt interest</td>
<td>1</td>
<td>0</td>
<td>0.5</td>
<td>0.25</td>
<td>0.25</td>
<td>0</td>
</tr>
<tr>
<td>Mkt equity</td>
<td>0</td>
<td>1</td>
<td>0.75</td>
<td>0.25</td>
<td>0.25</td>
<td>0</td>
</tr>
<tr>
<td>Mkt property</td>
<td>0.5</td>
<td>0.75</td>
<td>1</td>
<td>0.25</td>
<td>0.25</td>
<td>0</td>
</tr>
<tr>
<td>Mkt fx</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td>0.25</td>
<td>0</td>
</tr>
<tr>
<td>Mkt spread</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Mkt conc</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: QIS4

9. For the Global index there is also an optional approach referred to as a dampener, which is based on the theory that the likelihood of an increase in the value of a stock index is low when this value is high and high when this value is low.

In its report CEIOPS-DOC-70/10 of 29 January 2010 (CEIOPS 2010a), CEIOPS proposes the following correlation matrix for market risk.

With the market risks module defined, it is possible to deal in greater depth with the module for equity risk. In the QIS 4 approach, the regulator classifies equities into two indices:

- Global, which contains equities listed in EEA and OECD countries
- Other, which contains equities listed exclusively in emerging markets, non-listed equity, hedge funds, and other alternative investments.

It is worth noting at this level, that despite the very different intrinsic risks, private equity risk is dealt with here in an aggregate fashion along with the risks arising from investments in shares listed exclusively in emerging markets, hedge funds, and other alternative investments.

<table>
<thead>
<tr>
<th>Interest rate</th>
<th>Equity</th>
<th>Property</th>
<th>Spread</th>
<th>Currency</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest Rate</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>0.5/0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property</td>
<td>0.5/0</td>
<td>0.75</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spread</td>
<td>0.5/0</td>
<td>0.75</td>
<td>0.5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Currency</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Concentration</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Source: CEIOPS-DOC-70/10 of 29 January 2010
1. The Measure of Private Equity Risk in the Solvency II Standard Formula

So, the capital charge for equity risk (including all categories), noted SCR Mkt Equity, is measured by the impact on net asset value (NAV) of two shocks:

- a fall in the Global index (32% in QIS 4 and 45% in discussions currently underway except if the Dampener approach is applied)\(^9\)
- a fall in the Other index (45% in QIS 4 and 55% in discussions currently underway).

The shock scenarios are analysed net of hedges and risk transfers:

\[ \text{SCR Mkt Equity} = \sqrt{\sum_{r,c} \text{CorrIndex}_{r,c} \times \text{Mkt}_r \times \text{Mkt}_c} \]

Where Mkt\(_r\), Mkt\(_c\) are the capital charges for equity risk for each index, as indicated in the columns c and lines r of the of CorrIndex correlation table. The coefficient of correlation of the Global and Other indices is 0.75 (as it was in QIS 4).

<table>
<thead>
<tr>
<th>CorrIndex(\times)</th>
<th>Global</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0.75</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: CEIOPS-Doc-70/10 du 29 January 2010

In view of the controversy arising from its choice on the calibration of risks, CEIOPS published several consultation papers to justify these calculations. The measure of private equity risk was initially justified in consultation paper 69 (CEIOPS 2009a) and again in a document from in CEIOPS-DOC-65/10 of 29 January 2010 (CEIOPS 2010b).

The objective of these two reports is to justify the equity risk calibration chosen by CEIOPS. The calculation of private equity risk is measured by analysing the annual returns of the LPX 50 index (an index made up of listed firms whose main business is management of investments in non-listed firms such as the Blackstone Group and Eurazeo). We will return to the composition of this index in greater detail in section II. The calculation of an empirical 99.5% VaR based on percentiles (CP 69, CEIOPS 2009a, 10) leads to the application of a downwards shock of 68.67% to investments in private equity. Nonetheless, as CEIOPS has chosen to aggregate these risks and those arising from investments in shares listed exclusively in emerging markets, in hedge funds, and in other alternative investments, the overall shock scenario put forward in this document of November 2009 is 60%. This amount was revised on January 29th 2010 (CEIOPS 2010b) to 55% in order to allow for the diversification benefit between the four asset families which make up the “Other” index.

In addition, given the important role played by share price volatility—directly, through investments; indirectly, through the options and guarantees offered in insurance policies—the CEIOPS intends to incorporate an additional equity volatility shock (CP69, CEIOPS 2009a) in the QIS 5.

All the same, in view of the complexity it...
would add to the standard formula, some members of CEIOPS are not in favour of this change.

For each equity category (Global or Other), the capital requirement would be given by the change in net asset value arising from the application of two shock scenarios: one for share price level and one for volatility. The capital requirement would be the greater of:

\[
\text{SCR Mkt vol up} = \Delta \text{NAV} \mid \text{vol \_up, equities \_down}
\]

and

\[
\text{SCR Mkt vol down} = \Delta \text{NAV} \mid \text{vol \_down, equities \_down}
\]

where the scenarios for volatility are set at 60% for the upwards shock and at 15% for the downwards shock as noted in CP69 (CEIOPS 2009a). The upwards shock was revised in January 2010 (CEIOPS-DOC-65/1) and lowered to 50% (CEIOPS 2010b).

The correlations of the shock on the volatility of equities (vol \_up and vol \_down) and the level shock (45% for “Global” and 55% for “Other”) applied would be:

- 0.75 for the upwards shock applied to volatility
- 0 for the downwards shock.

This approach can be summarised in the following graph:
1.3.2. Application of a Coefficient of Correlation of 0.75 for Returns on Listed and Non-Listed Investments

As we mentioned in section I.2, as the property of sub-additivity is not respected when the measure of VaR is taken, CEIOPS put in place several correlation matrices. For investments in private equity, it settled on a correlation of 0.75 between the Global index (shares listed in the EEA and in OECD countries) and the Other index (shares listed exclusively in emerging markets, non-listed shares, hedge funds, and other alternative investments).

In the document published in January 2010 (CEIOPS 2010b), the calibration of the correlation of the Global and Other indices was justified by a study of the coefficients of the correlation of the distribution tails of the MSCI World index price and the specific indices for each asset class included in the Other index.

The results obtained are the following:

<table>
<thead>
<tr>
<th>Equity Type</th>
<th>Index</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Equity</td>
<td>LPX50 Total Return</td>
<td>83.59%</td>
</tr>
<tr>
<td>Commodities</td>
<td>S&amp;P GSCI Total Return Index</td>
<td>44.72%</td>
</tr>
<tr>
<td>Hedge Funds</td>
<td>HFRX Global Hedge Fund Index</td>
<td>77.31%</td>
</tr>
<tr>
<td>Emerging Markets</td>
<td>MSCI Emerging Markets BRIC</td>
<td>-52.82%</td>
</tr>
</tbody>
</table>

Source: CEIOPS-DOC-65/1, CEIOPS 2010b

It is worth noting that the return on the LPX50 and that of the MSCI World have a correlation of 83.59%. The approach taken by CEIOPS to studying the correlation of investments in private equity and those in shares listed in EEA and OECD countries is, as it happens, the subject of section II.
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula

The aim of this section is to show that the measure of private equity risk adopted by CEIOPS, a measure that relies on the LPX50, can, to some extent, be called into question, even if only for the choice of this index. After having analysed the characteristics of the LPX50 and shown the drawbacks of this choice (section 2.1.), we will propose, in section 2.2., another approach to the measurement of performance and risk, an approach founded on the private equity funds from the Thomson One database (the sample of the study is described in section 2.3.) Section 2.4. will deal with the correlation of the returns on investments in private equity and in listed shares.

