Alternative Investment Analyst Review

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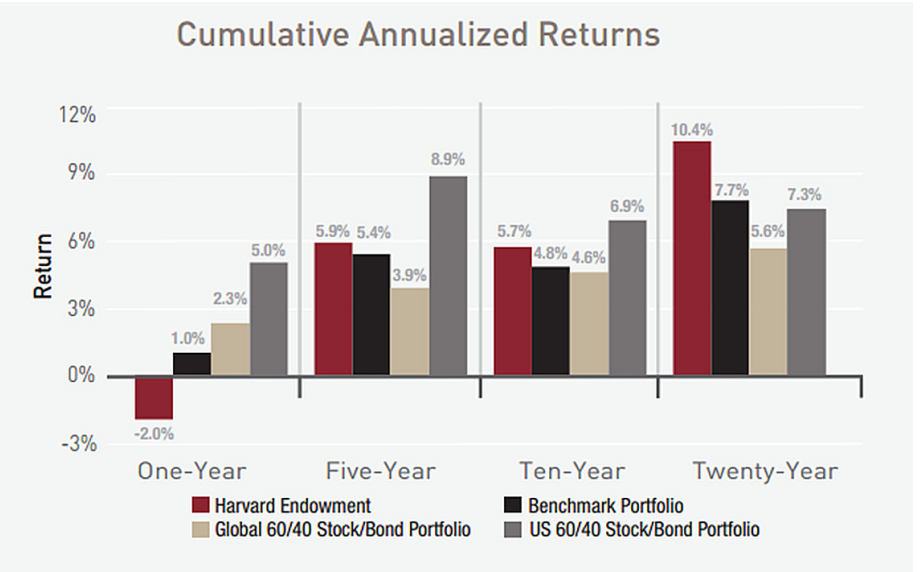
Editor's Letter

A Simple Approach to the Management of Endowments

Endowments and foundations are tax exempt and charitable organizations that rely on permanent pools of capital to fund their activities. Institutions such as colleges, universities, hospitals, museums, scientific organizations, charitable entities, and religious institutions own these pools of capital. When well funded and well managed, an endowment can provide a permanent annual income to the organization, while maintaining the real value of its assets in perpetuity.

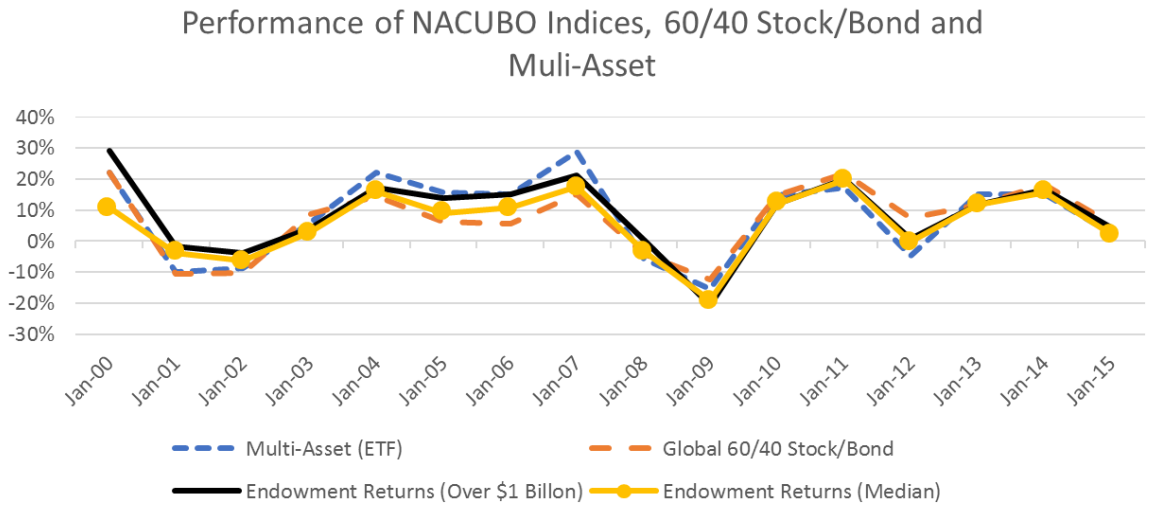
These institutions typically lack the internal expertise to manage their assets. Only the largest endowments and foundations have the resources to build an internal team to manage their assets. Small and medium size organizations may choose to outsource the management of their assets. However, whether they are small or large, managing the assets that fund these organizations' activities costs money. Of course, there is significant economies of scale in managing assets and for the largest endowments and foundations, the ratio of management expenses to total assets is expected to be relatively low. For instance, Harvard Management Company (HMC), which manages Harvard University's endowment, reported around $200 million in expenses while managing around $35 billion in assets. This means that Harvard University spends around 0.57% of its endowment to manage its assets. Of course, this figure does not include the fees that HMC paid its outside managers, which is not as relevant since the reported returns are net of these fees. The following chart, which is obtained from HMC's 2016 Annual Report, shows the performance of the fund over that past 1, 5, 10 and 20 years.



While the endowment has outperformed the basic US 60/40 stock/bond portfolio during the past 20 years, it has underperformed this portfolio during the past 1-, 5- and 10-year periods.

The NACUBO-Common Fund Study of university endowments reports aggregate annual performance of those organizations that report to the National Association of College and University Business Officers (NACUBO). The following chart displays the annual performance of the largest endowments, median performance of endowments, global 60/40 stock/bond ETFs and a multi-asset portfolio of ETFs. We will discuss this "mystery" multi-asset portfolio later.

We can see that all four indices show remarkable similarities. Interestingly, the median performance of endowments has matched the performance of the largest endowments in recent years. The following table displays the basic statistics:



The "mystery" multi-asset portfolio consists of various combinations of 23 equity, fixed income and alternative ETFs. It has provided nearly the same rate of return as the largest endowments with slightly higher volatility since 2000. Note that because endowments hold illiquid assets, a significant degree of smoothing is present in their returns.

2000-2015	Mean	Std Dev
Multi-Asset (ETF)	8.11%	13.44%
Global 60/40 Stock/Bond	7.13%	11.24%
Endowment Returns (Over $1 Billon)	8.82%	12.15%
Endowment Returns (Median)	5.99%	10.56%

Two important points must be raised here. First, notice that while endowment returns are net of asset managers' fees, they are not net of expenses paid by the endowment to its own staff to oversee the endowment. The ETF portfolios are net of all fees, of course. Second, endowment portfolios contain a significant amount illiquid assets, which could impose unexpected costs on them. The ETF portfolios consist of the most liquid ETFs.

The above figures raise an obvious question: What is the point of assuming significant illiquidity risk while spending significant amounts of resources to manage these pools of assets, when over the past 15 years their performance has matched those that can be earned by simple allocations to ETFs?

The above performance figures report aggregate numbers and there are bound to be some endowments who significantly outperform or underperform the above ETF benchmarks. For example, some endowments may have access to top tier hedge funds, private equity funds and real asset managers. Of course, not every manager can be top tier. Therefore, the question posed above is more applicable to those organizations that do not have access to these top tier managers. Since small and medium size endowments do not appear to have access to top tier managers that offer illiquid assets (e.g., hedge funds, private equity and real assets), it seems prudent that these funds consider allocations to more liquid and passive products. In addition, they can use available information to select allocations that replicate the performance of the

largest endowments using liquid ETFs. In fact, this is how the multi-asset ETF portfolio was created. That is, we used a set of available ETFs to replicate in real time the performance of an index representing the performance of largest endowments. Only the past performance of these endowments was used to construct the replicating ETF portfolio, which is held for the following quarter. This means, one can implement this procedure in real time to manage an actual endowment. The procedure requires one to rebalance the portfolio on a quarterly basis. For those who are curious, the following was the tracking portfolio for the first quarter of 2017.

RUSSELL 2000 ETF	PowerShares QQQ ETF	Materials Select Sector SPDR® ETF	Energy Select Sector SPDR® ETF	Red Rocks Global Listed Private Equity	SPDR Dow Jones Global Real Estate ETF	Cash, Short- & Medium-Term Treasuries
23%	24%	7%	8%	15%	14%	9%

Going forward, every quarter we will be posting the holdings of the replicating portfolio in this publication.

Hossein Kazemi

Editor

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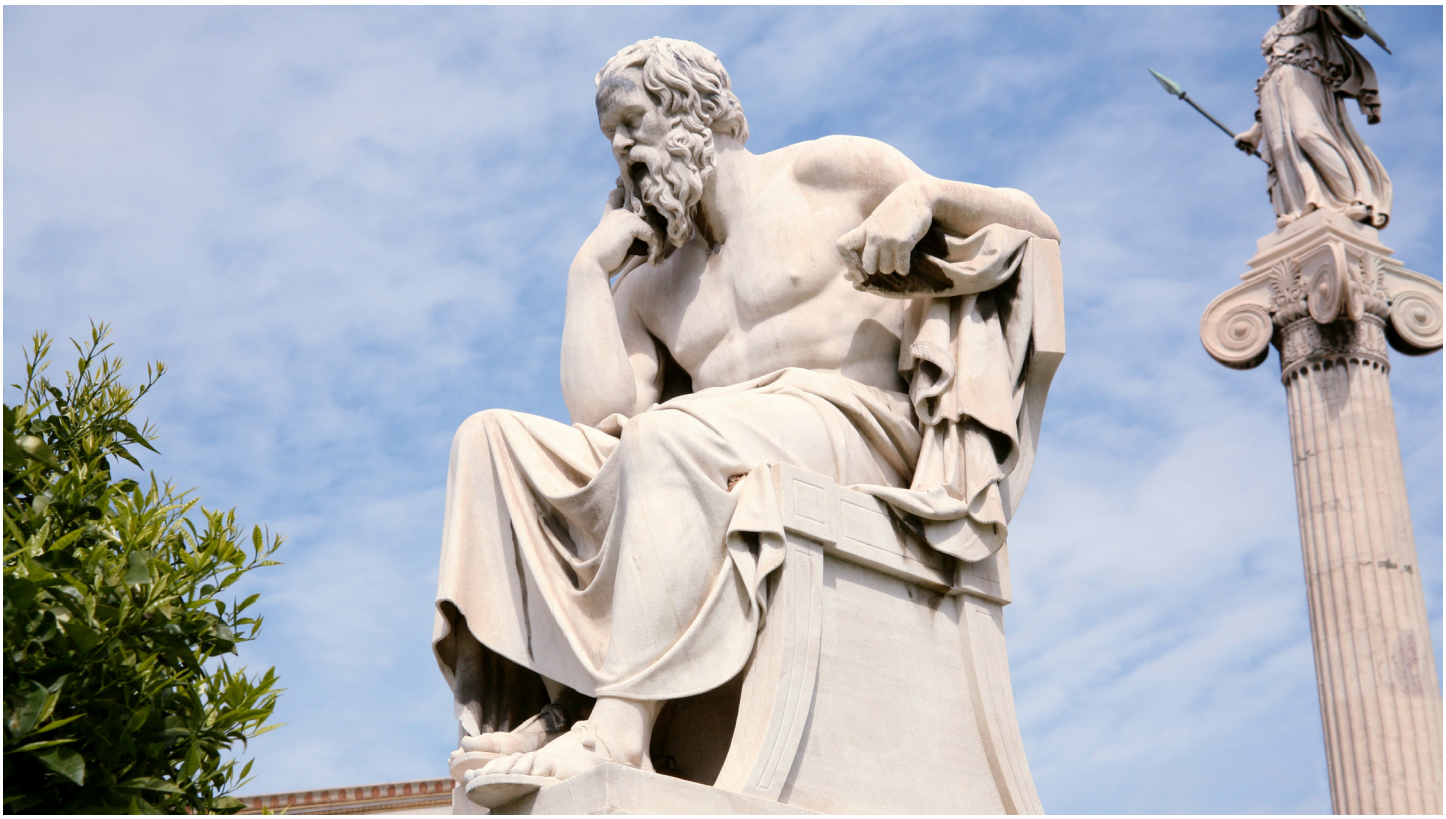

Hedge Fund Investment Philosophy:
A Methodology for Selecting Hedge Fund Managers and Constructing Hedge Fund Portfolios

Kostas Iordanidis
KI Capital GmbH

Introduction

Hedge funds are vehicles that invest in different asset classes in a flexible and unregulated way. Contrary to popular perception, hedge funds are not a separate asset class like equities, government bonds or commodities.

Hedge funds are heterogeneous and diverse. Even hedge funds that invest in the same asset class and follow similar investment strategies exhibit large differences in behavior over time. As a result, most (but not all) academic and practitioner studies of aggregate hedge fund performance and risk taking are deeply flawed and meaningless.

Sources of hedge fund returns

Hedge fund returns are a mixture of asset class systematic risk premiums, liquidity risk premiums and alpha that are enhanced by leverage[1]. Similar to traditional asset managers, hedge fund managers harvest traditional asset class premiums; equity market, equity style and capitalization, credit spreads (across the capital structure), emerging markets risk premiums as well as bond risk premiums, inflation and currency carry. Unlike traditional asset managers however, hedge funds have the flexibility to profit from investing in alternative asset classes such as market volatility, mortgages (complexity), convertible bonds (conversion premium), M&A spreads and derivatives.

Liquidity risk premiums constitute a significant source of many hedge fund returns; hedge funds tend to provide liquidity to financial markets.

The most desirable component of a manager's return stream is his/her ability to generate uncorrelated alpha. Unfortunately, pure alpha is very difficult to find and tends not to be sustainable over the long term. And when sustainable alpha does exist, it is typically associated with significant fees. There are only two sources of alpha; market inefficiencies and the ability (skill) of a manager to forecast (time) markets[2].

Hedge Fund Fees

Hedge funds typically carry substantial fees, a management fee of 1.5%-2.0% and a performance fee of 20%. The level and structure of fees has been a topic of constant debate in the industry. Drawing general conclusions on the appropriateness of fees for the whole industry is misleading. Managers that are highly skilled and strategies that are in short capacity would typically command higher fees. In contrast, one can today invest in a simple properly constructed long term trend follower for a management fee of 0.5% and no performance fee[3]. Lower fees can be a substantial source of (net) alpha for investors. Most new fund launches offer substantial fee discounts to early investors.

Investment beliefs

Successful investing in financial markets requires a clearly articulated set of investment beliefs. These beliefs should be consistent with the accumulated academic knowledge in economics and finance but also in other fields that study investor behavior, such as psychology, decision making theory and neuroscience. Beliefs should be empirically sound and account for the observed microstructure of financial markets.

Market efficiency

Markets are generally efficient in the long-run but not perfectly efficient. Future cash flows and discount rates are inherently uncertain. The intrinsic value of assets is unknown and noisy, but the noise is not random. Prices materially deviate from intrinsic value in a systematic way.

Markets reflect not only information but also the different and often conflicting points of view (beliefs) of diverse groups of investors. In the short-run, investors make investment mistakes that can – under certain conditions – become correlated[4]. Correlated investment mistakes can drive market valuations to extremes. These extremes can persist for a long time and it is difficult to estimate when they will get corrected. In the long run, however, prices mean revert to intrinsic value.

In addition, inefficiencies arise due to regulation, taxation, investor restrictions, differences in the investment horizon of market participants, supply/demand imbalances, and the pricing of complex illiquid securities. These inefficiencies can persist over time as in some cases it is difficult to arbitrage them. The existence of inefficiencies requires the presence of certain types of investors whose wealth is systematically drained by arbitrageurs either knowingly (e.g. regulation, central bank capital) or unknowingly (e.g. existence of noise traders).

Forecasting ability and investment views

Both arbitrage opportunities and market timing are a zero-sum game for the market and that is before managers charge their fees[5]. Net of fees, these strategies have a negative aggregate expected return, which implies that it is very hard to ex-ante identify managers with the ability to generate alpha in the long-term.

Systematic risk premiums vary with the economic cycle and are partially forecastable over medium term horizons. As such, they significantly affect changes in manager performance.

Alpha is also cyclical[6]. (both within and across asset classes) and depends on capital flows, changing volatilities and changing correlations. Alpha opportunities increase dramatically in periods of crisis as elevated uncertainty leads to higher dispersion securities. Very few managers are able to generate consistent alpha across market environments. As a result, having views on the factors that affect hedge fund returns is a critical component of manager selection and portfolio construction.

Hedge Fund manager selection

Manager profiling

A key component in evaluating and selecting a hedge fund manager is the construction of a profile of the manager's beliefs, views and expected behavior. The profile incorporates all available information on a manager, both qualitative through extensive manager interviewing and quantitative by analyzing the manager's past performance and risk metrics. It focuses on three principal areas of a manager's investment philosophy/strategy:

- Manager edge
  - o What is the manager's unique and sustainable (robust) competitive advantage?
  - o What are the manager's beliefs on how securities are priced?
  - o Why mispricings exist?
  - o What does the manager believe his advantage is in exploiting these miss-pricings?
- Alpha thesis
  - o How does the manager translate his beliefs into alpha generation?
  - o Is the alpha thesis robust and sustainable?
  - o Can alpha be attributed to known factors?
- Risk
  - o What does the manager believe risk is?
  - o What type of systematic risks does he take into his portfolio?
  - o How does the manager size and time positions?
  - o How risky is the manager's alpha thesis?
  - o How crowded is the manager's strategy? Is there a systematic "hedge fund" factor driving returns?

The profile provides an expected return distribution for the manager, a "prior" that is used as input to an independent Bayesian framework for testing, validating and/or falsifying manager beliefs. The manager profile evolves over time driven by weekly/monthly return and risk statistics and other qualitative information. The advantage of this approach is that it combines multiple sources of information and that it efficiently blends subjective due diligence information with risk and return data. The approach mitigates the impact of human biases in decision making and avoids the selective use of narratives to support ex-post explanations of both positive and negative surprises. Such a framework of course is as good as its underlying assumptions. All predictions should be viewed with a dose of critical skepticism.

Selecting hedge fund managers based on past performance

It is extremely difficult to forecast manager returns using historical performance. Randomness (luck) is a dominant driver of ex-post performance for the majority of managers, especially in the short run. Expected (ex-ante) alpha is unobservable and can differ significantly from realized (ex-post) alpha. Alpha opportunities are not riskless – they are associated with significant risk.

Investor preferences influence the success of a manager in the short run. Preferences are broader than what return and risk imply. Fear of contrarianism and the safety of following the herd, the allure of gambling and loss aversion are all human behavioral biases that affect manager success. In fact even if we could define and quantify what constitutes intrinsic quality of a hedge fund manager, short term performance and feedback would still be the driving factors that determine winners and losers in the industry. Historical return data are non-stationary. Limited data and short term histories make it extremely difficult to detect change in the data.

Financial markets are complex systems which are influenced by human behavior. The predictability of such complex systems is low, whilst the uncertainty surrounding our predictions cannot be reliably assessed, for three reasons:

- "Wild randomness": In most cases, prediction errors are not independent of one another. The distribution of errors is not normal and the variance of the distribution is not constant. This means that the variance itself will be either intractable or a poor indicator of potential errors.
- "Black swans": There is always a chance of totally unexpected occurrences materializing — and these can have massive impact.
- Model (epistemological) uncertainty: Probabilities of outcomes are not observable, and it is uncertain which probabilistic model to use. The true underlying return generating process cannot be uncovered by data.

Manager personality traits

Managing hedge fund portfolios is inherently a people business. Beyond qualitative and quantitative analysis of a manager's strategy, there are distinctive personality traits that characterize successful portfolio managers.

One of the most important identifiers of successful hedge fund managers is the difference between a good analyst and a successful portfolio manager[7]. Investors overestimate the importance of fundamental bottom-up expertise in choosing portfolio managers. Bottom-up knowledge is a necessary criterion for picking successful analysts, but a poor indicator of identifying successful hedge fund managers. It inherently biases the selection process towards concentrated long-term fundamentally driven hedge funds. The key difference between average and great hedge fund managers is to know when to sell positions and reduce risk. Having fundamental knowledge and monetizing it are very different things. What matters is whether the manager understands the trade-off between fundamental conviction in a position and flexibility in adapting to changing market conditions.

The success of quantitative funds provides support to the assertion that bottom-up domain specific knowledge is less important than risk management, sizing, and timing for picking successful hedge fund managers. Quantitative funds hold hundreds or even thousands of individual positions and have high turnover relative to fundamental stock pickers. They know a lot less about individual positions and yet can generate returns that are highly competitive to the returns of fundamental long biased managers.

In a recent paper, Dmitri Balyasny, the CIO of Balyasny Asset Management – a well-known multi-manager hedge fund – identified humility, confidence, a "growth mindset", long-term goal orientation and perseverance as the five personality traits of a successful portfolio manager[8].

Humility helps managers admit they are wrong and prevents them from holding on to losing positions. This provides the impetus for focusing on finding new investment opportunities. Confidence in themselves and in their process allows managers to take meaningful risk and to recover from drawdowns. A "growth mindset" and a relentless focus on incremental improvement facilitate learning from mistakes. Focus on long-term goals demonstrates the willingness of a manager to tradeoff short-term costs for long-term benefits. Finally, the survival of a manager over time – his perseverance – relates to his tenacity to overcome great challenges, especially during periods of crisis. How a manager deals with extremely stressful market and/or business environments provides invaluable information for successful manager selection.

Construction of Hedge Fund Portfolios

Hedge fund portfolio construction has three primary aims: (i) invest in a group of select managers who diversify across different systematic risks, (ii) do this in a manner that minimizes the exposure of the portfolio to traditional market beta, and (iii) maximize manager alpha at the portfolio level. Properly constructed portfolios will tend to be fairly concentrated in the number of managers, will have low exposure to equity market beta, and when evaluated over a full cycle, would likely have higher risk adjusted returns and significantly lower drawdowns than equity markets.

Views on systematic risk factors and on the sustainability of manager alpha drive portfolio construction. Sizing of individual holdings is driven by conviction and the value of fundamental diversification that the position brings to the portfolio. The level of conviction in a manager is a natural outcome of the manager selection process outlined above. Conviction is high for managers who perform in line with their profile over extended periods of time and deliver limited surprises. In contrast managers with erratic performance relative to expectations are low conviction managers. And by "fundamental diversification" we mean investing in managers who are qualitatively different as opposed to "statistical diversification" that is based on estimated volatilities and correlations across managers. Statistical diversification tends to be unstable and can evaporate especially during periods of crisis.

Liquidity also plays an important role in hedge fund portfolio construction. Market liquidity is time varying and driven by both structural and cyclical factors. There are times when investors can significantly profit from being liquidity providers to hedge fund

managers. What is important to keep in mind is that liquidity does not exist for the market as a whole.

Discretionary overlay (portfolio insurance)

Even the most carefully constructed portfolio of hedge funds would have exposure to systematic risk factors that can lead to significant drawdowns. To the extent that these drawdowns are unwanted, investors can deploy a portfolio overlay strategy to hedge some of these unwanted risks.

A discretionary overlay should use only the most liquid instruments available in markets. It requires a detailed understanding of each hedge fund's risk exposures and how these exposures vary over time. There is of course a cost associated with implementing an overlay, and this cost is highest in periods of market turmoil. Purchasing portfolio insurance selectively in periods when such insurance is cheap and looking for protection across asset classes can mitigate some of that cost.

Risk Management – Risk Factors unique to hedge fund managers

Human risk

The most important risk of investing in hedge funds comes from the behavior of the hedge fund manager. Hedge funds are led by highly talented individuals, who at times trade aggressively in order to achieve their return targets. Use of leverage can only exacerbate the consequences of risk taking. Recent evidence from neurobiological studies indicates that behavioral/cognitive heuristics, perceptions and emotions are the drivers of choice under uncertainty in financial markets. Functional Magnetic Resonance Imaging (fMRI) studies show that the prediction of a financial gain activates different parts of the brain than the prediction of a loss[9]. The activation of a particular neural circuit can lead to shifts in investor risk preferences. And the excessive activation of these neural circuits can lead to investment mistakes.

The manager selection process outlined above tries to mitigate human risk by relying on both qualitative and quantitative information to provide early warning signals of change in a manager's strategy.

Hedge fund risks are misunderstood by the investment community. What is particularly poorly accounted for by investors is business risk resulting from the complex interaction between manager performance, drawdowns, leverage, margin calls, counterparty risk, liquidity and the performance fee option embedded in hedge fund fees. Hedge fund managers have contractual obligations to their counterparties and investors. These obligations can be thought of as options that the fund is short[10].

- A "funding" option that the hedge fund is short to his counterparties that would force the fund to reduce leverage during crises. This option depends on the fund's performance and volatility and can lead to the fund's forced deleveraging especially in the presence of significant mismatches between fund assets and liabilities (investment horizon vs. funding terms).
- A "redemption" option to provide liquidity to investors when assets are needed the most. This can be especially costly for a fund with mismatches between the fund's underlying position liquidity and investor liquidity.

Diseconomies of scale

Manager size (assets under management) is a significant factor impacting hedge fund performance. The hedge fund industry lacks the discipline to face its biggest delusion; that hedge funds can get endlessly large and still deliver the benefits that made them "alternatives" in the first place – diversification, absolute returns and alpha.

Alpha is finite and not scalable. As alpha is a zero sum game, increasing alpha requires not only finding additional market inefficiencies but also an increasing number of suboptimal investors to profit from. Portfolio managers consistently and significantly overestimate the scalability of their process and their ability to generate returns as assets grow. Only a fraction of the skilled managers who can generate consistent performance with a $300M-$500M portfolio can do the same with $3bn-$5bn of assets.

Inevitably, asset growth leads to style drift, changes in both the risk profile of a fund and the way the business is managed. Large hedge funds can become too concentrated with their largest positions in crowded names that tend to be similar across many other funds. As managers search for performance they may increasingly utilize leverage and invest in illiquid securities. Such funds can become highly volatile and can experience uncharacteristically large drawdowns even relative to market losses. They end up becoming the ultimate beta fund – they don't just act like the market, they become the market.

Investors have time and time again ignored to their peril the impact of asset growth on fund performance. They chase performance by allocating capital to funds that have performed well in the recent past. Disappointed by the occurrence of large drawdowns they redeem from such managers at precisely the wrong time thereby exacerbating fund losses.

Drawdown Monitoring

Whilst no single risk measure can summarize the risks assumed by a hedge fund, drawdowns (both expected and realized) can be used to monitor and manage manager risk. Unlike other measures of risk, drawdowns are path dependent and tail correlated.

Market extremes provide a very useful laboratory for testing one's beliefs regarding hedge fund risk management. In order to risk manage a portfolio of hedge funds, it is essential to

- Monitor a manager's ability to manage portfolio exposure (gross and net) and leverage, especially during periods of crisis
- Analyze the manager's survival and recovery from large drawdowns
- Monitor growth in assets under management and its impact on performance and alpha. Does he take more directional market risk and does his position concentration increase?
- Monitor client behavior to assess the riskiness of the redemption option offered to clients
- Monitor asset liability mismatches and the true inherent liquidity of underlying portfolio.

Conclusion

In this note we presented a rigorous investment process tailored to hedge fund investing. Our framework combines multiple sources of qualitative and quantitative information for manager selection, portfolio construction and risk monitoring.

Hedge funds are exposed to complex market and business risks that are poorly understood by investors. Successful hedge fund investing necessitates a detailed understanding of the precise sources of hedge fund returns and risks.

Endnotes

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Author Bio

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Kostas Iordanidis is currently Managing Partner of KI Capital GmbH, a Swiss financial advisory firm he founded in 2010. KI Capital specializes in asset allocation, hedge fund manager research and hedge fund portfolio construction.

Previously, Kostas was Managing Director and Head of Hedge Funds at Unigestion SA, a Geneva-based fund of hedge funds with $3.2 billion of assets under management. Prior to that, he was Co-Chief Investment Officer of Olympia Capital Management (2005 – 2008), responsible for managing the company's $6 billion alternative investment portfolio. He has also been a member of the Board of Directors of the Fortelus Special Situations Fund, a European focused distressed hedge fund.

Kostas was First Vice President and Head of Asset Allocation at Julius Bear Asset Management (2003 – 2005), Co-Founder and Managing member of Z.I. Investments LLC (1999 – 2002) and Principal and Portfolio Manager at Lincoln Capital Management Co. (1994 – 1998).

He received his Ph.D. in Elementary Particle Physics and his MS in Quantitative Finance from the University of Wisconsin-Madison.

The Effects of Responsible Investment: Financial Returns, Risk Reduction and Impact

Jonathan Harris
ET Index Research

This report focuses on three key questions for responsible investors:

- Does responsible investment lead to outperformance or underperformance?
- Can responsible investing impact company behaviour?
- What is the optimal way to allocate an investment portfolio in a responsible way?

These questions are answered by constructing an equilibrium model of the financial economy in which active, neutral investors (with no knowledge or regard for environmental risk) and active, responsible investors (who take environmental risk into account) bid for shares in companies with varying levels of environmental risk.

The companies in turn are able to pay a cost to reduce their environmental risk. Companies choose the amount of reduction that they pay for so as to maximise their share price, as determined by demand for their shares from the active investors. In addition, several types of passive index investors are considered in the model including investors who follow a Divestment strategy, an Environmental Tracking (ET) index strategy and a combined Environmental Tracking and Divestment strategy.

Note that while environmental risk is the subject of this report, the results apply equally well to any extra-financial risk that may be considered by responsible investors.

Under realistic choices for the model parameters it is found that:

- Responsible investors, and index investors following responsible strategies, enjoy capital gains relative to neutral investors as the level of responsible investment increases.
- Responsible investing can have an impact on company behaviour, potentially leading to greatly reduced environmental risk in the economy.

- Among all practical responsible investment strategies considered in this report, the Environmental Tracking approach developed by ET Index Research exhibits the best characteristics.

Model

The model explored in this report builds on the seminal work of Heinkel, Kraus and Zechner (2001). To make the model realistic and relevant to actual investors, the setup outlined in the points below was used.

Company setup

The financial economy consists of investors and companies. There are *I* companies in the economy. The companies all have the same expected return, μ and standard financial risk (variance), σ^2. The correlation between the standard financial returns of different companies is a fixed parameter, ρ. The correlation and risk information can be mathematically summarized in the standard risk covariance matrix Σ.

Companies also have environmental risk, σ_E^2, so that each company i has total risk equal to the sum of its standard and environmental risks, $\sigma_{Total,i}^2 = \sigma^2 + \sigma_{E,i}^2$. The correlation between the environmental risks of different companies is ρ_E, and environmental risk is assumed to be uncorrelated with standard risk.

Each company's environmental risk exposure is driven by its individual level of environmental risk. Each company i is assigned an initial (prior to responsible investment) level of individual environmental risk given by:

$$\sigma_{e,i,0}^2 = a_0 \exp(\frac{b_{0i}}{I})$$

Here the parameters, a_0 and b_0, control the absolute level and the slope of the exponential curve of the environmental risk level across companies, respectively.

The curve of environmental risk levels across companies is shown in Figure 1.

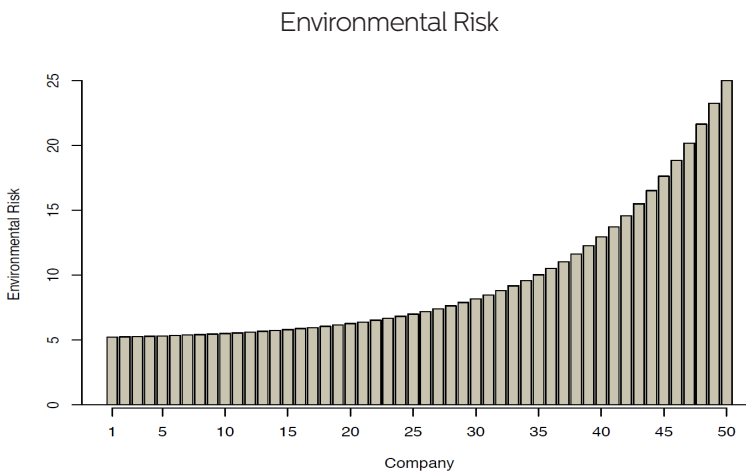

Figure 1: The initial total environmental risk of each company, prior to any risk reductions.

Risk reduction and costs

Companies may reduce their environmental risk for a cost by choosing a reduction parameter, $r_i \geq 0$, which reduces their individual environmental risk, $\sigma_{e,i}^2(r_i)$, but also their expected return, $\mu_i(r_i)$, in the following manner:

$$\sigma_{e,i}^2(r_i) = \sigma_{e,i,0}^2 \exp(-r_i)$$
$$\mu_i(r_i) = \mu - c_i r_i$$

Companies choose their risk reduction parameter, r_i, to maximize their share price. That is, a company is only willing to increase the value of its risk reduction parameter if the investors will value the resulting decrease in environmental risk more highly than the corresponding increase in costs that the company will incur. The investors will then be willing to pay more for the company's shares if the risk reduction parameter is increased.

The reduction cost parameter, c_i, for each company is set in proportion to the company's initial level of environmental risk:

$$c_i = c_0 \sigma_{e,i,0}^2$$

This ensures that companies with more environmental risk must pay greater absolute costs to reduce their risk.

Global risk and individual companies

The global nature of environmental risk is featured in the model in two ways:

1) Each company is exposed not only to the risks from its own environmental performance (and that of its supply chain), but also to the risk to the whole economy from the global sum of environmental risk that all companies create together. For example, consider that links have been drawn between the incidence of extreme weather events (which specifically affect the returns to insurance companies) and the global level of greenhouse gases (which is contributed to by every company).

2) If the global sum of environmental risks decreases, then the actual contribution of each company's environmental risk to its own financial risk will be smaller. For example, consider that if global greenhouse gas emissions were to suddenly drop dramatically, the various pressures on carbon-intensive businesses to lower their emissions would also decrease.

The above two ideas are incorporated into the model, in that each company's total environmental risk, $\sigma_{E,i}^2$, is defined as the sum of a fixed contribution, σ_{Global}^2, from the global risk, and a contribution from the individual risk of the relevant company, $\sigma_{e,i}^2(r_i)$, both multiplied by the level of global environmental risk relative to its initial level (prior to any company paying to reduce its risk), such that:

$$\sigma_{E,i}^2(r_i) = \left(\frac{\sum_i \sigma_{e,i}^2(r_i)}{\sum_i \sigma_{e,i}^2(0)} \right) (\sigma_{Global}^2 + \sigma_{e,i}^2(r_i))$$

The contribution of global environmental risk to each company's risk can be seen in Figure 1, as it defines a floor level of risk below which even the risk of the company with the lowest level of environmental risk (Company 1) cannot go.