2.1. The Drawbacks of the LPX50 as a Benchmark for Private Equity

The LPX50, an index calculated since 31 December 1985, is defined on the basis of the stock prices of the fifty largest listed private equity firms in the world. For a firm to be eligible, it must meet certain conditions:

- its main business must be private equity, which must account for at least 50% of the firm's net assets
- the firm must be listed on an exchange
- it must meet certain liquidity conditions, checked twice a year: a maximum bid-ask spread (BAS), an average minimum market capitalisation (MV in €mn), a minimum transaction volume per working day (TV), expressed as a percentage of market capitalisation, a minimum of continuity of transactions (CT), and a minimum number of price observations (OB) on the exchange.

The LPX index is split into regions and into financing and investment styles. The value of each LPX index is calculated and published daily on the basis of the closing prices of the component firms. By way of illustration, the table below shows the value of the liquidity ratios for each index in March 2010.

The A or B ranking is an additional variable that indicates whether the private equity firms in the index were ranked by market capitalisation (A) or by average transaction volume on the basis of daily prices over the preceding year (B).

<table>
<thead>
<tr>
<th>Index</th>
<th>BAS</th>
<th>MV</th>
<th>TV</th>
<th>CT</th>
<th>OB</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPX50</td>
<td>3.0%</td>
<td>80</td>
<td>0.05%</td>
<td>80%</td>
<td>150</td>
<td>A</td>
</tr>
<tr>
<td>LPX Major Market</td>
<td>1.5%</td>
<td>150</td>
<td>0.08%</td>
<td>98%</td>
<td>150</td>
<td>B</td>
</tr>
<tr>
<td>LPX Buyout</td>
<td>1.5%</td>
<td>150</td>
<td>0.08%</td>
<td>95%</td>
<td>150</td>
<td>B</td>
</tr>
<tr>
<td>LPX Composite</td>
<td>4.0%</td>
<td>20</td>
<td>0.03% / 0.06%</td>
<td>75%</td>
<td>150</td>
<td>A</td>
</tr>
<tr>
<td>LPX Europe</td>
<td>2.5%</td>
<td>80</td>
<td>0.10%</td>
<td>95%</td>
<td>150</td>
<td>B</td>
</tr>
<tr>
<td>LPX America</td>
<td>4.0%</td>
<td>50</td>
<td>0.08%</td>
<td>80%</td>
<td>150</td>
<td>B</td>
</tr>
<tr>
<td>LPX Venture</td>
<td>4.0%</td>
<td>20</td>
<td>0.06%</td>
<td>75%</td>
<td>150</td>
<td>B</td>
</tr>
<tr>
<td>LPX Direct</td>
<td>1.5%</td>
<td>150</td>
<td>0.10%</td>
<td>95%</td>
<td>150</td>
<td>A</td>
</tr>
<tr>
<td>LPX Indirect</td>
<td>4.0%</td>
<td>20</td>
<td>0.06%</td>
<td>75%</td>
<td>150</td>
<td>A</td>
</tr>
<tr>
<td>LPX UK</td>
<td>4.0%</td>
<td>20</td>
<td>0.06%</td>
<td>75%</td>
<td>150</td>
<td>A</td>
</tr>
<tr>
<td>LPX Mezzanine</td>
<td>2.5%</td>
<td>150</td>
<td>0.08%</td>
<td>95%</td>
<td>150</td>
<td>B</td>
</tr>
</tbody>
</table>

* a different values for entering/leaving the index
Source: LPX Guide to LPX Equity Indices March 2010 (LPX, 2010a)
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula

The LPX50 is relatively well diversified geographically, but, as the table below, from 26 February 2010, shows, it is made up primarily of companies that invest in leveraged buyouts.

### Characteristics: LPX50TR – basis: 26/02/2010

**Currencies**

<table>
<thead>
<tr>
<th>Currency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD</td>
<td>33.9%</td>
</tr>
<tr>
<td>EUR</td>
<td>19.7%</td>
</tr>
<tr>
<td>GBP</td>
<td>16.7%</td>
</tr>
<tr>
<td>SEK</td>
<td>9.5%</td>
</tr>
<tr>
<td>CHF</td>
<td>8.8%</td>
</tr>
<tr>
<td>CAD</td>
<td>6.5%</td>
</tr>
<tr>
<td>JPY</td>
<td>5.5%</td>
</tr>
<tr>
<td>BRL</td>
<td>4.5%</td>
</tr>
<tr>
<td>HKD</td>
<td>1.4%</td>
</tr>
</tbody>
</table>

**Regions**

<table>
<thead>
<tr>
<th>Region</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe ex UK</td>
<td>43.8%</td>
</tr>
<tr>
<td>North America</td>
<td>34.6%</td>
</tr>
<tr>
<td>UK</td>
<td>16.7%</td>
</tr>
<tr>
<td>Asia/Pacific</td>
<td>3.4%</td>
</tr>
<tr>
<td>South America</td>
<td>1.4%</td>
</tr>
</tbody>
</table>

**Private Equity Investment Styles**

<table>
<thead>
<tr>
<th>Style</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buyout</td>
<td>93.1%</td>
</tr>
<tr>
<td>Venture</td>
<td>5.5%</td>
</tr>
<tr>
<td>Growth</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

* Index market Capitalisation in EUR

### Attribution of Index Performance

- Price Effect: 2.3%
- Currency Effect: 0.8%
- Dividend Effect: 0.0%

### Largest Companies in the Index

- 3I Group plc
- Ratos AB
- Eurazeo S.A.
- Partners Group Holding AG
- Onex Corporation SV
- The Blackstone Group LP
- Wendel S.A.
- KKR & Co. (Guernsey) LP
- Apollo Investment Corporation
- Ares Capital Corporation

Source: LPX Newsletter February 2010 (LPX, 2010b)

In view of the definition of the LPX50, it is possible to call into question the notion that this index is truly representative enough to measure the regulatory capital required of insurance companies for their investments in private equity funds. In other words, does investing directly in listed firms involved primarily in private buyouts, such as Blackstone and Eurazeo, pose the same risks as investing in private equity funds or funds of funds?

Firstly, we note that the LPX50 index is not representative of investments of European insurance companies. It overweights “buyout” and “United States” categories. For instance, according to AFIC, the asset allocation to private equity in the portfolios of French insurance companies would be the following:

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venture Europe</td>
<td>81%</td>
</tr>
<tr>
<td>Buyout Europe</td>
<td>9%</td>
</tr>
<tr>
<td>Venture US</td>
<td>9%</td>
</tr>
<tr>
<td>Buyout US</td>
<td>1%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: EDHEC Business School
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula

Secondly, the non-liquid contractual nature of investments in private equity cannot be reflected in an index of publicly-traded shares such as the LPX50.

Finally, it is our belief that, as a result of the underlying investments, the LPX50 poses an idiosyncratic risk that is added to the risk of investment in private equity. According to Markowitz's modern portfolio theory (1952), the total risk of a security or of a portfolio is the sum of two components: systematic or market risk and specific or idiosyncratic risk.

Systematic risk stems from economic or market fluctuations such as recessions, budget deficits, inflation, interest rate swings, unemployment rates, and so on. All securities are exposed to this risk, which cannot be diversified away.

Specific or idiosyncratic risk, on the contrary, is the risk associated with each security individually, that is, independent of phenomena that affect the market as a whole. Idiosyncratic risk arises solely from elements that affect securities specifically. For example, profit visibility, development perspectives, and the management quality of a company that is part of the LPX50 constitute idiosyncratic risks – additional to the risks incurred by private equity funds of funds that are part of insurance companies’ portfolios.

Nonetheless, ceasing to use an index of publicly-traded shares to measure the risk of investment in private equity and its correlation with an investment in an index of companies listed in EEA and OECD countries would have the major drawback of rendering impossible classic approaches to the calculation of returns and to the measure of the correlation of the two indices of listed firms. It is thus necessary to define (section 2.2.) another measure of return that can be compared to that of an investment in an index of listed firms.

2.2. The Definition of a Performance Measure of a Listed Stock Comparable to that of Private Equity

Traditionally, the return on an investment, in particular when it is listed, is measured with a time-weighted rate of return (TWR). The geometric mean of the so-called holding period returns (HPR):

\[ HPR = \frac{(MV_1 - MV_0 + D_1)/MV_0}{HPR} \]

where \( MV_0 \) is initial market value, \( MV_1 \) final market value, and \( D_1 \) dividends or interest paid over the holding period.