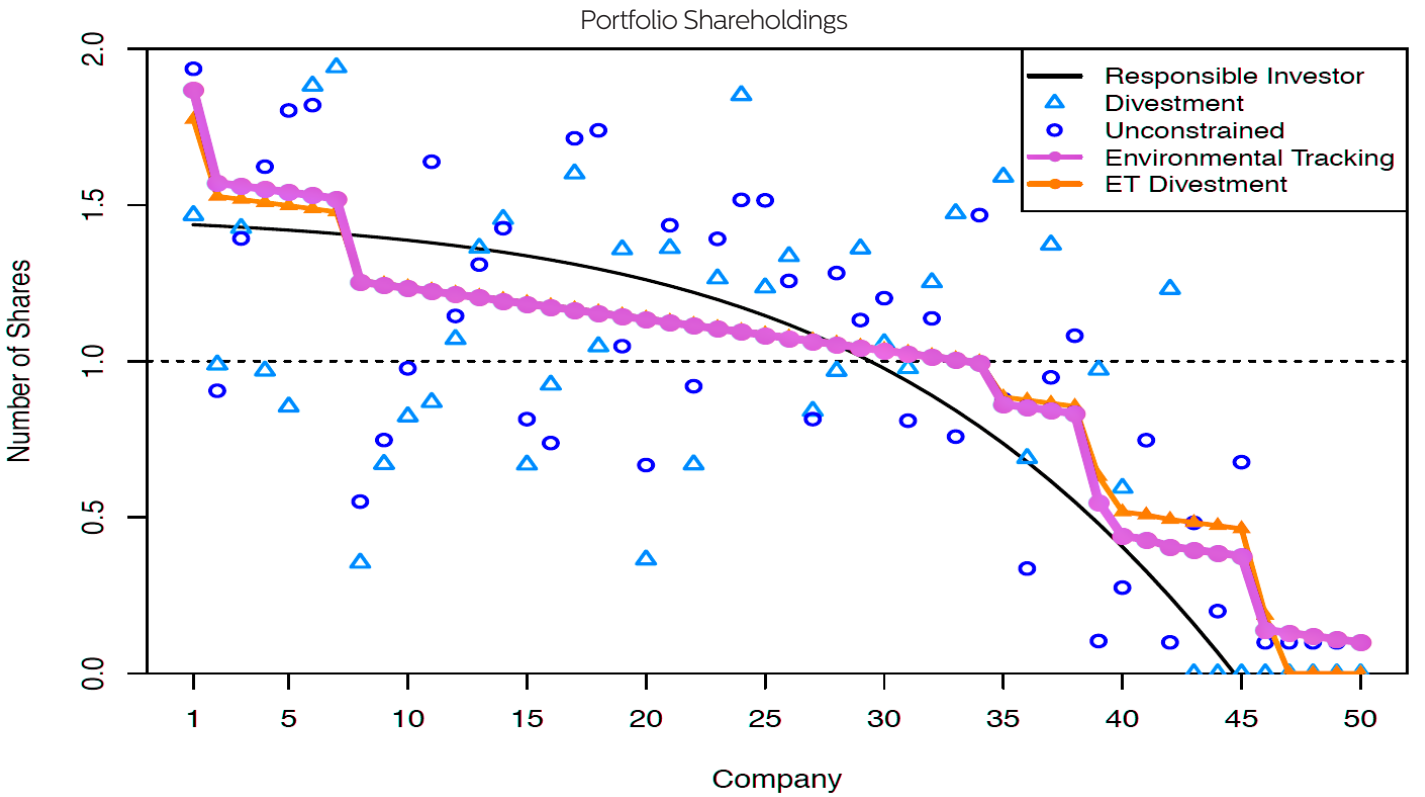

Figure 2: Typical portfolio shareholdings for each strategy. The market portfolio is to hold one share in each company.

Extensions of this model could allow for the companies to have different exposures to the global level of environmental risk. Companies are assumed to have the same exposure in this report for simplicity.

Investors

Each company issues one share for each investor in the economy. Thus, the "market portfolio", the portfolio that the average investor will hold, consists of one share in each company. However, any given investor may hold more or less than one share in each company.

A fraction, $0 \leq J \leq 1$, of investors are active investors, which means that they determine their own investment portfolio so as to maximize their own expected utility. The rest of the investors are passive index investors, which means that their investment portfolios are determined by an index provider (this is explained in more detail below).

Index investors may only hold long positions (that is, they must hold a non-negative number of shares of each company). Active investors are allowed to short sell (that is, they may hold a negative number of shares of any company).

A fraction, K_R, of active investors are "responsible investors", and the rest of active investors are "neutral investors".

Neutral investors only observe the standard risk of each company. Thus, they do not incorporate environmental risk information into the management of their portfolio.

Responsible investors observe both the standard risk and the environmental risk of each company. They incorporate environmental risk into their portfolio management strategy in the same way that they include standard risk in their investment decision making. This is the only difference between responsible investors and neutral investors considered in this report. However, as can be seen in Figure 2, this difference does lead to significant changes in shareholdings for the responsible investors.

Index Strategies

Index investors engage in responsible investment by following one of the responsible index strategies outlined below. Any index investor that does not follow one of the responsible index strategies simply holds the market portfolio. This is equivalent to all market-cap weighted index products, which make up the majority of index investment products today. The fraction of index investors holding the market portfolio is labelled K_M.

A fraction, K_D, of index investors follow a "Divestment" responsible index strategy, which means a strategy of divestment from (i.e. holding 0 shares in) the stocks with the greatest environmental risk until the net exposure to environmental risk has been reduced by more than 50%. The shareholdings of the rest of the portfolio are then adjusted so as to minimize tracking error with respect to the market portfolio. This strategy is representative of both divestment and best-in-class type indexes offered by real index providers. An example of portfolio shareholdings for a divestment strategy can be seen in Figure 2.

A fraction, K_{ET}, of index investors follow an "Environmental Tracking" responsible index strategy, which means a strategy that minimises tracking error with respect to the market portfolio with only three constraints:

1) That the total environmental risk exposure of the portfolio be reduced by 50%.

2) The minimum shareholding in any company is 0.1 shares (so as to differentiate this strategy from Divestment).

3) For each company the number of shares held must be greater than the number of shares held for any other company with more environmental risk.

This strategy is representative of the ET Low Carbon Index series created by ET Index based on the ET Carbon Rankings. An example of portfolio shareholdings for an Environmental Tracking strategy can be seen in Figure 2.

A fraction, K_U,of index investors follow an "Unconstrained" responsible index strategy, which means a strategy that attempts to minimize tracking error with respect to the market portfolio with only two constraints:

1) That the total environmental risk exposure of the portfolio be reduced by 50%.

2) The minimum shareholding in any company is 0.1 shares (so as to differentiate this strategy from Divestment).

This strategy is representative of some non-divestment indexes offered by real index providers. An example of portfolio shareholdings for an unconstrained strategy can be seen in Figure 2. The strategy is unconstrained in the sense that the number of shares held in each company in an unconstrained portfolio is not constrained to be in line with the environmental risk level of the company. This is as opposed to the Environmental Tracking strategies where companies with higher environmental risk will always be assigned lower portfolio shareholdings than companies with lower environmental risk (in other words the essence of Environmental Tracking is that shareholdings are 'constrained' by rankings based on environmental risk).

A fraction, K_{ETD}, of index investors follow an "ET Divestment" responsible index strategy, which means a strategy that combines the Environmental Tracking and Divestment strategies to minimize tracking error with respect to the market portfolio with two constraints:

1) That the total environmental risk exposure of the portfolio be reduced by 50%.

2) The number of shares held in any company must be greater than the number of shares held in any company with more environmental risk.

This is different from the Environmental Tracking strategy in that divestment is allowed. This strategy is representative of the ET Fossil Free Index series created by ET Index based on the ET Carbon Rankings. An example of portfolio shareholdings for an ET Divestment strategy can be seen in Figure 2.

Realistic information and the index provider

It is also important to include in the model the fact that in practice investors will only have imperfect information on the expected risks and returns of each company. No individual investor will have perfect information. In this model, though, the average active investor portfolio is derived assuming perfect information, as the active investors are assumed to be a large, diverse group of investors that when investing together lead to the same result in equilibrium as a single investor with perfect information. However, the same reasoning cannot apply to the index investors as in practice index investments are dominated by a handful of large players. Each of these players will have noise in the information that it uses to compute its index strategies. And due to the use of similar procedures this noise will often be correlated between index providers. Thus, in this model it is conservatively assumed that there is only one index provider that calculates the strategies for all the index investors.

The index provider makes a noisy estimate of the matrix of correlations between stocks in the economy. The correlation matrix is assumed to be equal to the true matrix plus random noise (to be mathematically precise, the standard risk covariance matrix Σ is perturbed by $dD'D$, where D is a matrix of values drawn from the standard normal distribution, so that the symmetric nature of the covariance matrix is preserved).

It is however still assumed that both the active investors and the index provider have perfect information on the level of environmental risk of each company.

Following Heinkel et al. (2001), each active investor, *j*, chooses their allocation, x_{ji}, to each stock, i , to maximize their utility function:

$$U_j = \sum_i x_{ji}(\mu_i(r_i) - P_i) - \frac{1}{2\tau}\sum_i \sum_k x_{ji}x_{jk}\sigma_{ik,j}(r_i, r_j)$$

where P_i is the price per share of company i, τ is the risk aversion parameter, and $\sigma_{ik,j}(r_i, r_j)$ is the covariance between returns of companies i and k as viewed by investor j.

Given a fixed percentage of responsible investors (among active investors) and responsible index investors (among index investors) all the investors determine their orders for shares in each company, and the companies decide how much to spend on reducing environmental risk until an equilibrium is reached and each company has a stable price per share. This equilibrium is determined by the market clearing condition: that for the equilibrium set of share prices the total demand for shares in each company (i.e. the holdings of all active and index investors) must equal the total supply (i.e. the number of shares each company has issued).

However, note that the equilibrium share prices and investor allocations change as the percentage of responsible investors and responsible index investors changes (that is, as the demand for shares with different environmental risk characteristics changes). The results of these changes are the focus of this report.

Choice of Parameters

The following parameter values were used:

- τ = 10 is a typical value for risk aversion (Ang, 2014).
- J = 85%, meaning that 15% of investors are passive index investors, is in line with observed levels of passive investment (Boston Consulting Group, 2015).
- σ^2 = 100 and μ=10 are consistent with Heinkel et al. (2001).
- ρ = 0.3 is a reasonable choice in line with average levels of correlations observed in the stock market globally over the last 25 years.

- $\rho_E = 0.5$ was chosen to reflect that the effects of environmental risk are likely to be more systematic and less diversifiable than standard risk (hence a higher correlation parameter than ρ above).
- The number of companies $I = 50$ was set simply to enable the computational solution of the model in a reasonable amount of time. The results were found to not vary significantly when tested with other numbers of companies.
- $\sigma^2_{Global} = 5$ (5% of the standard risk level σ^2) was set in order to include a non-trivial but still reasonable level of global environmental risk.
- The parameters which determine the distribution of environmental risk among the companies, $a_0 = 0.2$ and $b_0 = 4.6$, were set to give an exponential distribution to the level of environmental risk across companies, from very little (0.2% of standard risk) to a significant 20% of standard risk at the higher end. This reflects the distribution of carbon intensity levels observed in the ET Carbon Rankings. The resulting curve of environmental risk levels across companies is shown in Figure 1.
- The cost level parameter $c_0 = 0.1$ was set to give a level of reduction costs intended to be reasonable but conservative. With this parameter value the most environmentally risky company would have to spend 20% of profits to reduce its environmental risk by 63%. This compares conservatively to Heinkel et al. (2001), where all companies can eliminate 100% of their environmental risk for a cost of just 5% of their expected returns. This is conservative in this context because the greater the cost to reduce environmental risk the lower the impact responsible investors will have on the market. So, to provide a tougher test of the impact of responsible investors, greater costs are assumed for the average company in this report than in Heinkel et al. (2001)

The correlation noise parameter $d = \sqrt{0.1}$ was set such that the covariances were perturbed by noise with a standard deviation of 5% of the standard risk variances.

Except for the results shown in Question 5 in Section 4, it was maintained that $K_M = 1$, $K_D = K_{ET} = K_U = K_{ETD} = 0$, so that the results highlight the impact of responsible investors when index investors remain neutral. For Question 5, the index investors were alternately assigned 100% to each of the five index strategies (holding the market portfolio, Divestment, Unconstrained, Environmental Tracking, and ET Divestment), which enables Question 5 to show the different effects of different index strategies on global risk.

Results

The behaviour of the model as the number of responsible investors was increased from 0% to 100% was investigated to answer the following questions.

Question 1: How do the different investment strategies perform as the percentage of responsible investors increases?

As illustrated in Figure 3, as the percentage of responsible investors increases, responsible investors' portfolios enjoy capital gains (relative to investors in the market portfolio) as stocks start to be priced in line with responsible investors' expectations. The returns from this effect are greatest for the earliest responsible investors.

Capital gains also accrue to responsible index investors as the percentage of responsible investors increases. The Environmental

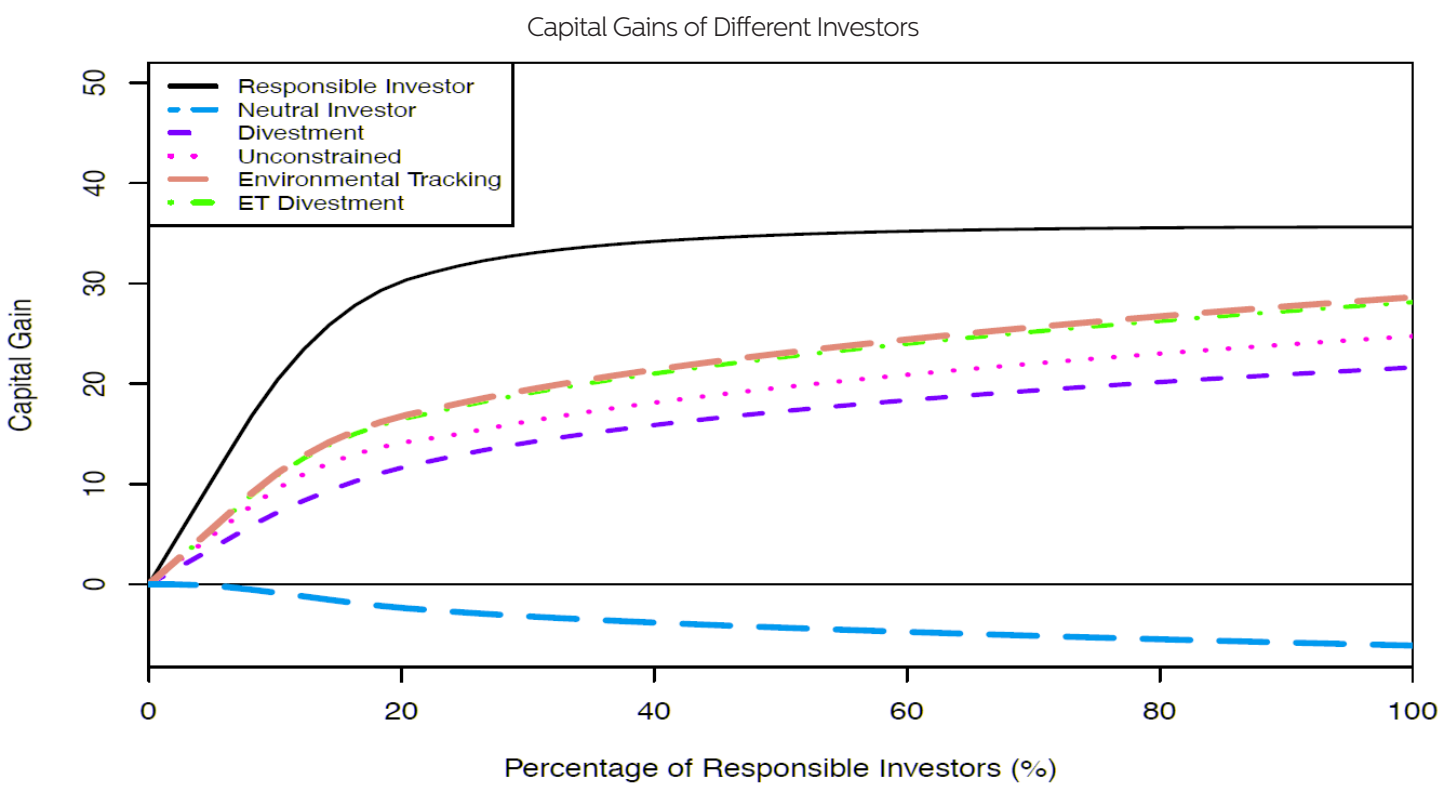

Figure 3: Cumulative capital gain of each strategy relative to simply holding the market portfolio, as the percentage of responsible investors (among active investors) increases from 0% to 100%.

Tracking and ET Divestment strategies experience the greatest capital gains of the index strategies. These gains are lower than the active responsible investor strategy, but the responsible investors' more extreme gains can be explained by the fact that they can take advantage of their lack of a short sale constraint (so they can bet more heavily against environmentally risky companies, and thus enhancing their returns).

Note that Figure 3 is the result when all index investors are assumed to hold the market portfolio. The results for different mixes of index investor strategies are similar.

Question 2: What do the shareholdings of the different investment strategies look like?

The portfolio for each strategy can be thought of in terms of the number of shares that is held in each company. Note that the market portfolio in this model consists of holding 1 share in each company. The tilt of a strategy's portfolio towards stocks with lower environmental risk can be assessed visually by looking at the strategy's shareholdings relative to the market portfolio.

The shareholdings of each responsible index strategy and the responsible investors' strategy are illustrated in Figure 2. These are the shareholdings when the percentage of responsible investors is still 0%, so that no company has made any risk reduction and each company's environmental risk is still as displayed in Figure 1.

The Unconstrained and Divestment approaches are clearly significantly perturbed by the small amount of noise that has been added to the correlation information used by the index provider. This occurs because the index provider is using their correlation information to produce a strategy that is optimal according to the information they have been given. However, as portfolio optimisation procedures can be very sensitive to the input information, when the noisy information is provided to the index provider's unconstrained optimisation model, a result arises that can appear to have little to do with the true environmental risk inherent in each company.

Despite the imperfect information available to the index provider, the Environmental Tracking and ET Divestment approaches maintain intuitive and reasonable share holdings (that is, the number of shares held in each company is in line with the environmental risk of the company). The Environmental Tracking-based strategies can achieve this because the shareholdings in each strategy are constrained to follow the rankings of the companies according to their environmental risk. This constraint provides order to the strategies' shareholdings, even though the Environmental Tracking strategies are also optimised to have low tracking error to the market portfolio.

Question 3: What do the expected returns of the different strategies look like, and how do they depend on the percentage of responsible investors?

Figure 4 shows the expected Sharpe ratio for each strategy as the percentage of responsible investors increases, in the case when index investors are assumed to hold only the market portfolio. The Sharpe ratio is a standard measure of risk-adjusted returns, equal to the expected return divided by the standard deviation of the expected returns.