TWR, then, the time-weighted return over a holding period defined by N time intervals is thus calculated:

\[ TWR = (1+HRP_1)(1+HRP_2)(1+HRP_3)\ldots(1+HRP_N) - 1 \]

Another classic performance measure is the internal rate of return (IRR), which corresponds to the rate of return at which the net present value is zero:

\[ \sum_{t=0}^{T} CF_t (1 + IRR)^{-t} = 0 \]

where \( T \) is the lifetime of the portfolio and the \( CF_t \) are the flows earned in period \( t \). Unlike the TWR, the IRR is highly sensitive to the timing and the size of the flows, which makes it the favoured means of gauging the performance of an investment.
in a private equity fund, characterised by irregular inflows and outflows. With respect to the formulation of the IRR, there is an implicit hypothesis that outflows are reinvested at the IRR.

The aim of this report is to estimate the correlation of the return on an investment in an index of listed firms and that on an investment in non-listed assets. Given the inflows and outflows characteristic of private equity, it is necessary to build a measure comparable to an equivalent investment in publicly traded markets. The comparison can be made by expressing the holding period of an investment over several years in private equity through the equivalent of a purchase of listed shares over the same periods. The distribution flows from an investment in private equity can then be expressed in a manner equivalent to a sale of securities at the same dates.

To do so, three academic approaches, taken by private equity professionals, have been devised:

- the index comparison method (ICM) from Long and Nickels (1996)
- the public market equivalent (PME) from Kaplan and Schoar (2003)
- the public market equivalent + method (PME+) from Rouvinez (2003a, 2003b).

1) The Index Comparison Method (ICM) from Long and Nickels (1996)

At the outset, the idea is to calculate the IRR of a portfolio of private equity by calculating the return per asset, vintage year, or the portfolio as a whole, by including the negative and positive signs of inflows and outflows.

The rate of return comparable for the index of publicly traded assets is defined by replicating the inflows to and outflows from private equity funds. To do so, at each date where an inflow or outflow is reported, a purchase or sale of listed securities is completed to duplicate each inflow or outflow, all while having these flows invested at the return of the publicly traded index. At the end of the period, the final flow resulting from the return on the publicly traded index and from the inflows and outflows makes it possible to determine the internal rate of return of this investment equivalent.

To illustrate our comments, we take the example used by Long and Nickels (1996) presented in the table next page. The benchmark is the S&P 500. The final value of the replicating portfolio (USD173.9m) is obtained by applying the returns on the index to the flows of a private equity fund. This value allows the IRR of the replicating portfolio to be calculated (2.09%). This IRR is then comparable to the true IRR of the private equity fund (3.18%). In this example, the private equity fund outperformed the publicly traded stock market.


To determine a performance measure for a listed stock comparable to that of an investment in private equity, Kaplan and Schoar (2003) chose to answer a different question to that of Long and Nickels (1996). They aimed at defining the amount that must be invested in the public market to generate the same return that an investment of one euro (discounted value) could generate in a private equity fund.
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula

The PME is thus calculated in the following way:

\[ PME = \frac{\sum_{t=1}^{T} f_t \prod_{s=t+1}^{T} (1 + R_{ts})}{\prod_{t=1}^{T} (1 + R_{ts})} \]

\( R_{it} \) is the return on the index of publicly traded stock for period \( t \), \( f_t \) the positive flows of the fund normalised for period \( t \). The normalisation of the positive flows is done by dividing each of the positive flows accumulated at period \( t \) by the present value of all investments (negative flows).

In this way, all flows are normalised to an initial investment with a present value of one euro.

One of the drawbacks of this PME approach (like that of Long and Nickels) appears when the performance of the private equity portfolio is better than that of the index and the final value of the equivalent investment in the index is negative. Indeed, the comparison of a long position in private equity and a short position in the index leads

---

### Table: Performance Measurement Ratio (PME) Calculations

<table>
<thead>
<tr>
<th>Period</th>
<th>Cash USD M</th>
<th>S&amp;P Return</th>
<th>Private Equity Index based on the performance</th>
<th>Cash USD M</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>5</td>
<td>105.0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>-</td>
<td>394.5</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>-</td>
<td>335.3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>20</td>
<td>402.4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>270</td>
<td>-</td>
<td>92.2</td>
<td>270</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>5</td>
<td>96.8</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>15</td>
<td>111.3</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>25</td>
<td>139.1</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>200</td>
<td>25</td>
<td>173.9</td>
<td>174</td>
</tr>
<tr>
<td>IRR</td>
<td>3.18</td>
<td></td>
<td>2.09</td>
<td></td>
</tr>
</tbody>
</table>

Source: Long et Nickels (1996)

---

Cash flow pattern from Thomson Venture Economic’s database for all vintage year 1985 funds (blue bars) and corresponding PME based on the S&P 500 total return index (gray bars) as per September 30, 2002.

Source: Rouvinez (2003a)
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula

To a mistaken PME (see box). The internal rate of return may then not exist, as Rouvinez (2003a) shows. In this case, the measure of correlation is not easily interpreted.

To avoid these negative net present values at period end, Rouvinez (2003b) devised a method, known as PME+, derived from the PME.

3) The Public Market Equivalent + (PME+) of Rouvinez (2003b)
This approach uses exactly the same framework as that of the PME approach developed by Kaplan and Schoar (2003), except that it overcomes its drawbacks by modulating the flows distributed by the private equity fund corresponding to outflows from the public index, so that an

The Drawbacks of the ICM and the PME:
The public market equivalent (PME) is a measure based on flows (investments and distributions) as well as on net asset value (NAV). Long and Nickels (1996) have shown that when they resorted to the ICM or the PME, for certain vintage years, the investment in private equity could have a positive net asset value, whereas the equivalent investment in the benchmark could result in a negative final benchmark value. In this case, to distribute the same amounts as those distributed by the private equity fund, an investor in the benchmark index is obliged to go short the index. Depending on the characteristics of the flows, some vintages may even have an indefinite rate of return. Rouvinez (2003a) reaches the same conclusion and even shows that in his sample more than one private equity vintage year in five has an equivalent investment in a stock market index (S&P 500) that results in a short position, some of which have an indefinite internal rate of return.

To illustrate the limitations of the IRR, let us take the following two examples:
1. Indefinite internal rate of return
Let the series of flows be: $F_{L0} = -50$, $F_{L1} = +100$ and $F_{L2} = -75$
The following equation yields the internal rate of return $IRR$:
$$-50 + \frac{100}{(1+IRR)^1} - \frac{75}{(1+IRR)^2} = 0$$
This equation has no solution in $IRR$, which means that this series of flows yields no internal rate of return.

2. Existence of several internal rates of return IRR
Let the series of flows be: $F_{L0} = -40$, $F_{L1} = +250$ and $F_{L2} = -250$
The following equation yields the internal rate of return $IRR$:
$$-40 + \frac{250}{(1+IRR)^1} - \frac{250}{(1+IRR)^2} = 0$$
The solutions for $IRR$ are 25% and 400%. Which should be taken?

So the PME does not make it possible to study the correlation of indices of publicly traded shares and non-listed shares. So as not to take short positions in the benchmark and avoid problems with the calculation of the IRR, Rouvinez (2003b) proposed the PME+ method.
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula

amount greater than the amount held in the public index will not have to be sold. To do so, it defines in a conventional way a scale factor to apply to the entirety of the flows distributed.

Let \( C_i \) be the capital investments, \( D_i \) the flows distributed, \( I_i \) the value of the index at period \( i \in [0, ..., N] \), \( S_+ \), \( S_- \) the sum of inflows to and outflows from the index with respect to the value of the index \( I_i \), and NAVN the residual value of the net assets, such that:

\[
S_+ = \sum_{i=0}^{N} \frac{C_i}{I_i}
\]

\[
S_- = \sum_{i=0}^{N} \frac{D_i}{I_i}
\]

\[
S_N = \frac{NAV_N}{I_N}
\]

One infers:

\[
S_+ - \lambda \cdot S_- = S_N
\]

The scale factor is thus expressed:

\[
\lambda = \frac{(S_+ - S_N)}{S_-}
\]

With respect to the previous figure for the PME, the PME+ approach can be illustrated in the following fashion:

Contrary to the European regulator, as for the reasons mentioned in section 2.2, we chose not to use the LPX50 listed index as a reference for the performance of private equity investments of European insurers. Therefore, it is not possible to apply the classic approach based on the comparison of listed indices’ financial returns. Section 2.2 presented three approaches, based on academic research, generally used by professionals in the private equity sector. We have shown the drawbacks of ICM and PME. We will therefore use the PME+ approach for simulations in the rest of our study.

Prior to measuring the correlation between the performance of a portfolio of private equity and that of listed shares, it is necessary to define an adequate sample of data.

2.3. The Sample of Private Equity Funds

In order to study the performance of a private equity portfolio and to suggest an...
alternative to the LPX50 index, our study uses the Thomson One database, which is the reference database in this subject. It presents information for private equity funds reported voluntarily by private equity funds (general partnerships) and their individual investors (limited partnerships). The latter are institutional investors or wealthy individuals who are offering their capital to private equity firms.

The principle of a private equity investment is the following. Investors provide capital to private equity firms. In general, these firms have a period of about five years to invest this capital; they then divest gradually over the next five to seven years. The Thomson one database contains information having to do with the timing (date when an inflow or outflow is registered) and the size of the flows, the residual net asset value (NAV), the size of the funds, the vintage years, the types of funds (venture, buyout, mezzanine), and liquidation status (liquidated or not). Added to this information are performance measures such as the internal rate of return, the ratio of cumulative total value to paid-in capital, and the ratio of distributed total value to paid-in capital. The measures of performance and flows are reported net of management fees and carried interest.

The calculation of the IRR is based on the series of inflows and outflows and possibly on the end value of the portfolio. So, if the fund has not been liquidated, it is necessary to extrapolate the outflows over the lifetime of the fund. Given the underlying of private equity, this exercise seems highly questionable. The convention to assess the historical performance of private equity investments is thus to take only funds that have been liquidated and closed.

So we have taken the set of liquidated and closed funds over the period from 1980 to 2009, in European and North American markets, to reflect the make-up of the private equity portfolios of European insurers. As the table below shows, our sample is made up of 1,120 liquidated and closed private equity funds, European and American, over the period of 1980 to 2009.

These funds are divided into sixty-nine vintage years. Three quarters of the 1,120 funds are from the United States and 70% are venture funds.

It should be kept in mind that, although taking only liquidated funds makes it possible not to have to extrapolate future outflows, it reduces the size of the sample by a considerable amount (as of the

<table>
<thead>
<tr>
<th>Market</th>
<th>Type of fund</th>
<th>Number of funds</th>
<th>% of market</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>Venture</td>
<td>620</td>
<td>73%</td>
<td>55%</td>
</tr>
<tr>
<td></td>
<td>Buyouts + mezzanine</td>
<td>229</td>
<td>27%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>849</td>
<td>100%</td>
<td>76%</td>
</tr>
<tr>
<td>Europe</td>
<td>Venture</td>
<td>164</td>
<td>61%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Buyouts + mezzanine</td>
<td>107</td>
<td>39%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>271</td>
<td>100%</td>
<td>24%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1120</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: EDHEC Business School, Thomson One
vintage years 2000 for US venture funds, 1997 for European buyout funds, 1999 for US buyout funds, Thomson shows no more liquidated funds). Moreover, there is a performance bias, as the performance of private equity in recent years is underrepresented.

A method to control in part for this bias and to increase the size of the sample by including more recent, non-liquidated funds was proposed by Kaplan and Schoar (2003). The choice of these funds is based on the study of the correlation of the internal rates of return IRR(NAV) calculated by using the net asset value of last period as the market value and internal rate of return IRR(CF) calculated only from the cumulative flows. Kaplan and Schoar (2003) thus increased the size of their sample by including non-liquidated funds that were more than five years old, given that the correlation of IRR(NAV) and IRR(CF) for these funds was 0.9. All the same, a high correlation does not necessarily lead to identical internal rates of return IRR.

Kaserer and Diller (2004), for example, have shown that, despite this high correlation, over the two or three years of the life of the fund IRR(NAV) and IRR(CF) were considerably different.

To avoid this problem, Kaserer and Diller (2004), have suggested taking only those funds whose net asset value (considered the last flow in the calculation of the IRR(NAV)) is weaker than the sum, in absolute terms, of positive and negative flows:

\[
\frac{RN_{AV_N}}{\sum_{t=0}^{N} |CF_t|} \leq q
\]

where \(RN_{AV_N}\) is the residual net asset value at the end of period \(N\) and \(q\) is an arbitrarily defined parameter. In Kaserer and Diller’s (2004) study, this parameter was set first at 10\% and then at 20\%.

We were unable to take this approach with our sample of funds, as the Thomson One database, for obvious reasons of confidentiality, would not provide us with data for individual funds.

Our sample thus encompasses the set of 1,120 liquidated and closed private equity funds, European and American, venture, buyout, and mezzanine, that voluntarily reported their inflows and outflows from the years 1980 to 2009 to the Thomson One database.

2.4. Study of the Correlation of the Performance of a Portfolio of Private Equity and that of Listed Shares

As we have noted in the preceding sections, comparison of the performance of private equity and that of an index of listed stocks requires an approach different from commonly used when the stocks are listed, an approach based on returns on the assets.

For each of 1,120 funds broken down into sixty-nine vintages, we must compare the performance of the private equity funds through the inflows, the outflows, and the net asset value defined at fund liquidation. By way of illustration, we present the net quarterly flows for venture private equity in Europe for the vintage year 1994 and the MSCI Europe index over the period.
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula

As mentioned above (section 2.2.), the comparison of performance is not direct, so for each of the sixty-nine vintage years the internal rate of return of the private equity funds (by geographical zone and type of investment, i.e., venture, buyout, or mezzanine) and the equivalent of this investment in an index of listed shares (PME and PME+) must be determined.

By way of illustration, the PME approach for the 1994 vintage venture private equity funds for Europe is shown in the figure below. By design, inflows and outflows are equal; only net asset value is different, which will lead to a different internal rate of return.

When the PME indicator is determined for each of the sixty-nine vintages, some net asset values at liquidation corresponding to an equivalent investment in the MSCI are negative, leading to problems with determining the internal rate of return of this equivalent investment (see the box on the drawbacks of the ICM and the PME). The figure below shows the vintage year 1998 venture Europe.
As explained in section II.2, we applied the PME+ approach to the sixty-nine vintage years to correct this problem, generating for the equivalent investment a net asset value (NAV) equal to that generated by the private equity investment.

When the entire set of the performances of the sixty-nine private equity vintages of our samples as well as that of the equivalent investments in an MSCI index of listed shares in keeping with the PME and the PME+ approaches were calculated, the measurement of the correlation could be done.

To estimate the coefficient of correlation of the returns on an investment in the MSCI index and those on an investment in private equity, we rely on several methods. We took the three following measures of correlation (their characteristics are described in appendix 1):

- Pearson correlation
- Spearman’s rank correlation coefficient
- Kendall’s rank correlation coefficient.

1) Pearson correlation
For each pair \((x,y)\) we calculate the correlation coefficient defined by:

\[
\rho_{x,y} = \frac{\text{Cov}(x,y)}{\sqrt{\text{Var}(x)\text{Var}(y)}}
\]

where \(\text{Cov}(x,y)\) is the covariance of the variables \(x\) and \(y\), \(\text{Var}(x)\) the variance of the variable \(x\), and \(\text{Var}(y)\) the variance of the variable \(y\).