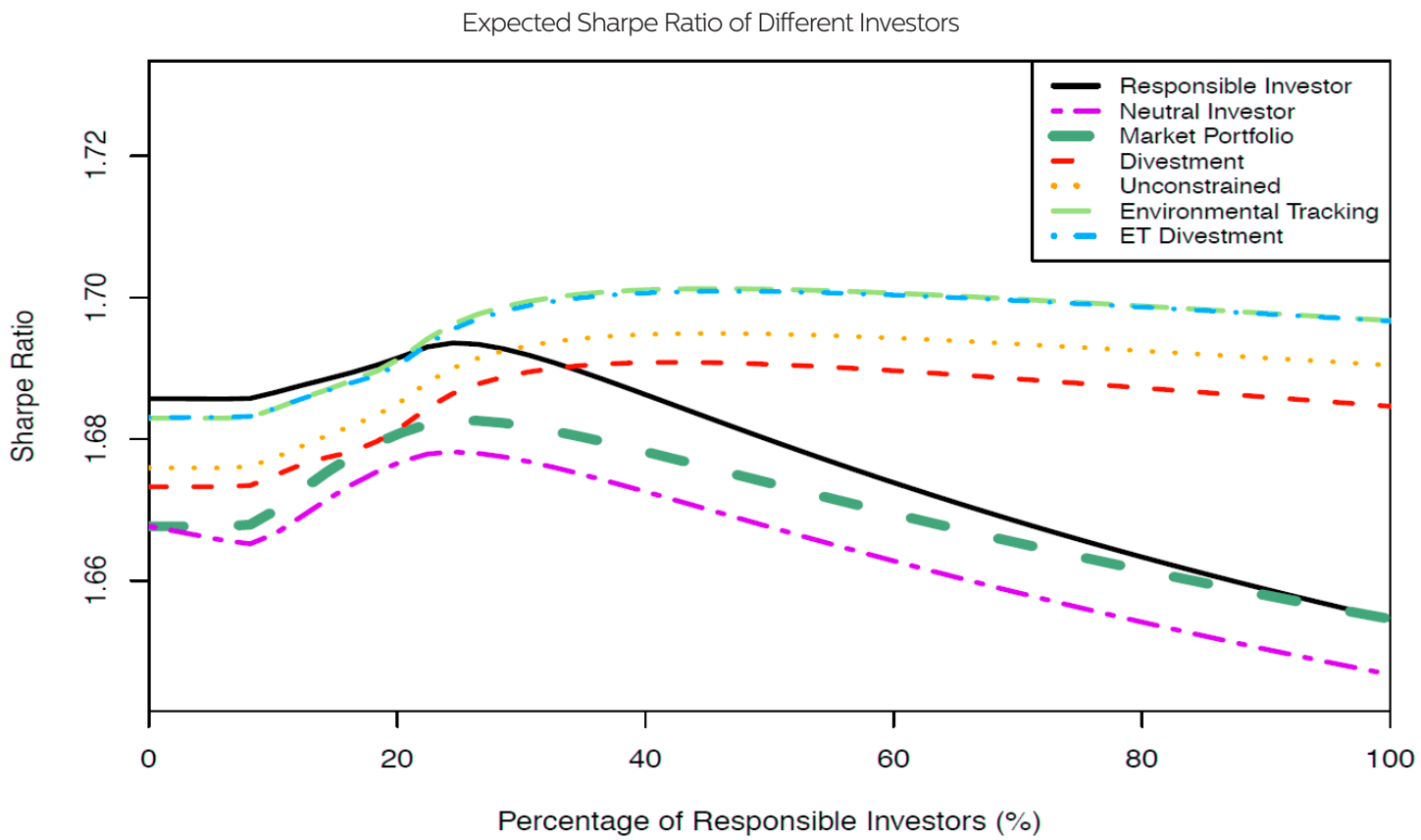

Figure 4: Expected Sharpe ratio of each strategy as the percentage of responsible investors (among active investors) increases from 0% to 100%.

The fact that the Sharpe ratios of all the responsible investment strategies are better than the neutral investor strategy makes sense as the responsible investment strategies take environmental risk into account. By not accounting for these risks, the neutral investor strategy is always missing out on information that could be used to improve its Sharpe ratio, and thus it will always have the lowest Sharpe ratio.

Similarly, the Market portfolio exhibits a lower Sharpe ratio than the responsible investor strategy when the percentage of responsible investors is low (so the market is dominated by investors that don't incorporate environmental risk information into their allocation). But the Market portfolio's Sharpe ratio converges to that of the responsible investor strategy as the percentage of responsible investors increases to 100% (when the Market portfolio becomes equal to the responsible investor portfolio).

The Environmental Tracking and ET Divestment strategies exhibit the highest Sharpe ratios. This appears to be because Environmental Tracking strategies can cut through the noise that has been added to the index provider's correlation information and still determine the (close to) optimal strategy when environmental risk is considered. As can be seen in Figure 2, the shareholdings in the Divestment and Unconstrained portfolios are heavily perturbed by the noise in the correlation matrix, and thus these strategies cannot expect to achieve an optimal Sharpe ratio. The shareholdings of the Environmental Tracking strategies, on the other hand, are clear and intuitive and the most similar to the responsible investor strategy shareholdings among all the index strategies.

The result that the Environmental Tracking strategies realise greater Sharpe ratios than even the responsible investor strategy, as the percentage of responsible investors increases, can be explained as the Environmental Tracking strategies can maintain a relatively aggressive strategy even as the percentage of responsible investors increases. However, as the percentage of responsible investors increases, the responsible investor strategy slowly starts to become the market portfolio and when this happens it can no longer be tilted towards lower environmental risk companies (which would help it maintain a higher Sharpe ratio).

Question 4: How do these results relate to theoretical "arbitrage" arguments that claim responsible investment will never be profitable or have impact?

Harmes (2011) contains an example of such an argument, where it is speculated that:

"The impression created is that ethically-motivated funds, including the large public defined-benefit pensions, would have sufficient assets to sell the shares of a company with poor environmental performance, causing the stock price to drop in a way that would create a real financial incentive for improved performance.

However, as basic financial theory indicates, this will simply not occur due to the existence of 'arbitrage.' Specifically, if a number of ethically-motivated investors sold-off the shares of a company with poor environmental performance, causing the stock price to drop, other investors would view that company as undervalued in market terms and would quickly purchase its shares causing the stock price to almost instantly return to its original value." (p. 114)

Harmes (2011) gives no reference to indicate where this argument comes from. It contains at least two major implicit assumptions:

- That neutral investors are massively, infinitely, more numerous than responsible investors, or that even if neutral investors are a minority they somehow have access to an infinite supply of capital with which to back their positions.
- That environmental performance is unrelated to financial performance, or that it is already fully reflected in current market prices, and thus that making use of environmental risk information will not enable responsible investors to outperform the market.

To treat this argument with mathematical discipline, in the context of the model of this report these assumptions could be translated into one (or a combination) of the assumptions discussed below.

It could be assumed that the fraction of responsible investors is zero ($K_R = 0$), as well as that all index investors only hold the market portfolio. In this case, responsible investors will of course have zero impact. However, if this is the only assumption, and environmental risk remains, then as shown in Figure 4, responsible investment still leads to improved risk-adjusted returns (as the first responsible investor, even when $K_R = 0$, enjoys a better Sharpe ratio than the neutral investors). Thus, it remains a rational strategy to implement.

It could also be assumed that the cost to companies to reduce environmental risk is extremely high. In this case, the responsible investors will again have zero impact as it is true that they will not be able to affect share prices sufficiently to lead to companies paying the cost to reduce environmental risk. However, as with the previous point, if this is the only assumption, and environmental risk remains, then as shown in Figure 4, responsible investment still leads to improved risk-adjusted returns. In fact, high costs will lead to environmental risks remaining large as companies won't invest in risk reduction. Because responsible investors will consider this enduring environmental risk, they will be able to generate better Sharpe ratios than neutral investors. Thus, responsible investment remains a rational strategy to implement. In addition, if the fraction of responsible investors does increase, then early responsible investors will still enjoy capital gains (as in Figure 3) despite having no initial impact on company behaviour.

Finally, it remains to make the assumption that environmental risk is zero (in the financial context of this report). This could be the case if either environmental performance has no relationship to financial performance or if environmental risk is fully contained within standard risk (i.e. it is "priced in"). In this case, it is true that the rational responsible investors of this report will invest according to the same share allocations as neutral investors and thus have zero impact and achieve exactly the same returns as neutral investors. And it is only this assumption that will lead to this null result for responsible investment, with or without the other assumptions reviewed above. However, this result depends on the strong assumption that environmental risk is exactly zero.

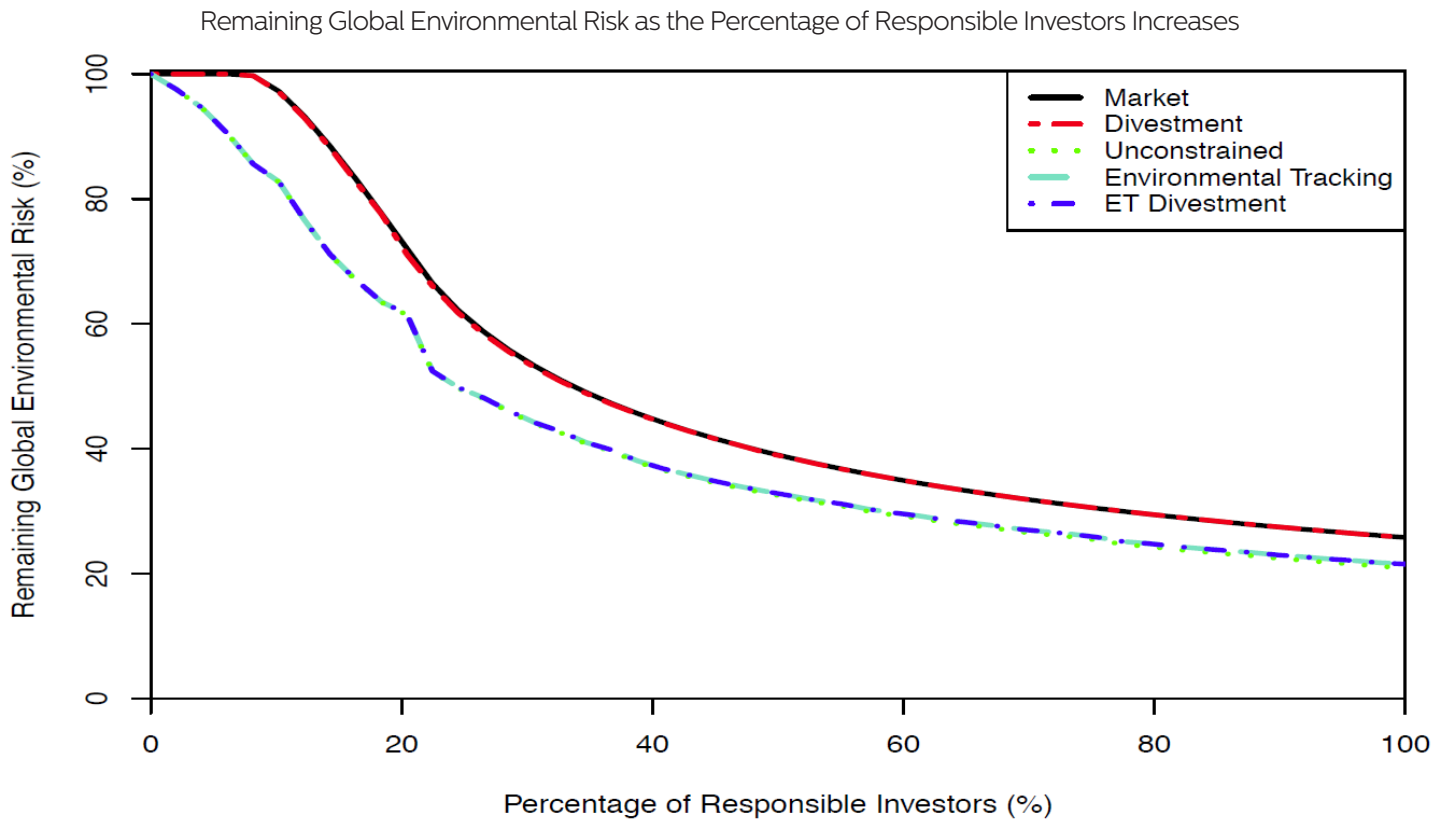

Figure 5: Remaining global environmental risk as the percentage of responsible investors (among active investors) increases from 0% to 100%. The five lines show the curve when index investors all follow one of the listed strategies.

Harmes (2011) contains a disciplined review of the forms that environmental risk can take, and the practical constraints that limit the ability of the market to have fully priced in these risks at the present time. The fact that environmental risks exist in the real economy, but that there are structural reasons to believe that these risks are not fully priced into the financial markets, suggests that environmental risk is not exactly zero.

Question 5: What impact do responsible investors have on the level of risk in the overall economy?

Figure 5 shows the level of global environmental risk as the percentage of responsible investors (among active investors) is increased from 0% to 100%, under 5 different scenarios where it is assumed that all index investors follow a single one of the 5 index strategies (holding the market portfolio, Divestment, Unconstrained, Environmental Tracking, and ET Divestment). That is, the fractions of index investors in each of these strategies (K_M,K_D,K_{ET},K_U,K_{ETD}) are each separately set equal to 1 (forcing the other fractions to 0) to produce one of the curves.

Firstly, these results show that responsible investors can have an impact as an increasing number of responsible investors leads to a dramatic drop in global environmental risk. This drop arises because responsible investors investment choices have convinced companies that it is worth paying the cost of environmental risk reduction.

Secondly, these results show that index strategies which consider environmental risk across all companies, and not just among the riskiest ones, have the greatest positive impact on global risk reduction. The Market and Divestment scenarios are bundled together on the right, while the Environmental Tracking, ET Divestment and Unconstrained strategies are all together on the left demonstrating much faster global risk reduction curves (in terms of the percentage of responsible investors required to achieve a given amount of global risk reduction). This is surprising as the Divestment strategy has been designed to have a level of environmental risk reduction greater than or equal to the other responsible index strategies (that is, 50% risk reduction). So, the reduction of environmental risk exposure of the Divestment strategy, and hence of its demand for environmentally risky shares, should result in similar price pressure to the other responsible index strategies and hence similar effects on the global risk reduction curve.

However, note that to truly reduce global risk by a large amount, even with the exponential shape of the risk curve in Figure 1 (which means that the riskiest companies account for a majority of global risk), all companies must elect to reduce their environmental risk. Further analysis of the results shows that it is the least environmentally risky companies who act first to reduce their risk, as while these companies do have low environmental risk levels, it is cheap for them to further reduce these risks relative to the riskiest companies (which have proportionally higher costs). Thus, the Divestment strategy, by not offering incentives to all companies (for example, commitments to invest more in a company's stock if it reduces its risk, like the Environmental Tracking strategy offers), does not offer greater incentives to the early, low-risk companies that begin the reduction in global risk. Thus, even if all index investors follow the Divestment strategy it does not accelerate the amount of global risk reduction as the percentage of responsible investors increases.

Figure 5 does show, however, that the adoption of the Environmental Tracking strategy by index investors (and of the other responsible index strategies that consider environmental risk across all companies), can accelerate the reduction in global risk levels that occurs as responsible investors become a larger percentage of the investor population.

Conclusion

In this report the model of Heinkel et al. (2001) has been extended to yield a (still) simple but realistic equilibrium model of the financial markets to assess the effect of responsible investors on the market.

The key findings are that:

- *Purely out of utility-maximizing self-interest on the part of both themselves and companies, responsible investors can create a significant decrease in global environmental risk.*
- *All responsible investment approaches, both active and index-based, enjoy capital gains as the percentage of responsible investors increases.*
- *In practical settings, Environmental Tracking approaches are the best performing strategies, both in terms of capital gains as the percentage of responsible investors increases and in terms of expected Sharpe ratio.*
- *All responsible investment strategies benefit most from increases in the percentage of responsible investors when this percentage is still small - thus investors considering responsible investment strategies should act now to maximise returns.*

Additionally, note that while not explored as an effect in this report, the clear signal sent by investors following an Environmental Tracking strategy makes these strategies an excellent tool for influencing both companies and other investors. This can complement other engagement activities that an investor pursues, and ultimately lead to a faster increase in the number of responsible investors and thus to earlier capital gains for the first investors to implement these strategies.

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Jonathan is the Chief Technical Officer and Head of Research of ET Index Research, a responsible investment strategy firm. With over a decade of international experience in finance, Jonathan's expertise is in portfolio management and risk modelling. Before joining ET Index Research he was at Credit Suisse where he completed the development and implementation of a global multi-asset class portfolio risk model. Previously he has worked at investment and trading houses in Europe, North America, Australia and Asia. Jonathan holds an MSc in Financial Mathematics from Stanford University, and a BSc (Honours) in Physics and Mathematics from the University of British Columbia. He is currently completing research towards a PhD in Finance at EDHEC Business School.

Equity Markets Valuation Using CAPE

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Introducing the CAPE ratio

When it comes to global equity portfolio allocations, relative stock market valuations are one of the most critical factors that influence investors' decision-making. "Are stocks undervalued or overvalued?" is an old and ongoing debate among financial market participants. This question is of the utmost importance given its considerable investment implications.

One way to address the issue of determining whether the stock market is relatively cheap or expensive, is to use the Cyclically Adjusted Price-Earnings ratio (CAPE), a measure developed in 1998 by the Nobel Prize-winning economist Robert Shiller of Yale University and his former colleague Prof. John Campbell (now at Harvard) .

This measure is the real (i.e. inflation adjusted) index price level divided by a 10-year average of real earnings. By using a 10-year average, the CAPE reduces the cyclical element of earnings' fluctuations, and thus is particularly appropriate for comparing valuations over long horizons - whereas the traditional price earnings ratio is more business-cycle sensitive and volatile. The CAPE ratio is often presented as one of the best forecasting models for long-term equity returns, and multiple papers have been published on this subject .

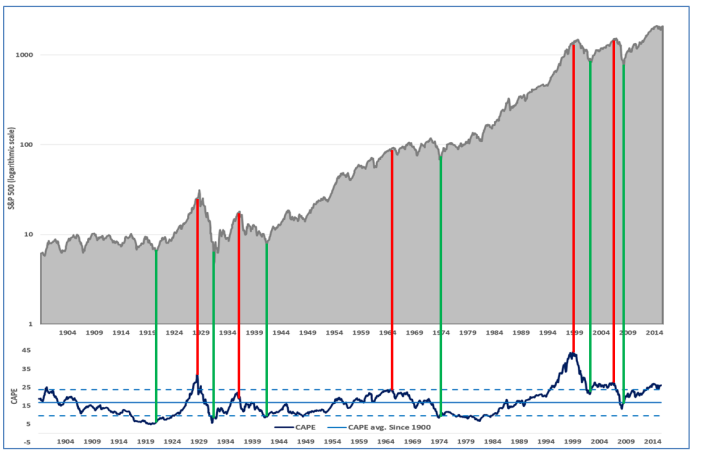
In this paper, we first discuss the pros and cons of using this indicator as a market timing tool, we analyze what current valuations say about expected stock returns, and then we provide CAPE measures for the US and European equity markets, two markets of interest to institutional investors.

CAPE as a market timing tool?

The advantages

Historically, low CAPE values, i.e. below 10, have been followed by higher stock market returns, and conversely, high valuations, i.e. CAPE values above 25, have generally led

Exhibit 1: S&P 500 and CAPE values since 1900



Source: Shiller's website, Author's calculations

to lower expected returns, and increase risks of major stock market sell-offs. For example, the CAPE correctly warned in the years before 1929, 2000, and 2007 that the US stock market was relatively expensive – with CAPE values higher than 25, far above its 20th-century average of 15.2 – and the market subsequently crashed. Hence, as a mean reverting indicator of market valuation, the CAPE can be useful in a world where investors sometimes forget that trees do not grow to the sky.

The two following graphs in Exhibit 1 represent the S&P 500 index and the CAPE values since 1900. The green and red lines linking these two graphs correspond to 11 major market inflection points. As a rule of thumb, they are associated with either low CAPE values followed by bull markets (green lines), or high CAPE values followed by upcoming bear markets (red lines).

However, one can note that the CAPE ratio has remained relatively high over the last two decades. It is equal to 26.2 as of July 2016 and so far, its 21st century average stands at 25.3, a 66% greater level than its 20th century average of 15.2. In this context, after the bursting of the internet bubble in 2000 (following an all-time high CAPE value of 44.2 in Dec. 1999), the market bounced back in Feb. 2003 despite a still relatively elevated CAPE of 21.2.

The S&P 500 levels and CAPE values associated with the 11 market inflection points depicted above are presented in Exhibit 2 below.

As we can see in Exhibit 2, there is a strong correlation between the CAPE ratio and market inflection points. Most bullish markets were preceded by low CAPE values, while bearish markets followed high CAPE measures.

Along the same lines, Exhibit 3 shows the cumulative price return over the following 10 years as a function of the current CAPE ratio. Here again, the negative slope coefficient confirms that high

Exhibit 2: S&P 500 and CAPE values at inflection points

	Aug 1921	Sep 1929	Jun 1932	Feb 1937	Apr 1942	Jan 1966	Dec 1974	Aug 2000	Feb 2003	Oct 2007	Mar 2009
CAPE	5.2	32.6	5.6	22.2	8.5	24	8.3	42.9	21.2	27.3	13.3
S&P 500	6.45	31.30	4.77	18.11	7.84	93.32	67.07	1485.46	837.03	1539.66	757.13
Upcoming Market	Bullish	Bearish	Bullish	Bearish	Bullish	Bearish	Bullish	Bearish	Bullish	Bearish	Bullish

CAPE values should sound as an alarm bell for investors, whereas low CAPE values might look like compelling entry points and longer-term opportunities.

Furthermore, the coefficient of determination (R^2) indicates that market valuation alone explains 15% of the cumulative price returns over the next 10 years.

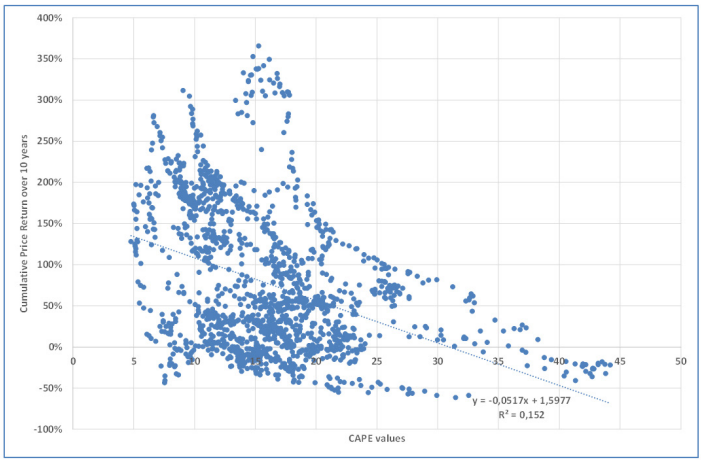
For all the above reasons, the CAPE seems to be an effective market valuation metric. Nonetheless, it is one thing to value the market, but another to correctly time it.

The drawbacks

Indeed, when it comes to market timing, the CAPE effectiveness is largely questionable. With a 10-year average S&P 500 earnings per share of $80.6 as of July 2016, and historical minimum and maximum CAPE values respectively equal to 4.8 (in Dec.1920) and 44.2 (in Dec.1999), simulating the potential corresponding S&P index values at constant earnings would lead to an index level as low as 385.7 or as high as 3563.2. Such a large range makes it difficult, if not impossible, to time the market using the CAPE alone.

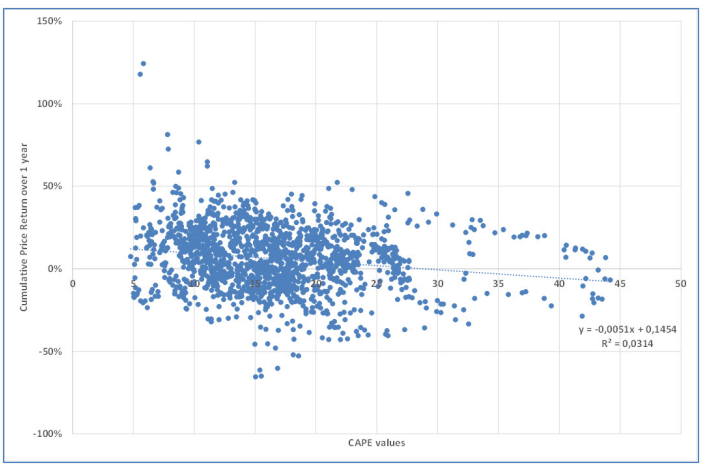
Besides, in the short-term, there is no clear relationship between current CAPE and cumulative price returns over 1 year (see Exhibit 4 below). As Shiller acknowledged himself, the "CAPE was never intended to indicate exactly when to buy and to sell".

Exhibit 3: Cumulative price returns over 10 years as a function of the CAPE



Source: Shiller's website, Author's calculations

Exhibit 4: Cumulative price returns over 1 year as a function of the CAPE



Source: Shiller's website, Author's calculations

Sometimes, it can take a while before the market reverts to the CAPE's historical mean, e.g. since the beginning of the 21st century, the CAPE has spent only nine months (out of 199) below its all-time historical average of 16.7. In such cases, the CAPE has been a poor timing indicator, and blindly translating the ratio into buy or sell orders would have been disastrous for investors.

Moreover, as Siegel (2016) pointed out, another flaw in the CAPE is related to the changes in earnings computation since the early 1990s. The introduction of the mark-to-market accounting by the Financial Accounting Standards Board impacted the way US GAAP (Generally Accepted Accounting Principles) earnings are calculated. These new standards have led to a downward bias in earnings during market downturns, when asset prices are depressed, and heavy losses are potentially concentrated in few financial stocks. This results mechanically in an increased CAPE, and subsequently in lower forecasted equity returns.

Last but not least, it may be at the same time both a strength and a weakness, but the CAPE does not take into account the current market environment. While ultra-dovish central banks policies and low to negative interest rates are clearly underpinning current equity valuations, the CAPE remains insensible to the prevailing "lower for longer" market paradigm, and TINA "There Is No Alternative" effect pushing US stock market to all-time highs.

Having gone through the main advantages and disadvantages of the CAPE, we are now going to take a closer look at current equity market valuations in US and in Europe.

Equity markets valuation using CAPE

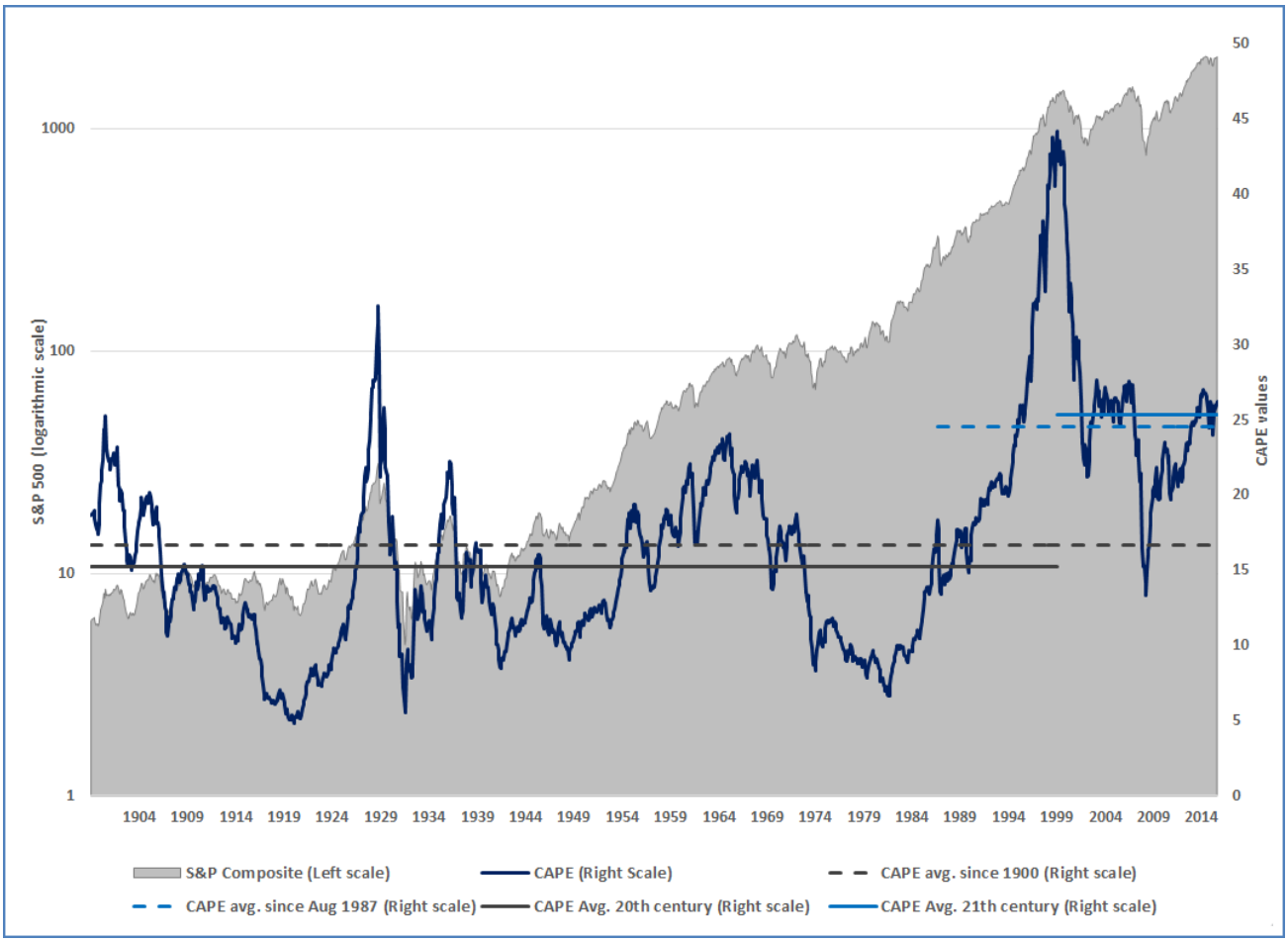
The case for the US equity market

The following chart in Exhibit 5 presents the S&P 500 index (left scale), and the CAPE ratio along with some of its historical averages (right scale).

Moreover, to further put market valuation into perspective, Exhibit 6 provides a comparison of the current CAPE value of 26.2 (as of July 2016) with those multiple historical averages and its all-time average.

Depending on the selected period for the long-term average, investors might consider that the US equity market is either largely overvalued (by 57% or 72%), or just a bit higher than its historical standards (by 7% or 3%). Then, choosing which horizon is the most relevant is a very important but subjective question. As Siegel mentions: "When we say overvalued vs. history, we have to ask, is this period like history?" In our view, using a long-run average including the Great Depression, both 1st and 2nd world wars and the subsequent Cold War is inappropriate because market conditions are totally different now. Thus, we

Exhibit 5: S&P 500 and CAPE values since 1900



Source: Shiller's website, Author's calculations

Exhibit 6: CAPE historical averages vs current market valuation

	Avg. 20th century	Avg. Since 1900	Avg. All-time	Avg. Since Aug 1987	Avg. 21st century
Values	15.2	16.7	16.7	24.5	25.3
Current relative valuation	$\frac{(26.2-15.2)}{15.2} = +72\%$	+57%	+57%	+7%	+3%

propose August 1987 as a starting date for historical comparison since it corresponds to the nomination of Alan Greenspan as the president of the FED. In our view, this arguably marks the beginning of a new era for investors with the so-called "Greenspan put" resulting in higher equity valuations. On this basis, the US equity market appears to be slightly overvalued (by 7%) relative to its average since that date, but hardly in bubble territory.

The case for the European equity markets

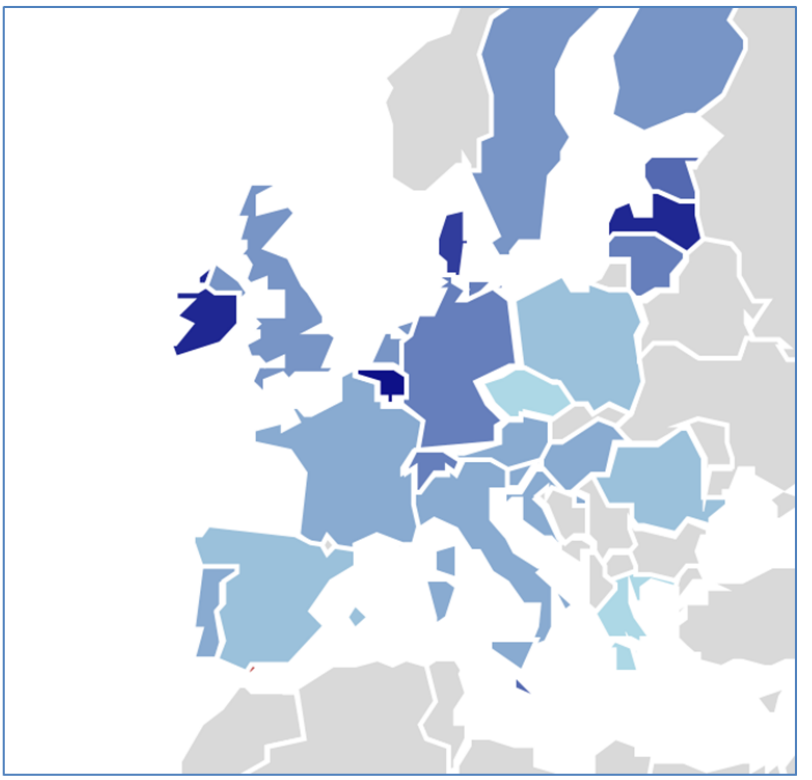
Using Shiller's methodology, we have also worked out the CAPE ratio for 26 European stock markets and presented the results in Exhibit 7 below.

There are very large discrepancies in CAPE values across Europe. At first sight, with a ratio of two, Greece looks extremely cheap while the Irish, Latvian and Belgian markets are deemed expensive with CAPE values respectively equal to 38.5, 38.5 and 45.8. This does not automatically imply these markets are heading for a fall, but it does suggest there is better value and upside potential in other European equity markets.

However, before reaching any definitive conclusions on the attractiveness of one country relative to another, when comparing stock markets with different index compositions, one might keep in mind that the CAPE can be sector-dependent. For example, Price/Earnings valuations tend to be relatively low for the banking sector, while they are generally higher for the technology sector. So, part of the differences in the CAPE of European markets can be attributed to the relative sector weightings of the different stock market indices. However, while this can explain our results, it does not affect them : Valuations in the Old Continent are largely

Exhibit 7: European equity markets valuation

Country	Bloomberg Index	CAPE as of July 2016
Belgium	BEL20 Index	45.8
Latvia	RIGSE Index	38.5
Ireland	ISEQ Index	38.5
Denmark	KFX Index	35.9
Malta	MALTEX Index	27.3
Estonia	TALSE Index	26.3
Switzerland	SMI Index	23.9
Lithuania	VILSE Index	22.5
Germany	DAX Index	20.4
Finland	HEX Index	19.1
Netherlands	AEX Index	17.2
United Kingdom	UKX Index	16.4
Sweden	OMX Index	16.3
France	CAC Index	15.6
Luxembourg	LUXXX Index	15.5
Hungary	BUX Index	15.4
Croatia	CRO Index	14.5
Portugal	PSI20 Index	13.7
Austria	ATX Index	13.3
Italy	FTSEMIB Index	13.3
Slovenia	SBITOP Index	13.1
Romania	BET Index	10.6
Spain	IBEX Index	9.4
Poland	WIG20 Index	7.9
Czech Republic	PX Index	3.5
Greece	ASE Index	2.0



Source: Shiller's website, Author's calculations

Legend: The light blue colour is associated with relatively "cheap" markets on a CAPE basis while dark blue is associated with relatively 'expensive" markets.

dispersed but with CAPE values equal to 13,3 for Italy, 15,6 for France, 16,4 for UK and 20,4 for Germany, the main European markets are largely below the US CAPE level of 26,2.

Conclusion

Although the CAPE was never intended to be an indicator of impending market crashes, high CAPE values have been associated with such events and conversely, low CAPE values have gone hand in hand with high cumulative long-term price returns. Hence the importance of following this indicator regularly.