Because of the small number of observations (see appendix 1), this indicator is not very robust; for this reason, we use more suitable approaches, such as those of Spearman and Kendall, which rely on rank statistics, which are
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula

less sensitive to the distribution of the values in the sample of small size.

2) Spearman's rank correlation coefficient

This test makes it possible to determine the existence of links between two quantitative variables X and Y, when the number of observations is too small to use the linear correlation coefficient. From there, one replaces the values with their rank by creating new variables X' and Y' and one determines the correlation coefficient r':

\[
r' = 1 - \frac{6 \sum (Y_i' - X_i')^2}{n(n^2 - 1)}
\]

3) Kendall rank correlation coefficient

This is another correlation measure of two variables X and Y based on ranks while creating new variables X' and Y'. The Kendall rank coefficient is defined by:

\[
\tau = \frac{2S}{n(n-1)}
\]

Where n is the number of observations and S, after ordering X', is the difference between the number of concordant pairs (observations where Y'j > Y'i) and the number of discordant pairs (where Y'j < Y'i).

The results obtained are presented in the following section.

Summary of results

The first table below shows the results of the correlation of the private equity performance and that of an equivalent investment determined according to the PME approach (IRR PME). The second table shows the results of the correlation of private equity performance (IRR PE) and that of an equivalent investment determined according to the PME + approach (IRR PME+).

When a return measure such as PME is used, the correlation is generally higher than the 0.75 selected by CEIOPS. Nevertheless, due to the drawbacks inherent in this return measure (non-existent or multiple IRR, see box in section 2.2.), these results cannot be used to assess the correlation of private equity performance with that of listed shares.

When we base the return comparison on the IRR PME+ measure, the correlation obtained, and that for the different available methods, is lower than 0.75. As shown in the table above, the robust confidence interval at 95% does not contain the value of 0.75 for venture US and venture Europe portfolios which represent 70% of the 1120 private equity funds in our sample (see table in section 2.3.).

<table>
<thead>
<tr>
<th>Results of the correlation of IRR private equity and IRR PME+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation estimations with PME</td>
</tr>
<tr>
<td>Type</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Buyout Europe</td>
</tr>
<tr>
<td>Buyout US</td>
</tr>
<tr>
<td>Venture Europe</td>
</tr>
<tr>
<td>Venture US</td>
</tr>
</tbody>
</table>

Source: EDHEC Business School
To better reflect the investments of European insurance companies, our proposal is to aggregate the four families of private equity (two geographic zones coupled with two types of investments: buyout and venture) into one portfolio. The allocation proposed is as follows: 81% invested in buyout funds in Europe, 9% in venture funds in Europe, 9% in buyout funds in the United States and 1% in venture funds in the United States (estimations from AFIC).

The creation of this aggregated portfolio implies allowing for eventual correlations of the four families of private equity. To do so, we redefined the investment flows per vintage year and per period for each of the four families, based on a pre-defined weighting of an insurance company’s model portfolio (81% in Europe buyout, 9% in venture Europe, 9% in buyout US and 1% in venture US).

The new model portfolio so defined, we proceeded as previously to the calculation of the internal rate of return IRR for private equity and of the comparable measure on the listed share market, PME+, for each vintage year of the aggregated model portfolio:

### Table: Correlation of IRR Private Equity and IRR PME+

<table>
<thead>
<tr>
<th>Type of measure</th>
<th>Pearson</th>
<th>Spearman</th>
<th>Kendall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vintage Europe</td>
<td>0.66186</td>
<td>0.174519</td>
<td>0.888743</td>
</tr>
<tr>
<td>Vintage US</td>
<td>0.54457</td>
<td>0.085696</td>
<td>0.812540</td>
</tr>
<tr>
<td>Venture Europe</td>
<td>-0.08169</td>
<td>-0.516726</td>
<td>0.386875</td>
</tr>
<tr>
<td>Venture US</td>
<td>0.13688</td>
<td>-0.325350</td>
<td>0.546308</td>
</tr>
</tbody>
</table>

Source: EDHEC Business School

This result table shows that the correlation (Kendall’s tau) of investments in private equity (the four families aggregated) and those in listed markets is only 0.30. This is explained on the one hand by the weight in the portfolio of buyout European funds (81%) which have a correlation of 0.54 and on the other hand by the negative correlations between Europe and the United States as shown in the two tables next page.

Again here, the results show that private equity performance is significantly less correlated to that of listed equity markets than the CEIOPS selected correlation coefficient of 0.75 assumes.
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula

<table>
<thead>
<tr>
<th>Variable</th>
<th>With variable</th>
<th>N</th>
<th>Correlation estimates</th>
<th>Confidence interval at 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venture Europe IRR</td>
<td>Buyout Europe IRR</td>
<td>21</td>
<td>0.57416</td>
<td>0.189425 - 0.806060</td>
</tr>
<tr>
<td>Venture Europe IRR</td>
<td>Venture US IRR</td>
<td>21</td>
<td>0.32005</td>
<td>-0.129531 - 0.660485</td>
</tr>
<tr>
<td>Venture Europe IRR</td>
<td>Buyout US IRR</td>
<td>21</td>
<td>0.23033</td>
<td>-0.223587 - 0.602146</td>
</tr>
<tr>
<td>Venture Europe IRR</td>
<td>Venture Europe PME +</td>
<td>21</td>
<td>0.32080</td>
<td>-0.128716 - 0.660952</td>
</tr>
<tr>
<td>Venture Europe IRR</td>
<td>Venture US PME +</td>
<td>21</td>
<td>0.16288</td>
<td>-0.289139 - 0.555505</td>
</tr>
<tr>
<td>Venture Europe IRR</td>
<td>Buyout US PME +</td>
<td>21</td>
<td>0.40586</td>
<td>-0.031324 - 0.712676</td>
</tr>
<tr>
<td>Buyout Europe IRR</td>
<td>Venture US IRR</td>
<td>21</td>
<td>0.16485</td>
<td>-0.287279 - 0.556907</td>
</tr>
<tr>
<td>Buyout Europe IRR</td>
<td>Buyout US IRR</td>
<td>21</td>
<td>0.21780</td>
<td>-0.236081 - 0.593671</td>
</tr>
<tr>
<td>Buyout Europe IRR</td>
<td>Venture Europe PME +</td>
<td>21</td>
<td>0.30098</td>
<td>-0.150226 - 0.648418</td>
</tr>
<tr>
<td>Buyout Europe IRR</td>
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<td>0.80759</td>
<td>0.577099 - 0.918920</td>
</tr>
<tr>
<td>Buyout Europe IRR</td>
<td>Venture US PME +</td>
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<td>0.41137</td>
<td>-0.024702 - 0.715522</td>
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<tr>
<td>Buyout Europe IRR</td>
<td>Buyout US PME +</td>
<td>21</td>
<td>0.51837</td>
<td>0.111676 - 0.776335</td>
</tr>
<tr>
<td>Venture US IRR</td>
<td>Buyout US IRR</td>
<td>21</td>
<td>-0.08132</td>
<td>-0.495607 - 0.363116</td>
</tr>
<tr>
<td>Venture US IRR</td>
<td>Venture Europe PME +</td>
<td>21</td>
<td>-0.01547</td>
<td>-0.460109 - 0.402380</td>
</tr>
<tr>
<td>Venture US IRR</td>
<td>Buyout Europe PME +</td>
<td>21</td>
<td>0.41250</td>
<td>0.001000 - 0.728224</td>
</tr>
<tr>
<td>Venture US IRR</td>
<td>Venture US PME +</td>
<td>21</td>
<td>0.33016</td>
<td>-0.118400 - 0.666811</td>
</tr>
<tr>
<td>Venture US IRR</td>
<td>Buyout US PME +</td>
<td>21</td>
<td>0.16017</td>
<td>-0.291681 - 0.553583</td>
</tr>
<tr>
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<td>0.76832</td>
<td>0.503696 - 0.901127</td>
</tr>
<tr>
<td>Buyout US IRR</td>
<td>Buyout Europe PME +</td>
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<td>0.27162</td>
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<tr>
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<td>0.27430</td>
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<td>Buyout US PME +</td>
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<td>0.79804</td>
<td>0.558885 - 0.914631</td>
</tr>
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<td>Buyout US PME +</td>
<td>Buyout Europe PME +</td>
<td>21</td>
<td>0.35353</td>
<td>-0.092236 - 0.681247</td>
</tr>
<tr>
<td>Buyout US PME +</td>
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</tr>
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<tr>
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<td>Buyout US PME +</td>
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<td>0.55995</td>
<td>0.169154 - 0.798598</td>
</tr>
<tr>
<td>Buyout US PME +</td>
<td>Buyout US PME +</td>
<td>21</td>
<td>0.61348</td>
<td>0.247275 - 0.826327</td>
</tr>
<tr>
<td>Venture US PME +</td>
<td>Buyout US PME +</td>
<td>21</td>
<td>0.52784</td>
<td>0.124526 - 0.781461</td>
</tr>
</tbody>
</table>