Obviously, stock markets are a complicated system, with many moving parts, and neither the CAPE, nor any other single "magical" indicator can come up with what "should be" their valuations, particularly in today's unique market paradigm.

However, given the strong correlation with the CAPE and long-term equity returns, this measure can be a valuable input for any institutional investor willing to identify which equity markets are likely to offer the best potential. From the initial portfolio construction to the periodical allocation review, this CAPE assessment can be made regularly over the life of the equity investment program.

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ESG In Infrastructure

Abigail Beach
EMPEA

In infrastructure investing environmental, social and governance (ESG) issues remain critical considerations for practitioners given the long-term time horizon and often relatively significant financial investment required. During the first half of 2016 US$1.8 billion of capital was invested in infrastructure and real assets in emerging markets.[1] ESG considerations and best practices evolve as capital is continually raised and deployed across the asset class. Relative to other asset classes such as private equity, infrastructure investing is comprised of a complex and nuanced mix of ESG factors including land acquisition, resettlement, community engagement and environmental impact. These complexities are revealed in the industry standards and guidelines as well as the types of risks, considerations and priorities that influence a firm's ESG management system for infrastructure investing.

Industry Standards and Guidelines

Industry standards and guidelines are often the foundation for investors' ESG management systems in infrastructure investing.[1] The World Bank Group EHS Guidelines & Industry Sector Guidelines, the IFC Performance Standards, Equator Principles, PRI Principles, CDC's ESG Toolkit for Fund Managers, and Infrastructure Sector Profile are commonly cited references. The World Bank Group Environmental, Health, and Safety (EHS) Guidelines and the Industry Sector Guidelines are technical reference documents which can be tailored to risks and contexts of specific projects, including varying local regulations. Included in the EHS Guidelines are performance levels and measures

1. Industry standards & guidelines
   These are commonly referenced resources by practitioners active in infrastructure in emerging markets.
   - The World Bank Group EHS Guidelines
     - ► Industry Sector Guidelines
     - ► IFC Sustainability Webinar Series
   - IFC Performance Standards
   - Equator Principles
     - ► Equator Principles Implementation Notes
   - PRI Principles
   - CDC Toolkit
   - CDC Infrastructure Sector Profile

that are typically accepted by IFC and believed to be realistic in "new facilities by existing technology at reasonable costs."[II] The IFC Performance Standards also provide a framework to manage environmental and social risks.[III] As a risk management framework, the Equator Principles (EPs) provide a base standard to support responsible decision making. EPs are designed to be applied globally and across industries.[IV] The Principles for Responsible Investment (PRI) are six principles developed by global institutional investors to reflect the current ESG issues related to investments.[V] CDC's ESG Toolkit for Fund Managers is a comprehensive reference guide for ESG related issues. There is a specific section dedicated to helping Fund Managers (GPs) develop a tailored ESG management strategy.[VI] In addition, GPs will benefit from the toolkit's infrastructure profile which is part of the guide's sector profiles. For practitioners active specifically in the energy sector, the Actis Energy Impact Model is a comprehensive tool that can be easily adapted.[VII] Maximizing the value of these standards and guidelines requires practitioners to tailor and customize them to align with the context of their infrastructure investment. Paul Winters, Managing Director, Chief Compliance Office and General Counsel for Denham Capital explains, "The operating environment is key. For each infrastructure project we incorporate and align the current operating environment context into our ESG strategy." Part of the operating environment also involves integrating local regulations and standards as well as individual ESG guidelines that institutional investors may have. Institutional investors will typically outline their ESG best practices, guidelines and procedures through legal commitments including the LPA and side letters.[2]

Key Challenges

Managing the social element

ESG factors in infrastructure investing create a unique set of challenges for practitioners. With best practices and industry guidelines many practitioners feel that the environmental element of ESG can be modeled and managed effectively under the appropriate ESG management system. The social aspect of ESG, specifically stakeholder engagement, land acquisition and resettlement are much more dynamic, unpredictable elements. Therefore, the social element of an ESG management system requires a much more nuanced and tailored approach. As stewards of investors' capital it is critical that a firm maintains its social license to operate from the community, otherwise the financial and reputational ramifications can be catastrophic. IFC's Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets is often referenced by practitioners and can be helpful in building out a firm's tailored community engagement approach.

Establishing the right balance

Given the sensitivity and associated potential risks around community engagement, resettlement and land acquisition a key challenge for a firm is to create an ESG action plan that is both comprehensive and pragmatic. Dr. Archana Hingorani, CEO of IL&FS Investment Managers explains, "it can be a challenge to form an ESG action plan for the investment, which is both comprehensive in terms of risk coverage and is also pragmatic in terms of its implementation and monitoring." A comprehensive ESG strategy is virtually worthless if it is not feasible to implement.

Fit for purpose

An effective ESG management approach will consider and take into account the current realities of the business operating environment. A key challenge in infrastructure projects, especially brownfield projects, is tailoring an ESG management strategy so that it is what Dean Alborough, ESG Advisor, AIIM calls "fit for purpose" in the given context. Creating a strategy that is fit for purpose will require practitioners to understand the current context, business procedures and practices for each infrastructure project.

Implementation

Even the most comprehensive and tailored ESG management strategy is useless if the strategy cannot be implemented appropriately. Infrastructure investing requires engagement with a diverse set of stakeholders, each of whom may have different practices and procedures. Ensuring that a firm's ESG management strategy is communicated and implemented appropriately across the supply chain can be a challenge. It is advisable for practitioners to therefore think about how their ESG policy will be communicated, implemented and monitored early in the strategy development phase. A firm's level of ownership can impact its ability to implement its ESG management strategy. In infrastructure projects where firms have majority stake in the investment it can be relatively easy to execute on a strategy. In the emerging markets context, many firms take a minority stake in investments. In cases where ability to exert influence is limited, it is critical that a firm's ESG requirements and conditions be negotiated early in the investment process. Dr. Archana Hingorani, CEO of IL&FS Investment Managers illustrates this point and explains "our Fund's ESG policy and the implementation of such a system, and its monitoring, is built into the investment agreement." Dean Alborough, ESG Advisor, AIIM offers that "limited influence doesn't necessarily mean a firm has to have low influence." Instead he suggests that firms develop good influence over an asset by building relationships of trust with the investee company's leadership over time.

2. When to consider ESG issues
   Council members agreed that it is in the best interest of the fund to consider ESG issues at the earliest possible stage of the investment process.
   In doing so, the fund will have the ability to:
   - Better understand the potential risks
   - Incorporate ESG requirements and procedures in the investment agreement
   - Better align their ESG strategy with the current operating environment
   - Identify potential areas for value creation
3. Main drivers for ESG management in infrastructure investing
   For our Council Members the main drivers for developing an ESG management strategy include:
   - *Risk management*
     Firms recognize that level of ownership doesn't translate to brand risk. If a firm owns 15% of a company and that company fails to comply with regulations the firm's reputational damage is not limited to 15%. Firms see the opportunity to mitigate risk through an effective ESG management strategy.
   - *Value creation*
     There is growing thought leadership around the idea that managing ESG issues can help support investment returns by creating value and identifying profitable investment opportunities.
   - *Investor requirements*
     As institutional investors' level of sophistication around ESG issues continues to grow their ESG considerations and reporting will change. Members noted that private capital investing is a people business. People have varying views and objectives. This leads to a diversity in the ESG drivers. To maximize utility, firms should understand the individual drivers behind each of the stakeholders they engage with.

Nature of the project

The nature of infrastructure projects (brownfield v. greenfield projects) can impact a firm's ESG strategy. Greenfield projects imply that initial ESG due diligence assessments and environmental and social impact assessments (ESIAs) will be required. These assessments can be done under the supervision of the firm. According to Andrew Affleck, Managing Partner, Armstrong Asset Management, "construction phase impacts, which are normally the most important, need to be managed as part of greenfield investments." For brownfield investments Mr. Affleck notes that "assessment of legacy impacts and retroactive review and improvement of E&S management at the corporate and project levels needs to be carried out."

Developing an ESG Management System

Leveraging industry standards and guidelines and understanding the key challenges related to ESG in infrastructure investing will help practitioners build an effective ESG management system (ESGMS).[3] The rationale for developing an effective ESGMS is that doing so will create a framework to manage ESG risks and opportunities associated with infrastructure assets. According to the CDC ESG Toolkit for Fund Managers, "ESGMS are now well established as good practice in the private equity industry."[VIII] Typically, the objective of an ESGMS is to create a systematic approach to incorporate ESG material issues across the investment lifecycle. ESGMS will provide a firm with a great deal of data often at varied levels of granularity. This data can be valuable, even actionable data, if it is appropriately disseminated and incorporated. It is critical for firms to provide formal reporting and communication channels across the firm structure. Individual assets' ESG reports need to be effectively and efficiently incorporated into Board and LP reports. Any information and decisions made at the executive level then need to be appropriately communicated to investee companies. To optimize this process many firms choose to conduct formal quarterly reports which feed into their larger annual reports and any other reports required by their investors. Aditya Aggarwal, Partner, IDFC notes that his firm "has a framework for ESG information dissemination which goes all the way to their LPs." This regular monitoring and reporting of the projects helps to ensure ESG issues at the project level are managed in accordance with the firm's broader ESG strategy. It is equally important to periodically review an ESGMS and incorporate lessons learned and changes in the firm's strategy or portfolio. This will help to ensure that the ESGMS is relevant and fit for purpose.

Buy-in and ownership

ESGMS are only effective if the firm's leadership buys into the strategy behind it. To facilitate this firms may choose to have their Board adopt or even help develop an ESG policy. Acquiring executive leadership approval is only part of the equation, the other vital component requires the development of clear ownership, roles and responsibilities. Even the most comprehensive ESGMS will be virtually useless without someone (or some people) managing it. Many firms choose to dedicate a full-time resource or resources to manage the development, implementation and monitoring of their ESGMS. However, there is no standard approach to ESGMS ownership, instead firms should organize roles based on individual expertise and capacity. Firms may also decide to work with an ESG consultant or advisor initially to build up internal capacity to manage their ESGMS in the future. The most successful ESGMS owner(s) will have the ability to communicate the strategy and empower their investment professional colleagues to take responsibility for ESG performance and help manage it through their daily business activities.

Monitoring

A valuable ESGMS will include benchmarks or KPIs to help evaluate the ESG performance across infrastructure assets. These benchmarks or KPIs should be reevaluated periodically to ensure that they align with the firm's ESG priorities and are relevant to the current operating environment. It is also critical that projects that fail to meet the benchmarks or measures be provided with action plans to address disparities between firm expectations and project realities.[4]

ESG Trends in Infrastructure

As capital is continually deployed in the space lessons learned and trends start to formulate. Notable trends in the space include:

Acknowledgment of potential value creation opportunities

Andrew Affleck, Managing Partner, Armstrong Asset Management describes, "a move from viewing ESG management as purely about risk management towards an understanding that ESG management can create value and also positively differentiate the fund from others." As drivers for ESG management evolve the issues considered and best practices may change as well.

Impact of local regulations

Local regulations are critical considerations in any private capital investment, but regulatory changes can have relatively large impact on infrastructure projects. Aditya Aggarwal, Partner, IDFC notes that recent changes to India's land requirements and sustainable development for land losses have led to a fine tuning of their ESG strategy. This is why it is key to have an ESG management strategy that can easily be adapted to reflect changes in the operating environment.

4. The Value of ESG management systems (ESGMS)
   The CDC ESG Toolkit for Fund Managers provides comprehensive guidance for creating effective ESGMS. According to the Toolkit, "a well-designed and properly implemented ESGMS should add value to the fund and its stakeholders by":
   - Integrating ESG factors across the investment life cycle
   - Creating a framework to manage ESG issues at the fund and investee company level
   - Identifying potential value creation opportunities
   - Establishing a framework to engage with stakeholders
   - Supporting a fund's ESG monitoring and reporting activities

   The CDC ESG Toolkit for Fund Managers provides comprehensive guidance for creating effective ESGMS:
   - Getting started
   - Fund Environmental and Social Management Systems

5. The Value of ESG management systems (ESGMS)
   Practitioners in the space may find this sample of publicly available resources related to ESG issues in infrastructure useful:
   - Actis Energy Impact Model
     (http://www.act.is/media/1404/final-actis-energy-booklet-april-2016.pdf)
   - ERM chapter on effective management of ESG risks in major infrastructure projects
     (http://www.erm.com/en/insights/publications/effective-management-of-esg-risks-in-major-infrastructure-projects/)
   - GEREEF Impact Report
     (http://geeref.com/assets/documents/GEEREF%20IMPACT%20REPORT%202015_FINAL%20final_public.pdf)
   - PGGM Responsible Investment in Infrastructure
     (https://www.pggm.nl/english/what-we-do/Documents/responsible-investment-in-infrastructure_pggm.pdf
   - Responsible Investment in Infrastructure—a case study compendium from PRI
     (https://www.unpri.org/download_report/3784)

Enhanced reporting

LPs are seeking enhanced reporting around ESG. Members noted an increased interest in reporting on key material issues and having a better line of sight. Individual reporting requirements have changed as LPs have become more sophisticated around ESG issues. For additional information on ESG reporting please refer to the EMPEA ESG Reporting brief & Reference Guide.

Emphasis towards clean & renewable energy

Members noted that greater interest in climate change issues and the overall enhanced emphasis on ESG considerations has created a trend of constructing a renewables and clean energy heavy portfolio.

Conclusion

The illiquid nature, long-term time horizon and potential social and environmental impacts of Infrastructure projects influence ESG considerations in the space. Practitioners who recognize these nuances, leverage industry guidelines and make their ESG strategies fit for purpose are better positioned to manage ESG opportunities and risks.[5]

About EMPEA

EMPEA is the global industry association for private capital in emerging markets. We are an independent non-profit organization with over 300 member firms, comprising institutional investors, fund managers and industry advisors, who together manage more than US$1 trillion of assets and have offices in more than 100 countries across the globe. Our members share EMPEA's belief that private capital is a highly suited investment strategy in emerging markets, delivering attractive long-term investment returns and promoting the sustainable growth of companies and economies. We support our members through global authoritative intelligence, conferences, networking, education and advocacy.

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As EMPEA's Manager of Strategic Engagement, Abigail's focus is on advancing members' interests in the emerging markets private capital space through the organization's twelve Councils and the Immersions platform. In collaboration with the Councils, Abigail has developed innovative industry resources and content, including co-authoring material on institutional quality impact investing for Springer International's book: "Positive Impact Investing and Organizational Culture", and producing the EMPEA ESG Reference Guide and Infrastructure Investing Heat Map. Abigail represented EMPEA on PRI's working group for the development of the 2015 Limited Partners' Responsible Investment Due Diligence Questionnaire (LP Responsible Investment DDQ). Through EMPEA's Immersions platform, Abigail has supported the facilitation of over 600 LP:GP meetings globally.

Prior to joining EMPEA, Abigail worked for the Initiative for Global Development (IGD), where she gained experience in generating business value for companies and investors in emerging and frontier markets. During her tenure she worked with members such as Visa Inc. and Pearson plc creating impact assessment tools and advising on their socio-economic impact strategies in African markets. She co-authored several thought leadership reports on maximizing business and social value and African private equity investment opportunities.

Abigail is currently pursuing an Executive Global Master's in Management at The London School of Economics and Political Science. Abigail holds an executive certificate in Global Corporate Social Responsibility from the Thunderbird School of Global Management. She graduated summa cum laude with a Bachelor of Science in Business Administration and Economics from the Moore School of Business; University of South Carolina. Abigail complemented her degree with studies at Stellenbosch University, Vienna University of Economics and Business, and American University. Abigail began her career as a community development worker in South Africa, specializing in entrepreneurship and MSME development in informal settlements.

Shifting Australia's Infrastructure Mindset to the Long Game

Garry Bowditch
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Movers and shifters in infrastructure

This section presents an overview of some long-term trends in infrastructure. It reviews the big behavioral drivers that may shape infrastructure development in Australia, and interprets what that means for governments to provide infrastructure and the future involvement of private sector capital and expertise.

Introduction

The Australian status quo for infrastructure is similar to the broader Organization for Economic Co-operation and Development (OECD). It has had the benefit of an enormous legacy of roads, bridges, tunnels, and water energy and gas reticulation systems, along with a rich fabric of social amenities that support the economy.

It is true the bulk of this infrastructure is ageing, and its economic lives are being extended beyond original expectations. But the opportunities to revitalize this infrastructure have never been better, with a globally connected marketplace for design, engineering, technology and construction services. The transfer of technology and human capital between jurisdictions is high and is expected to intensify. Together these forces should assist Australia, and other developed and developing nations, to adapt and repurpose their infrastructure in a timely and purposeful way.

The composition, size and living patterns of societies continue to grow and evolve. Urbanization is well recognized around the world for the unprecedented impact it is having on the density of settlement and the associated infrastructure needs it is demanding. Australia continues to be one of the most urbanized nations on the planet and the infrastructure agenda for cities needs further enhancements particularly in respect of integrated long term planning of transport and land use, and access to sustainable funding and financing sources.

Australia has a population growth that is more akin to a developing nation, with growth approximately three times that of China (OECD 2016[1]). Figures 1 and 2 show that Australia is set to be the second fastest growing OECD nation and that, in absolute terms, Australia is set to increase its population more than any other developed country except the United States, Mexico and Turkey. Coupled with population growth is a dramatic shift in the demographics where aging will see shifts in living patterns and use of infrastructure that will place new and unexpected demands on the system.

A society that is more educated, connected and informed than previous generations is also emerging as an important ingredient to the infrastructure task. Both community and customers that make up the critical mass of stakeholders in infrastructure are more assertive in expressing their expectations of infrastructure. The complexity of planning, delivering and managing infrastructure has become more challenging, and will demand a great deal more of policymakers, project leaders and industry partners.

Governments must reassess and see that they too earn their social license for infrastructure to be developed. Without this, the scope for wastage and risk of discontent is acutely high for all stakeholders.