Source: EDHEC Business School

| Kendall’s tau correlation coefficient of the 4 categories of private equity (N = 21) |
|----------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 1.00000 | 0.44095 | 0.34845 | 0.08717 | 0.22488 | 0.25637 | 0.16706 | 0.28089 |
| 0.44095 | 1.00000 | 0.19437 | 0.11418 | 0.15382 | 0.62637 | 0.31714 | 0.38404 |
| 0.34845 | 0.19437 | 1.00000 | -0.15461 | -0.04296 | 0.33760 | 0.36754 | 0.61990 |
| 0.08717 | 0.11418 | -0.15461 | 1.00000 | 0.60053 | 0.23873 | 0.20292 | 0.62745 |
| 0.22488 | 0.15382 | -0.04296 | 0.60053 | 1.00000 | 0.33840 | 0.36754 | 0.61990 |
| 0.25637 | 0.62637 | 0.33760 | 0.23873 | 0.33840 | 1.00000 | 0.46036 | 0.52936 |
| 0.28089 | 0.34804 | 0.05798 | 0.62745 | 0.20292 | 0.36754 | 0.46036 | 1.00000 |

Source: EDHEC Business School
2. On the Suitability of the Calibration of Private Equity Risk in the Solvency II Standard Formula
The Solvency II risk-based approach is a breakthrough in the perception and measurement of risks compared to the existing system, Solvency I. Yet, the standard formula calibrations and correlation should not be taken lightly (see appendix 2). Their effects are several, on policyholders and daily management of insurance companies (asset management, liability management, asset/liability management, hedging, the products offered to policyholders (guarantees and options), shareholders’ equity, and equity equivalents, governance) as well as on the financing of health, retirement or on many sectors of activity through liability (construction, medicine) or directly on their activity (real estate and private equity).

According to AFIC, private equity in France is financed up to 20% by insurance companies. In Europe, many insurers think that the current calibration is likely to halt their investments in this asset class. The capital requirements for this type of assets are considered prohibitive.

This publication studies the calibration of the correlation coefficient of private equity performance and that of listed equity. In the last impact study QIS 4 (QIS4 2008), the CEIOPS proposed a correlation coefficient of 0.75 which was maintained in the document CEIOPS-DOC-65/10 published in January 2010 (CEIOPS 2010b). The CEIOPS justified its choice by the study of the correlation of the LPX50 index and the MSCI World index which resulted in a coefficient of 83.59%. In the end, as the CEIOPS has chosen to deal with private equity, shares listed exclusively in emerging markets, hedge funds, and other alternative investments in one asset class, the correlation coefficient kept for these type of investments was 0.75.

As a first conclusion, this publication shows that the measure of private equity risk adopted by CEIOPS, a measure that relies on the LPX50 index, can be called into question. In fact, this index defined on the basis of the stock prices of the fifty largest listed private equity firms in the world, poses an idiosyncratic risk that is added to the risk of investment in private equity. In order to correct this drawback, our proposal is to directly retain the performance of private equity funds from the Thomson One database. Our sample is made up of 1,120 liquidated and closed private equity funds, European and American, over the period of 1980 to 2009. These funds are divided into sixty-nine vintage years. Three quarters of the 1,120 funds are from the United States and 70% are venture funds.

Lacking continuous quoted prices as for the LPX50 index, it was necessary to determine the performances of private equity and equivalent investments in the listed equity market. In accordance with the practices of the private equity industry and academic approaches, we have calculated the internal rates of return (IRR) of private equity funds by vintage year, geographic zone, as well as the Public Market Equivalent Plus measure (PME +) for the listed equity market. The correlation measures analysed were the Pearson coefficient, Spearman rank coefficient and the Kendall rank coefficient.

The rank correlation coefficients of each of the four families of private equity and the MSCI are significantly lower than 0.75 and
Conclusion

Statistically significant. The Kendall rank coefficients are the following:

- **buyout** Europe: 0.54,
- **buyout** US: 0.44,
- **venture** Europe: 0.11
- **venture** US: 0.21

Furthermore, we have studied the correlation coefficient of insurance companies’ model portfolio of investments in private equity (the allocation estimation of AFIC is 10% in the United States and 90% in Europe, 10% in venture capital and 90% in buyout). The correlation coefficients according to the Kendall and Spearman methods are 0.30 and 0.37 respectively.

In conclusion, our study shows that private equity performance is significantly less correlated to that of listed equity markets than assumed in the 0.75 correlation coefficient selected by the CEIOPS.
Conclusion
Appendices
Appendices

Appendix 1: Correlation Coefficients

The choice of a correlation coefficient relies on different factors:
- the type of measurement scale used to express a variable
- the nature of the underlying distribution (continuous or discrete)
- the characteristics of the distribution (linear or not)

1) Pearson correlation

The most widely used correlation coefficient is the Pearson correlation, also known as the “linear correlation coefficient”. It determines the degree of linearity between two variables. To assess the reliability of the information given by the correlation coefficient, a significance threshold is used assuming that the distribution of residual values (deviations with respect to the regression line) follows a normal distribution and that the variance of residual values is constant. One of the drawbacks of the Pearson correlation coefficient is that its value can be highly dependent on the distribution of the observed variables when the sample size is small.

As the Pearson regression is defined by the minimisation of the squares of the distances between each data point observed and the regression line, to include or exclude certain data points when the sample size is relatively small may be translated by strong correlation coefficient sensitivity.

2) Spearman rank correlation

The Spearman rank correlation allows one to study the link between two quantitative variables measured over the same population, for small size samples, and therefore when it is impossible to use the linear correlation coefficient.

According to the Spearman rank method, the values are replaced by their rank. The steps to determine the correlation coefficient are the following:
- The ranks from 1 to n for variables X and Y are first determined (ties are randomly selected)
- The ranks replace the variables, thus creating new variables X’ and Y’
- The correlation coefficient is given by:

\[ r' = 1 - \frac{6 \sum (Y' - X')^2}{n(n^2 - 1)} \]

- The test of significance is established in the following way:
  - If the number of observations is higher than 10, the significance of r’ is verified by using the Pearson coefficient statistical tables for r with n-2 degrees of freedom.
  - If n ≤ 10, the Spearman table is used.

For instance, let’s consider four independent random variables A, B, C, D. We would like to study the correlation of A and B, A and C and A and D.

<table>
<thead>
<tr>
<th>Variables</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ranks</th>
<th>A’</th>
<th>B’</th>
<th>C’</th>
<th>D’</th>
</tr>
</thead>
<tbody>
<tr>
<td>A’</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>B’</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>C’</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>D’</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

To determine the correlation, the variables are organised according to their ranks. The correlation coefficient r’ with n equal to 7 is:

<table>
<thead>
<tr>
<th>Correlation</th>
<th>A - B</th>
<th>A - C</th>
<th>A - D</th>
</tr>
</thead>
<tbody>
<tr>
<td>r’</td>
<td>0.96</td>
<td>-0.21</td>
<td>0.67</td>
</tr>
</tbody>
</table>
In order to determine whether the hypothesis of lack of correlation should be rejected or not, the correlation coefficients obtained are compared to the values of the Spearman table, according to the risk $\alpha$ chosen and the degrees of freedom. Below we can appreciate the table values for $\alpha$ less than or equal to 5% and $\alpha$ less than or equal to 1%.

Spearman table:

<table>
<thead>
<tr>
<th>n</th>
<th>$\alpha \leq 5%$</th>
<th>$\alpha \leq 1%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>0.89</td>
<td>0.83</td>
</tr>
<tr>
<td>7</td>
<td>0.79</td>
<td>0.93</td>
</tr>
<tr>
<td>8</td>
<td>0.74</td>
<td>0.68</td>
</tr>
<tr>
<td>6</td>
<td>0.68</td>
<td>0.83</td>
</tr>
<tr>
<td>10</td>
<td>0.65</td>
<td>0.73</td>
</tr>
</tbody>
</table>

If the null hypothesis is defined as "$H_0$: there is no correlation between the two variables", the results are the following:

- We dismiss the null hypothesis of lack of correlation. There is a strong correlation between A and B: the probability of the variables not being correlated is less that 1%.
- We cannot dismiss the null hypothesis of lack of correlation between A and C (0.21 is less than the threshold defined for a 5% probability).
- We cannot dismiss the null hypothesis of lack of correlation between A and D (0.67 is less than the threshold defined for a 5% probability).

3) Kendall rank correlation (Kendall’s tau)

Kendall’s tau is also based on ranks of variables. Two approaches co-exist:

Approach 1:
- The bivariate series $(x,y)$ is ordered according to one of the variables, for instance variable $x$.
- Each observation $i$ is compared to other observations $j$ in order to determine whether the ranks of the second variable $y$ are in a natural order. Thus, we note:
  - $+1$ if $x_i < x_j$ and $y_i < y_j$
  - $-1$ if $x_i < x_j$ and $y_i > y_j$
- For the $n (n-1) / 2$ couples $(x_i, y_i)$, we calculate the sum of the results $S$ obtained in the previous step. The maximum value of the sum for $n$ equals to $n (n-1) / 2$.
- Kendall’s tau equals the ratio of $S$ and the maximum possible sum ($n (n-1) / 2$):
  \[ \tau = \frac{2S}{n(n-1)} \]

Approach 2:
- The variable $x$ is ordered from 1 to $n$
- For each observation $x_i$, the number of observations that have a value $y_j > y_i$ and for which the order $j$ is higher than $i$ ($j>i$) is counted.
- The sum of the ranks $R$ is calculated. Kendall’s tau is given by $\tau = 4R/n (n-1)-1$.
- It is also possible to calculate $S$: $S = 2R - n (n-1)/2$ or $S = R - n (n-1)$, Kendall’s tau is given by $\tau = 2S / (n(n-1))$.

The table below shows the two variables for which Kendall’s tau is calculated:

<table>
<thead>
<tr>
<th>xi</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>yi</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>9</td>
<td>8</td>
<td>10</td>
<td>7</td>
</tr>
</tbody>
</table>

Approach 1

| xy>yc: +1 | 7 | 8 | 6 | 6 | 4 | 4 | 1 | 1 | 0 | 7  |
| xy<yc: -2 | -2| 0 | -1| 0 | -1| 0 | -2| -1| -1| 0  |

Approach 2

| xy>yc: +1 | 7 | 8 | 6 | 6 | 4 | 4 | 1 | 1 | 0 | 0  |
| xy<yc: -1 | -2| 0 | -1| 0 | -1| 0 | -2| -1| -1| 0  |
Kendall’s tau as from the first approach is defined by:
\[
\tau = \frac{2S}{n (n-1)}
\]
Where \( S = 29 \) and \( n = 10 \).
We thus have \( \tau = \frac{2 \times 29}{10 \times (10-1)} = 0.644 \).
Kendall’s tau as from the second approach is defined by:
\[
\tau = \frac{4R}{n (n-1)} - 1
\]
Where \( R = 37 \), \( S = 2R - n (n-1)/2 = 74 - 45 = 29 \), therefore \( \tau = \frac{4 \times 37}{10 \times (10-1)} - 1 = 0.644 \).

Appendix 2: Study of the sensitivity of the regulatory capital requirement for private equity to the correlation coefficient of the performance of listed equity and that of non-listed equity

The aim of this appendix is to study the regulatory capital requirement for equity investments (SCR Mkt Equity) according to the correlation coefficient of the performance of listed shares and that of private equity. In order to measure the impact of diversification benefits (according to different correlation coefficients) on the capital requirement, we also determine the capital requirement’s marginal cost when there is an increase in the percentage invested in non-listed shares in an equity portfolio.

To carry through these measures, we consider an insurers’ asset portfolio of €1bn of which 10% is invested in equity. We also consider two scenarios. In the first scenario the weight of private equity is 2% of the total investments and in the second one it is 1%.

The objective of our simulation is to measure the sensitivity of the amount of capital requirement for equity risk to different correlation coefficients of the performance of listed shares and that of non-listed shares, by applying the shocks defined in QIS 4 (32% for listed shares and 45% for non-listed ones) 2010. Le choc simulé sur les actions cotées passe de 32% selon QIS 4 à 45% selon ce document. Celui sur les actions non cotées augmente de 45% à 55%.

The table next page shows the results of our simulations according to the weight of non-listed shares (scenario 1 and 2) and to different correlation coefficients.

According to QIS 4, for a total of €1bn of insurance assets of which 8% are invested in listed shares and 2% in non-listed shares, the capital requirement for equity risk (SCR Mkt Equity) is €34.6m before diversification benefits (correlation coefficient equal to 1).

If we choose a correlation coefficient of 0.75 of listed shares performance and that of private equity, as proposed by the regulator, the capital requirement changes to €32.89M. For coefficients of 0.5, 0.25 and 0 the decrease in capital requirement for equity risk, compared to a coefficient of 0.75, would be 5.5%, 11.3% and 17.5%.
respectively. The table thus shows the important role of the correlation matrix in the calculation of regulatory capital requirements.

This sensitivity to the correlation coefficient is naturally stronger when the weight of private equity is higher compared to that of listed shares; therefore the non-listed equity risk would be more demanding in capital than the listed equity risk.

We have performed a further simulation to determine the capital requirement’s marginal cost when the asset allocation is modified while integrating different diversification benefits (correlation matrix). The results are shown in the table below:

<table>
<thead>
<tr>
<th>Correlation Coefficient</th>
<th>scenario 1</th>
<th></th>
<th>scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SCR Mkt Equity €M</td>
<td>Change %</td>
<td>SCR Mkt Equity €M</td>
</tr>
<tr>
<td>1</td>
<td>34.60</td>
<td>5.2%</td>
<td>33.30</td>
</tr>
<tr>
<td>0.75</td>
<td>32.89</td>
<td>0.0%</td>
<td>32.31</td>
</tr>
<tr>
<td>0.5</td>
<td>31.09</td>
<td>-5.5%</td>
<td>31.29</td>
</tr>
<tr>
<td>0.25</td>
<td>29.18</td>
<td>-11.3%</td>
<td>30.24</td>
</tr>
<tr>
<td>0</td>
<td>27.14</td>
<td>-17.5%</td>
<td>29.15</td>
</tr>
</tbody>
</table>

Source: EDHEC Business School

The results show that when the asset allocation to private equity changes from 10% to 20% of the total investments in equity (a change from 90% to 80% in listed shares) and when the diversification benefit is high (correlation coefficient lower than or equal to 0.5), the global effect on the capital requirement is negative. This means that when the diversification benefit is high enough it can offset the additional capital requirement resulting from the increase in the allocation of private equity in the equity portfolio.

On the contrary, when the correlation coefficient is 0.75 (level proposed by the regulator in QIS 4 and in the January 2010 consultation paper in preparation for QIS 5) the diversification benefit is not sufficient to offset the capital requirement resulting from an increase in the share of private equity in the equity portfolio, which is translated as an additional capital requirement of 1.80%.