Sustainability as a word to describe infrastructure is an important and relatively new development in the vernacular of the industry, as is the emergence of resilience. Together they could be attributed to the issues of climate change and other environmental issues, but the community's expectations for more accountability and responsibility for the resultant service outcomes are in play as well. In particular, enhancing productivity through doing more with less, accommodating a society where time and space are scarce and sensitive to disruption and volatility are critical factors in shaping the policy and operating context of the industry. It is also related to the fact that cyber threats are real and significant across every dimension of the infrastructure system.

The political economy is also an important and enduring trend maker in the sector. Politics of infrastructure are favoring big and complex, and 'transformative' appears to be a word of choice for politicians in describing infrastructure. This in part reflects the difficulty in getting agreement to build infrastructure, and that bi-partisanship is more likely if the project is big. The preponderance of mega projects to be late and over budget is well documented.[2] However, less common is the ability for such projects to be responsive to new information and circumstances. This is often inadequate owing to poor project governance standards that could undermine the social license for both current and future projects.

The next section discusses the importance of retaining a strong institutional memory so that all stakeholders in infrastructure retain a more informed perspective on the size and scope of their current challenges relative to their predecessors. This will be followed by a forward looking assessment of megatrends that are the potential drivers of change expected to shape the infrastructure landscape over the next century.

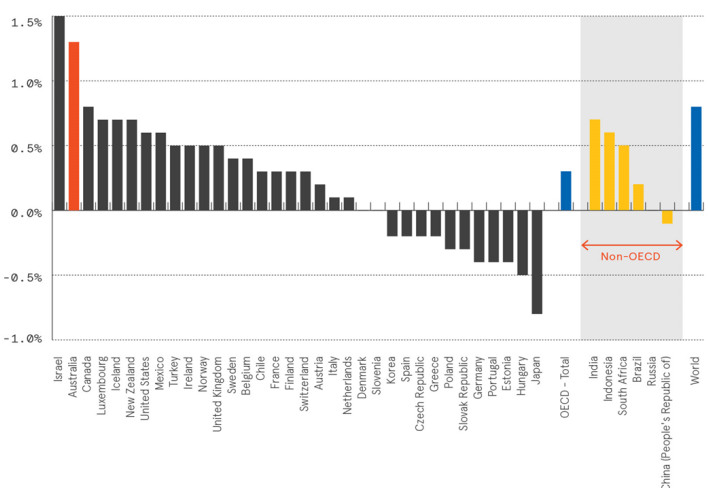
Learning an old lesson again

Infrastructure and human development are synomonous. The waves of innovation that heralded new opportunities for human endeavor and then displaced the old infrastructure are commonplace. But surprisingly, the relationship between economic growth and infrastructure is an area of considerable political and academic debate. Many macroeconomic and microeconomic studies have added to the body of discussion, but have not secured a consensus on its magnitude, causation and timing.[3]

Infrastructure as a word is relatively new and it continues to attract rich variations in definition. According to Goldsmith[4], it first appeared in the Oxford English Dictionary in 1927, and was more often used in a military context up to about 1960. The Proceedings of the Institution of Civil Engineers (Great Britain), published continuously since 1826, contained the first reference to the term infrastructure in 1933 in connection to ports and public works in India.

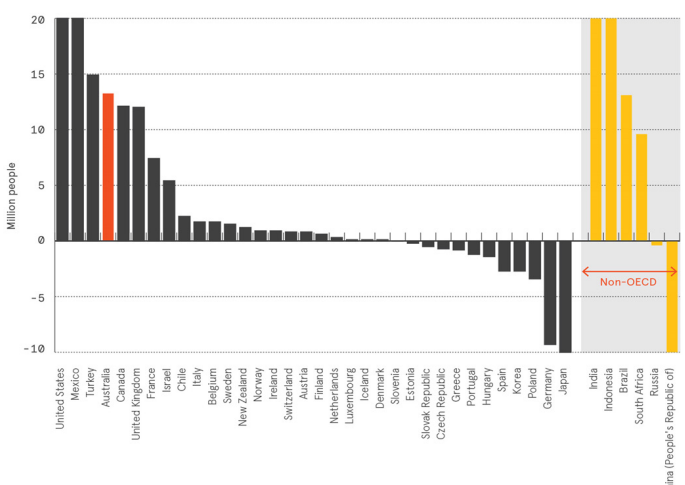
While the physical characteristics of an infrastructure asset and its function has been the cornerstone of most descriptions, there have been subtle shifts in describing the services the asset

Figure 1: Projected average annual population growth rate 2016-2050, OECD and Selected other countries



Source: Organization for Economic Co-operation and Develepment (OECD). 2016. Historical population data projections (1950-2050)

Figure 2: Projected addition to population by 2050, OECD and selected other countries



Source: Organization for Economic Co-operation and Develepment (OECD). 2016. Historical population data projections (1950-2050)

delivers, particularly as private capital is involved and long-term contracts secured. For example, the provision of the actual road is incidental to the fundamental point that the lanes on the road are available, safe and accessible. This has served to be a powerful force for change, when authorities focus on services delivered from the physical asset rather than just building assets.[5]

Despite the technical advancement in infrastructure evident today, much of this has been done in spite of a weak institutional memory. This loss of knowledge from previous infrastructure endeavors, however, is not unique to the modern context. While this is no excuse for permitting a weak institutional memory, it appears that some of the most bold infrastructure endeavors in human history suffered from the same problem.

For example, the Roman Empire created a network of roads and townships coupled with communications systems that would stand proud against any modern context. Importantly, the networks were subject to clear asset standards and project governance. These were standardized in the Law of the Twelve Tables in 450 BCE. There was a strong focus on whole-of-life costs, for example roads constructed to a standard to minimize ongoing maintenance costs. The Romans left a well-documented process on the 'how to' of building physical infrastructure.

Vitruvius (70-10 BCE) lamented, however, that the good practices of the past were being forgotten, and that the Romans had completely forgotten the disciplines of the Greeks in controlling the costs of public works. He cited a law in the Greek city of Ephesus that required architects, when entrusted with public works, to lodge a cost estimate with the magistrate. On completion, if the final costs did not exceed the estimate the architect was celebrated with decrees and honors. When the cost exceeded the estimate by no more than a quarter of the original estimate, it was defrayed by the public purse and no punishment inflicted. But when the cost overrun was more than 25 percent, the architect was required to pay the excess out of his own pocket.[6]

A compelling lesson from history is that our societies would be well served by having a strong institutional memory. In the current policy debate in Australia, it is expressed slightly differently as the need for evidence-based policy development and decision-making. However, calls to address this in infrastructure continue to be inadequate and urgent action is required to ensure these principles are applied.[7]

Wrestling with megatrends

A distinguishing characteristic of infrastructure is its relatively long economic life. It therefore has to accommodate the ebb and flow of multiple trends in business and society and their changing needs. In the case of transport such as bridges and tunnels, they can extend well beyond a century, which is also true for water-related assets like dams and reticulation systems. In the case of energy and social infrastructure assets, their economic lives are typically shorter but still last for many decades.

A megatrend, as defined by the Commonwealth Scientific and Industrial Research Organization (CSIRO), is a major shift in environmental, social and economic conditions that will substantially change the way people live. Megatrends are relevant to contemporary decision making and may prompt a rethink of governance models, business processes and social systems.[8]

It is from this perspective that a study of megatrends can be useful, not for trying to predict the future but for understanding the range of behaviors and forces at work that can shape our economy and society and in turn infrastructure. These megatrends are not intended to be comprehensive nor exhaustive but rather to start a conversation and debate about the drivers of change and their implications.

Megatrend 1: The inflation of expectations

The defining characteristics of successful infrastructure in Australia continues to shift because of a combination of factors related to wealth and income levels along with technological advancement and its availability to broader groups of people.

Traditional measures of the quality of a road in early 1900s were dominated by engineering considerations, such as smoothness of the journey, incidence of potholes. This evolved with an expectation of adequate street lighting to ensure safety, and the use of traffic lights at intersections for safety and improved flow by the mid-1950s.

Further enhancements continued with design flexibility to enable contra-flows to deal with peak demand and breakdown lanes and breakdown car removal services for clear lanes and regular traffic flow. More recent decades have seen real-time traffic information and measures like HOT (high occupancy transit lanes) on selected roads. Over time the basic road has changed from a piece of bitumen-based infrastructure into a higher level technological, information-based service asset. In doing so, it has graduated into a new class of asset performance that can accommodate time sensitive customers, especially in respect to accessing other transport modes, such as airports, as well as heavily congested areas such as central business districts.

Planning infrastructure for the future will need the design to be flexible enough so it can provide for not only additional capacity, but also the ability to break down traditional concepts of aggregate demand into more refined service outcomes for a variety of customer groups. It will also need to have greater service capacity per unit of physical infrastructure.

Other sectors in the economy are experiencing the complexity of demand, particularly in tourism and retail where the customer is seeking an experience (service) rather than the basic consumption of a product. This is affecting infrastructure in all its different forms, as the following examples show.

- Energy customers are expecting to know the origin of their power supply, and are expressing preferences for access to certain power sources that have attributes of no carbon or less intensive carbon emissions.
- Airports are no longer just concerned with the aeronautical functions of aircraft movement and safety. More contemporary drivers include landside facilities such as parking and shopping, along with airline passengers able to reach the hub conveniently, by positioning gates nearby for ease of interchange between planes.

- Water and waste provision is shifting with expectations of stronger environmental standards in the harvesting and distribution of water. Customers are also expecting responsible use of waste, which has triggered innovations for the production of renewable energy and recycled water. This is still evolving in Australia, but wastewater has the potential to change from a cost to a new revenue source.

The upshot is that community and customer expectations are on the rise, and that the static physical assets of infrastructure will need to evolve into dynamic service centers to cater for a plethora of preferences from the community and customers.

The ability to fulfil the escalating expectations of infrastructure customers will demand a different approach from policymakers. Not only is the traditional presumption that infrastructure is a 'one size fits all' for customers and services rapidly approaching redundancy the process of 'right sizing' will remain challenging. That is, how to fund infrastructure of the right size and the time taken to reach reasonable capacity utilization will have even more complexity to it.

Implied in this megatrend is how a focus on bigger, more solid assets may not correlate with the ability to meet the finer resolution of services required, and that more of this may be resolved at a micro-scale using technology, customer-to-customer and business-to- customer solutions that are discussed next.

Megatrend 2: Blurring boundaries

Traditionally infrastructure has benefited from a clear definition of the entities that supply infrastructure, and those that use it. The configuration of energy, water, and transport networks and the supporting regulations continue to have a strong mono-directional flow from producer to the user. The interaction with the customer is often minimal and perfunctory at retail level, but this is often changing for larger business customers.

Technology innovations are undermining this relatively simple 'supply-push' model where producers (which often are monopolies) create the assets and services that are pushed through the network according to a schedule of production and service timetable.

This simple 'supply-push' relationship between producer and user is eroding and 'demand-pull' forces are growing in importance. They bring potentially significant implications for the incumbent producers, and invite new suppliers to enter that can shift industry dynamics.

Supplier and customer boundaries are being eroded by technology that has lowered the transaction costs associated with making infrastructure available to a market of buyers and sellers. This is sometimes referred to as the sharing economy.

Examples of this in the infrastructure sector relate to transport and energy, and are causing greater complexity for policymakers to manage these innovations, and assess the implications for forward planning.

Australia has experienced a disruption in transport from new technologies, both from global and home- grown sources, generally known as a transport asset sharing platform. Uber is commonly recognized in this space, with its introduction to Australia in 2012, and then the introduction of UberX in mid-2014.

The blurring of the boundaries that has emerged with Uber and similar sharing platforms in the supply of transport services is yet to be fully understood or appreciated. These systems, however, do seem to have the capability to liberate latent spare capacity in the private vehicle fleet through an on-demand delivery model.

This is enabled when drivers that are registered on these sharing platforms can at their discretion liberate their time and spare capacity of a private vehicle for a financial return. The consequence of this additional supply is that customers can choose their vehicle of choice, and have a logistic solution to their exact point-to-point journey requirements.

The take-up of this technology remains relatively nascent; nonetheless as it matures and competition intensifies it raises the possibility that the sharing economy could in part meet the escalating freight and passenger logistics task of the nation's cities and regions. Aggregate demand modelling for future public transport projects will need to be cognizant of the potential risks of overstating the need for new projects because of unanticipated shifts in user behavior and technology that can reveal new supply side capacity.

A similar argument can also apply to driverless vehicles, where road productivity may be transformed by higher vehicle density, assuming the technology can do so without loss of speed or safety when vehicles are networked together.

Traffic simulation undertaken by FP Think (2014) suggests that with 75 percent of vehicles autonomous, freeway capacity might be increased by 35 percent.[9] The Bureau of Infrastructure, Transport and Regional Economics (BITRE 2015) estimates that if autonomous vehicles account for 30 percent of the light vehicle fleet by 2030, congestion in Australia will be reduced by around a quarter.[10]

Such technology could also accelerate the blurring between the consumption and supply of infrastructure services as ownership models change to exploit the new opportunities of generating third party revenue from latent capacity in the vehicle fleet.

In the case of the energy sector, the interplay between customer and supplier is also emerging as a source of disruption to the traditional model of centralized dispatch of electricity. For example, households with solar panels (and batteries) are increasingly capable of being more self-sufficient and independent from the electricity grid. As their micro-production of energy becomes more efficient, the excess power can be injected into the grid, making the household both a consumer of electricity from the grid and a source of production to it.

In both cases, replacing the 'push' model of infrastructure production in energy and transport logistics appears to be only a matter of time, as it is resource intensive, and inefficient in matching supply to customer preferences.

The more organic, dynamic and complex set of arrangements where technology is enabling the blurring of production and consumption of infrastructure services has the benefit of

liberating latent production capacity, and satisfying a more diverse and range of customer needs and expectations. As this megatrend evolves it may bring with it a number of implications.

- It may challenge infrastructure planners to question and re-evaluate demand forecasts for future infrastructure based on historical trends.
- Higher vehicle productivity may imply a future of fewer cars that travel more and deliver enhanced mobility but with a more cost effective vehicle-sharing ethos.
- It may refocus efforts to ensure legacy infrastructure can remain viable, as necessary, to interface with and accommodate new technology that liberates latent capacity and enhances customer service.
- It may enable a price for service culture to emerge. Instead, sharing assets can shift the size and scope of the so-called infrastructure dollar deficit, and reduce new capital investment requirements.

Finally, the need for new infrastructure to meet the strong population and economic growth of Australia will continue to be a priority for the medium term. However, the dividends to the nation of greater flexibility in reusing and repurposing existing infrastructure with the benefit of new technology needs greater understanding. This is a priority for public transport agencies to adopt new technologies that could delay or potentially substitute costly new projects in favor of more capital-efficient solutions.

An early understanding of the consequences and opportunities of the megatrend blurring boundaries could yield the economy and taxpayer a significant productivity boost, and money saved for the taxpayer from delayed or abandoned projects.

Megatrend 3: Risking innovation

Innovation is fundamental to our wellbeing, and wherever there are challenges and necessities of life to be met, there will be inventiveness. Extracting the full potential of innovation is desirable, provided it is legal to do so, and where its benefits exceed costs. But there are an expanding array of institutional, contractual, governance and cultural impediments that are frustrating the innovation process.

These regulatory and institutional impediments to innovation can have a number of effects, including the ability to stop innovation altogether, or shift the innovation to another less efficient part of the value chain.

For example, during the period of the early 1900s with the introduction and rapid propagation of private motor vehicle ownership in the United States, there was a ride-sharing scheme started in 1914 by L P Draper, a car salesman in Los Angeles. He observed very long queues to catch the public transport trams in the city so he set up a sign on his car to say he would take passengers wherever they wanted to go for a 'jitney' (slang for a nickel).[11]

Draper met with extraordinary success, by 1915 there were 50,000 rides per day in Seattle, 45,000 rides per day in Kansas and 150,000 rides per day in Los Angeles. Uber founder Travis Kalanick says that Uber 100 years later is doing 157,000 rides per day in LA. But within just a few years the Jitney bus was regulated and taxed out of existence, as the monopoly public transport authorities imposed onerous conditions and licensing fees on it because according to Kalanick they saw the ride-sharing scheme as pernicious.

The global economy had to wait almost 100 years before another scaled attempt at ride sharing began. In the meantime, without ride sharing, car ownership exploded and so did the inefficiencies of accommodating a car fleet that was prevented from extracting the true efficiencies of the private motor vehicle. Kalanick argues the results are congestion, massive carbon emissions and excessive spare capacity as private vehicles were used for less than 10 percent of their productive capacity. Cities were affected, with at least 30 percent of the building stock devoted to car parks and building and maintaining bigger roads.[12]

Innovations in the electricity distribution network are occurring vigorously at the household level, particularly in the form of micro-solar production and storage of energy. Regardless of the motivations of the households to adopt new technology (e.g. reduced carbon or hedging against future energy costs) maintaining continuous, reliable and secure electricity remains essential for the vast majority of customers.

The costs associated for household to invest in their own energy production and storage to maintain an uninterrupted energy supply is onerous; and it may not be beneficial from a social welfare perspective for them to do so. That is because the risks associated with accessing a suitable energy source and preventing an outage could be achieved much more efficiently at a higher level of the network.

For example, dealing with these types of risk can be effectively managed, if regulation permitted more customer-led innovation and adoption of new technology to occur within the central network, and in this case at the sub-station. The basic economics at play is that installation of batteries at the the sub-station could enable better risk pooling across a larger groups of people/ households.

Furthermore, different consumption and production profiles from households across neighborhoods can enhance reliability and cost effectiveness where technology and innovation enables greater efficiency and reliable two way flows between generation, storage and consumption. Improving the network configuration between households and their local sub-station may also infer wider economic benefits to management of the very elongated east coast grid and the role fossil fuel has had to play in helping to stabilize the network.

Customers can and should be driving change in the way assets and networks are governed. But too often regulatory and institutional arrangements are less dynamic, and can be quick to treat innovation as unnecessarily disruptive, denying both customers and taxpayers better services and superior productivity. While this could be boiled down to monopolies just seeking to protect their economic rent, it is also possible that infrastructure governance has over emphasized cost minimization and protecting the status quo in the interests of continuity and reliability of service delivery.