The following tables repeat the previous simulations while integrating the shocks proposed by the CEIOPS in the document CEIOPS-DOC-65/10 of January 2010. The shock applied to listed equity changes from
32% in QIS 4 to 45% in this document. The shock applied to non-listed equity increases form 45% to 55%.

<table>
<thead>
<tr>
<th>Correlation Coefficient</th>
<th>scenario 1 SCR Mkt Equity €m</th>
<th>Change %</th>
<th>scenario 2 SCR Mkt Equity €m</th>
<th>Change %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47.00</td>
<td>4.8%</td>
<td>46.00</td>
<td>2.7%</td>
</tr>
<tr>
<td>0.75</td>
<td>44.84</td>
<td>0.0%</td>
<td>44.77</td>
<td>0.0%</td>
</tr>
<tr>
<td>0.5</td>
<td>42.58</td>
<td>-5.1%</td>
<td>43.51</td>
<td>-2.8%</td>
</tr>
<tr>
<td>0.25</td>
<td>40.19</td>
<td>-10.4%</td>
<td>42.21</td>
<td>-5.7%</td>
</tr>
<tr>
<td>0</td>
<td>37.64</td>
<td>-16.1%</td>
<td>40.87</td>
<td>-8.7%</td>
</tr>
</tbody>
</table>

Source: EDHEC Business School

Marginal cost relative to a change in equity allocation

<table>
<thead>
<tr>
<th>Correlation coefficient</th>
<th>Sensitivity of the capital requirement to the change in the weight of private equity in the asset portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From 20% to 10%</td>
</tr>
<tr>
<td>1</td>
<td>-2.13%</td>
</tr>
<tr>
<td>0.75</td>
<td>-0.16%</td>
</tr>
<tr>
<td>0.5</td>
<td>2.19%</td>
</tr>
<tr>
<td>0.25</td>
<td>5.04%</td>
</tr>
<tr>
<td>0</td>
<td>8.58%</td>
</tr>
</tbody>
</table>

Source: EDHEC Business School

The same previous conclusions concerning the sensitivity of the capital requirement for equity risk (with higher amounts in €m due to the increase in the shocks considered compared to those in QIS 4) and the sensitivity of the diversification benefit to the marginal cost of private equity compared to listed equity are found. Thus, if the correlation coefficient is lower than or equal to 0.5, the diversification benefit following an increase from 10% to 20% in the share of private equity broadly offsets the additional cost of private equity compared to listed equity; so the capital requirement decreases overall.
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Acronyms
## Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFIC</td>
<td>Association Française des Investisseurs en Capital</td>
</tr>
<tr>
<td>BSCR</td>
<td>Basic Solvency Capital Requirement</td>
</tr>
<tr>
<td>CEIOPS</td>
<td>Committee of European Insurance and Occupational Pensions Supervisors</td>
</tr>
<tr>
<td>CF</td>
<td>Cash Flow</td>
</tr>
<tr>
<td>CP</td>
<td>Consultation Paper</td>
</tr>
<tr>
<td>ECOFIN</td>
<td>Economic and Financial Affairs Council</td>
</tr>
<tr>
<td>EEE</td>
<td>Espace Economique Européen</td>
</tr>
<tr>
<td>HPR</td>
<td>Holding Period Return</td>
</tr>
<tr>
<td>ICM</td>
<td>Index Comparison Method</td>
</tr>
<tr>
<td>IFRS</td>
<td>International Financial Reporting Standards</td>
</tr>
<tr>
<td>IRR</td>
<td>Internal Rate of Return</td>
</tr>
<tr>
<td>MCEV</td>
<td>Market Consistent Embedded Value</td>
</tr>
<tr>
<td>MCR</td>
<td>Minimum Capital Requirement</td>
</tr>
<tr>
<td>MSCI</td>
<td>Morgan Stanley Capital International</td>
</tr>
<tr>
<td>NAV</td>
<td>Net Asset Value</td>
</tr>
<tr>
<td>OCDE</td>
<td>Organisation de Coopération et Développement Economique</td>
</tr>
<tr>
<td>PE</td>
<td>Private Equity</td>
</tr>
<tr>
<td>PME</td>
<td>Public Market Equivalent</td>
</tr>
<tr>
<td>PME +</td>
<td>Public Market Equivalent +</td>
</tr>
<tr>
<td>QIS</td>
<td>Quantitative Impact Study</td>
</tr>
<tr>
<td>RNAV</td>
<td>Residual Net Asset Value</td>
</tr>
<tr>
<td>SCR</td>
<td>Solvency Capital Requirement</td>
</tr>
<tr>
<td>SCR def</td>
<td>Capital requis au titre du risque de contrepartie</td>
</tr>
<tr>
<td>SCR Health</td>
<td>Capital requis au titre du risque de souscription en assurance santé</td>
</tr>
<tr>
<td>SCR Life</td>
<td>Capital requis au titre du risque de souscription en assurance vie</td>
</tr>
<tr>
<td>SCR Mkt</td>
<td>Capital requis au titre du risque de marché</td>
</tr>
<tr>
<td>SCR NL</td>
<td>Capital requis au titre du risque de souscription en assurance non-vie</td>
</tr>
<tr>
<td>TWR</td>
<td>Time-Weighted Rate of Return</td>
</tr>
<tr>
<td>VaR</td>
<td>Value at Risk</td>
</tr>
<tr>
<td>VaR</td>
<td>Value at Risk</td>
</tr>
</tbody>
</table>
About the EDHEC Financial Analysis and Accounting Research Centre
About the EDHEC Financial Analysis and Accounting Research Centre

The Financial Analysis and Accounting Research Centre was created in 2006 around the theme of company valuation. Cultural and technological changes now make it possible to use multiple dynamic analyses, the cornerstone of which is the discount rate. There is an abundance of academic research into the determination of the discount rate, but the gap between academe and business seems to be growing wider by the day. In practice, those who do the valuations often oversimplify, invalidating their reasoning; they may even ignore theory and transform the discount rate into a black box to hide the absence of objective and academic foundations in the determination of the risk premium and of beta.

The objective of the EDHEC Financial Analysis and Accounting Research Centre is to call into question certain financial paradigms, in particular that which consists of separating idiosyncratic risk—because it is diversifiable—from the risk premium and to provide the financial markets (financial analysts, investors, companies, rating agencies, auditors) with new light on the discount rate and to recommend new ways to determine it.

The great diversity of backgrounds is one of the advantages of the Centre (specialists in financial analysis, in accounting, in law, researchers from academe or from business), and it allows the Centre to take a multi-disciplinary approach to financial analysis: company valuation, the impact of IFRS and Solvency II on insurance companies, the impact of IFRS on the valuation and pricing of risk, the growing use of fairness opinions, the status of the outside expert, and the measurement of intangible assets.
About AFIC
About AFIC

The Association Française des Investisseurs en Capital (AFIC) includes all the private equity structures (venture capital, expansion capital, buyout, turnaround capital) operating in France. The association has 270 active members – corporate shareholders – who accompany and finance the growth of nearly 5000 companies in France. AFIC also has 200 associate members from a wide range of related professions which support and advice investors and entrepreneurs in the structuring and management of their partnerships.

AFIC is the only French professional association dedicated entirely to the private equity business. It is a member of the Association Française des Etablissements de Crédit et des Entreprises d’Investissement (AFECEI). AFIC membership is one of the conditions required by the Financial Markets Authority (AMF) in approving the practice of the profession by management companies.

Beyond, its mission of control and development of generally best practices, AFIC federates, represents and assures the promotion of private equity business among institutional investors, entrepreneurs, opinion leaders, and public policy makers. It thus contributes to the financing of the economy, more precisely the financing of SMEs and SMLs, to promote economic growth and entrepreneurial spirit.

The French private equity business is ranked number 1 in continental Europe, and represents more than 20% of the European market today.
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