Australia should seek to enable, as many parts of its infrastructure networks be open to innovation and led by the customer.

However, when this is not possible owing to the impact of regulation or other restrictions, customer led innovation can be forced to the periphery of networks like at the household level. Greater freedom to adopt new technology and innovate at the household level can be very costly and potentially inefficient compared with what could be achieved if the network were more adaptable to customer requirements.

Infrastructure governance practices: a customer's friend or foe?

This section reviews current infrastructure governance practices with a special focus on land transport, and how this vital sector of infrastructure is engaging with, and enabling innovation, adaptability and customer-led services.

Introduction

The following section examines governance arrangements for publicly available contracts, some of which are PPPs, through two different but complementary lenses.

- Firstly, effectiveness in mobilizing resources in the early life cycle of infrastructure, from project inception to final delivery.
- Second, to understand how asset owners and operators that work within these long term governance arrangements manage the changing requirements from shifting long-term economic and social change over the asset life cycle.

Access to contractual documents, especially those relating to PPPs was limited owing to commercial in confidence. Only Victorian contracts were examined, with contract summaries relied upon for other PPPs. A list of the contracts reviewed is detailed in Appendix B found in the full report available online.*

Getting the basics right

There is a broad range of public infrastructure governance models at work in Australia as outlined in Table 1, with many variations, they basically range from the examples given below.

- Direct government provision: cradle to grave direct government provision where public sector design and construction contracts are led by public works departments. Operation and maintenance occurs through traditional contracting with private sector parties to supply some or all of these services to government agencies.
- Corporatization of government trading enterprises, which has introduced greater balance sheet discipline and accountability to the delivery of infrastructure services.
- Privatization of assets, which is now commonplace in sectors such as airports and telecommunications.

Much of the focus on infrastructure governance reform has been concerned with seeking to get the basics right. Reform effort focused on project origination linked to infrastructure needs assessments and development of value for money criteria used at the investment decision (business case) stage and contract execution. Technical enhancements have also been sought in the preparation of project documentation and procurement, including risk allocations and ensuring transparent competitive processes.

Lifting the quality of governance around whole- of-life asset management has seen significant developments in design and lifecycle maintenance to maximize lifetime value. PPPs have been at the forefront of this advancement, using output (rather than input) specifications and a risk allocation process to help drive efficiencies in whole-of-life design and operation.

The role of government as both a buyer and customer is very important in setting the way the market meets its needs. Despite improvements in governance arrangements, governments still have much room for further improvement, especially in respect to customer-led infrastructure decision- making. This improvement process will take time and is most likely to occur when governments evolve from being a basic buyer of infrastructure assets to a facilitator for deeper interaction between customers and asset owners. This will require governments placing market design at the center of infrastructure governance.

Market design is concerned with the way governments organize market actors, information, pricing signals, risk allocation and scope for innovation to achieve public policy objectives. The most basic precondition for this to occur is for governments to be more explicit, clear and transparent about the objectives of their infrastructure interventions, and in turn bring equal clarity with respect to the problem they are seeking to remedy.

The setting of clear objectives and problem identification when commissioning projects can help give the public and private service providers greater latitude to innovate. That is because the government is less prescriptive about inputs, which can invite more vigorous innovation including extracting more value from existing infrastructure, rewarding capital savings initiatives that reflect their true economic value to the taxpayer, and focusing on service outcomes rather than the more superficial physical characteristics of the proposed solution.

From this perspective, market design matters, as it goes to the core of asking the right things of the markets and shaping the values and behaviors of the market participants to deliver against clearly stated public policy objectives.

Challenging infrastructure to adapt

Markets can be a powerful means of transmitting signals for change and as a catalyst for infrastructure to adapt to the dynamic

Table 1: Overview of infrastructure governance models

Delivery Forms	Direct provision	Contracting	SOEs	PPPs	Regulated privatisation	Privatisation with liberalisations
Role of government	Planner, manager, producer	Planner and manager	Owner and planner	Planner and regulator	Regulator	Referee
Project selection	Government	Government	SOE and government	Government	Private firms but with government influence	Private firms
Governance mechanisms	Command and control	Public procurement law	Corporate governance	Contractual agreements	Sector regulation	Competition policy

Source: Organization for Economic Co-operation and Develepment (OECD), Towards a Framework for the Governance of Infrastructure, September 2015 (pp.26)

needs of customers and community. Of course, markets require customers and suppliers, and while this is a simple proposition there has been an extraordinary level of administrative complexity that has evolved around procuring infrastructure and delivering services.

This has occurred because of a number of factors, not least among them is that much of the infrastructure sector is made up of large monopoly entities that require regulation to ensure market power is not used inappropriately. In other cases, regulatory standards are important so infrastructure complies with public policy objectives such as safety, reliability and universal access.

Governance arrangements for utility services, such as electricity, gas, water and telecommunications, have changed greatly in the past twenty years and market forces play a much greater role in determining the services provided and which parties provide them. The private sector's role has increased markedly over this period.

Road and rail services exhibit monopoly characteristics and the government's role is still dominant and relatively little use is made of market forces and cost reflective prices to find out consumer preferences and inform future investments. Subsidies enabling heavily discounted prices compared to cost of delivery have somewhat perversely enabled the availability of infrastructure services to meet universal access and social equity objectives, but at the same time they have also blunted the quality of customer interaction.

For many public infrastructure services, the procurement of assets and service delivery is done administratively, and therefore the purchaser (in other words the government department or agency) acts on behalf of the users and customers. While this is done on a best endeavors basis, it nonetheless causes a wider separation between final consumer and infrastructure service purchaser/ procurer compared with competitive markets. It can also result in a less flexible service offering that is made on a 'take it or leave it' basis.

Equally, the distinction between funders and users is important. The latter generally has very limited scope to influence service provision because a government agency acts as purchaser and administratively determines service type and standard.

Table 2 provides a high level overview of the governance arrangements for service recipients and purchase arrangements and the scope for customer engagement that apply in a number of sectors that make up infrastructure. Despite a very wide spectrum of customer models there is a clear skew to relying on administrative-led service provision, which is where customer interaction is predetermined according to a production or service timetable schedule that is set by the infrastructure owner/ purchaser.

In the case of urban arterial roads and urban passenger rail, the primary beneficiaries of the infrastructure services are direct community users (the travelling public). For urban water services, the direct beneficiaries are those who receive the water services; however, very important externalities exist also in respect of public health. This is similar to urban roads and urban passenger rail where externalities in respect of public safety, congestion, air quality, and land use agglomerations are involved. Importantly, urban water users are paying overall for the full cost of providing these services, but individually may not be bearing the direct cost of the water service provided to the household.

It would be fair to point out that highly competitive markets operate in stark contrast to these examples. For instance, direct community users are in fact customers and are both the purchaser and funder of the service or product. Mobile telephony comes closest to this in the infrastructure sector.

In essence, where users of the infrastructure services are also funders, there appears to be much more scope for them as active agents in determining what, when and how services are supplied. That is being a customer as opposed to a passive 'user' where services are offered on a 'take it or leave it' basis.

The extent to which infrastructure users can transform into infrastructure customers entirely depends upon the nature of the infrastructure governance arrangements in place. While urban water users still have relatively little impact on the nature of services provided, wholesale customers appear to have a larger influence in electricity. In the case of mobile telecommunications, the customer is more fully empowered.

The state of play with governance in land transport towards supporting and empowering customers is in need of further reform. In fact, land transport continues to entrench the community as 'users' and significant reform is necessary to begin the transformation to the status of a customer and with it more disciplined investment, innovation and adoption of technology.

Translating administrative process to customer outcomes

Within Australia, specialist public sector agencies are responsible for arterial road and urban passenger rail system-wide service delivery. There has been considerable effort and reform to be more customer-centric. The models used range from a single entity with responsibility for planning, funding and delivery (e.g. roads in Victoria) to a purchaser- provider model (e.g. NSW, rail in Victoria).

It is important, however, to recognize that when infrastructure entities are established with relative autonomy and clear performance objectives and accountabilities, together this can help achieve better customer interaction and outcomes. This was borne out when the Australian Government and states undertook widespread corporatization in the late 1980s and 1990s. Improving the technical efficiency of the government trading enterprises, along with more disciplined capital investment to meet customer requirements were important outcomes.

Under a purchaser-provider model, a central public transport entity coordinates public transport and undertakes network-wide planning and contracts specialist service delivery entities to meet specified service level requirements. Performance-based contracts set out service delivery and reporting requirements to be met by the specialist delivery agencies.

There are important differences between models, and also within models, that influence the service responsiveness of the agencies. This is illustrated below by looking at the nature of the objectives set for the delivery agencies and the scope and specificity of key performance indicators (KPIs).

Table 2: Purchasers and service recipients

Sector	Service recipients	Purchaser	Customer engagement
Urban arterial roads	Direct community users (drivers and passengers)	Taxpayers (major); Direct community users (minor – despite tolls with full and partial cost recovery)	Limited, owing to lack of direct user charging (about 8 percent*) being a small proportion of road revenue. In the case of toll roads, there is potential of a higher level of engagement but may require a change in the contract deed to shift to a more active customer approach.
Urban passenger rail	Direct community users (passengers) Road users (via reduced road congestion)	Taxpayers (major); Users (minor – subsidised fares)	Limited, owing to lack of direct user charging to recover costs (under 30 percent**), prevents deeper price for quality exploration with customers. Strong attempts to create a customer oriented culture among public transport agencies through mainly punctuality and cleanliness performance criteria.
Urban water	Direct community users	Direct community users (postage stamp pricing)	Medium, scope to bundle services such as maintenance asset purchasing for water appliances and plumbing.
Corrections	General public (major) Inmates (minor)	Taxpayers	Very limited.
Highly competitive markets (eg mobile telephony)	Direct community users (customers)	Direct community users (customers, full cost recovery)	Unfettered for engaging, anticipating and shaping customer product and services. Active price discovery mechanism to allocate capital and manage risks. Full spectrum of price for quality offering.

**BITRE (2015) Australian Infrastructure Statistics Yearbook, Table T1.4*
***BITRE (2013 Urban Publiec Transport: updated trends, information sheet 59, p.12*

Suppliers of infrastructure services through traditional government contracts often have little commercial incentive (and few tools) to change supply arrangements to better satisfy customer needs. For instance, even in the case of current toll road PPPs there is limited use of the price mechanism for users to pay for a particular service outcome (e.g. HOT lanes on a motorway[13]). In Australia, toll road owners/operators generally have contractual discretion to lower tolls in off- peak periods (but generally do not as demand is inelastic) but on the other hand they do not have the discretion to raise tolls during peak periods.

However, even in best practice jurisdictions, there appears to be room for further improvement to better reflect opportunities for a more dynamic and service oriented approach to the customer within the broader transport system. That is governance arrangements tend to be modally centric, and have limited emphasis concerning the quality of the intermodal interface between trains, trams, buses, cars, bicycles and walking.

However, there are positive developments toward a better modal interface. For example, Transport for NSW is about to provide a customer discount for changing modes with the Opal Card from mid-2016. This is a powerful indicator of system-wide governance awareness and giving greater priority to a more seamless intermodal approach to transport logistics.

It is not clear, however, the way in which service standards and levels are set among the agencies reviewed in Appendix A (available to view in the full report online*) and what mechanisms are in play to allow these to be varied over time with changing customer and community priorities. Customer satisfaction surveys are important but they have limits in informing decision-makers about willingness to pay and the opportunity cost of investing in one area compared with another.

While considerable administrative effort has been expended by public agencies to understand user requirements and reflect it in specifying service type and quality, there is very little in these

processes that resemble market characteristics where prices and quality of service are set by customer interactions.

Surprisingly, it appears that clarity of objectives and accompanying KPIs directed at the customer appear to be more readily acknowledged with a purchaser- provider model than some PPPs. This is discussed further in the next section.

When market-based reforms are neither possible nor appropriate, governments can establish specialist delivery agencies with specific and transparent KPIs in favor of the customer, and reinforced with strong and independent monitoring arrangements. These were also the guiding principles at work in the period of wide spread reform of government trading enterprises in the late 1980s and early 1990s in Australia.

Internationally, some jurisdictions have been reforming their governance models for managing arterial roads that have been informed by the Australian experience and extended into areas that Australia did not include at that time. The following paragraph discusses Highways England as an important case example to help inform the next wave of reform for Australia.

Highways England

Highways England was established in 2015 as a government owned strategic highways company with responsibility for managing the English strategic roads network. Compared to the agency it replaced, Highways UK the new Highways England has been empowered with a strong governance model to be customer-centric and more accountable for its capital and maintenance decisions. It has the mandate to develop a 25-year vision along with a certainty of funding arrangements that are on a 5-year basis. Importantly, its funding level has been boosted significantly above that of recent years, to reflect past chronic underfunding of the road network.

Private contractors are responsible for the design and delivery of road maintenance in a particular area of England for a period of four or five years, with the option to extend to seven years. The road user has been placed at the center of Highway England's focus along with much longer-term planning.

The Department of Transport has set Highways England clear and measurable performance targets aimed at providing better and more efficient roads that is financially sustainable and forward-looking. Rigorous and transparent assessment of Highway England's performance, including by specialist independent agencies, is as part of the reform process.

Understanding the changing needs of road users through regular surveys and through its 'Smart Motorways' initiative is a focus of Highways England. It is aiming to make use of communications and other innovations to increase the capacity of a motorway by a third while only slightly increasing its physical footprint.

Highways England is a useful case example to inform the Australian land transport reform agenda. Providing funding certainty and access to a big enough revenue base to meet the life cycle costs of managing an arterial road network will present special challenges and inevitably will require a new set of financial arrangements between the Australian Government and the states.

Can customer responsiveness thrive in PPPs?

An underlying intent to PPPs is that the parties will work cooperatively to address changing circumstances and together the contractual parties will be open to new opportunities that are mutually beneficial during the term of the contract. To facilitate this, PPP contracts generally make explicit provision for change initiatives proposed by the private party. Key elements to these provisions typically are:

- government approval is required before any change can be made
- government must respond as soon as possible to the private partner's proposal
- parties agree to sharing costs and benefits
- unless specifically agreed by a government, agreement to a change proposal does not provide the private partner any relief from meeting its original contractual obligation.

In practice, private partners have activated change provisions in relatively few circumstances, as shown in the following examples.

- In the case of availability PPPs, where the private partner's focus is on cost reduction rather than revenue enhancement, there is often little scope for initiatives that materially reduce its costs while providing additional benefit to government. And where such proposals require significant additional payments by government, often the contracting agency does not have the fiscal autonomy to agree to such changes without going through the approval processes to secure an additional appropriation.
- Where the private partner's revenues come largely from users, there is greater scope in practice for private partners to suggest mutually beneficial value creation changes. However, in practice, these provisions are not designed for large value creation proposals. Governments have an underlying preference to use competitive tendering processes where it is practical to do so.

There appears to be a greater scope exercised by governments to transfer risk under PPP contracts, particularly full service toll road contracts. However, this has not translated to a high level of specificity in KPIs for customer service outcomes.

Risk transfer is based on the proposition that risk is transferred to the party best able to manage it. In the case of the private sector toll road concession holders, they generally have no control over the adjacent roads network or traffic flow and are essentially passive in their ability to control patronage. Developing new products and services, and use of the prices to engage and shape demand are extremely limited.

The upshot is that toll road concession holders are least able to manage patronage risk from a network perspective, and this is exacerbated further with very limited flexibility within the PPP contract to engage with and find the pricing and quality service outcomes.

This makes the operational flexibility of PPP toll roads very limited, and relatively static compared with the broader road network. Making changes is complex and potentially costly to the taxpayers, as the concession holder is entitled to compensation where changes are financially adverse.

There is also a high level of public interest sensitivity with variations to contracts. Some governments have established unsolicited bid frameworks to deal with large value creation proposals rather than rely on contractual mechanisms.[14] For instance, the Victorian Guideline states that: "Proposals must meet a series of important tests and be in the public interest to proceed under the guideline. Proposals will only proceed where they meet Government objectives, provide benefits to the community and achieve value-for-money."[15]

Unsolicited bids associated with live PPP projects that have been approved in Victoria include widening the Tullamarine Freeway component of City Link. This has required associated contractual amendments to the City Link PPP agreement.

While mechanisms exist to adjust PPP contracts, there is a legitimate question as to whether they are suited to the changes that arise in the adaptation to new technology and shifts in customer preferences over the medium to long term.

For example, road PPPs typically are very long-term contracts, ranging up to 40 years in length and rail PPPs can be up to 20 years. This period of time make it entirely possible that new technology, such as smart motorways and even 'driverless' vehicles could present a broad spectrum of challenges and opportunities to materially alter these contracts.

PPPs specify detailed performance requirements, and payment arrangements for meeting those performance requirements, day in, day out, for the length of the contract term. The winning PPP tenderer is the party that shows it has the best proposal to meet those requirements for government. As such, PPPs can provide a best value for money outcome for government compared with other delivery models in meeting the prescribed performance requirements, and in doing so provide long-term certainty for both parties to meet their obligations.

PPPs generally contain mechanisms for dealing with changes, such as capacity augmentations and/ or refinements to KPIs. In some tender processes, 'flexibility' is an evaluation criterion and tenderers are asked to provide a design that more readily allows for likely changes. For example, a government may anticipate that a proposed prison will require expansion in the future and ask PPP bidders to submit designs that will facilitate ready expansion when required in a way that minimizes cost and disruption to prison operations.

Consistent with this approach, change provisions in road and rail PPP contracts allow government options to secure additions like a road traffic lane or rail capacity. Change provisions also extend to improving service levels, along with mechanisms that determine the compensation provided to the private partner for undertaking the associated capital works and related ongoing operational costs. It should be noted, however, that the focus with these change provisions is concerned with securing the government's desired change at least cost.

All road PPPs acknowledge that government is free to make any changes – physical and operational (e.g. changing speed limits) to the broader arterial road network. The PPP contract cannot fetter government in its role as network operator. However, governments can face greater administrative complexity and financial compensation claims if the change leads to the concessionaire losing money.

This is particularly relevant in toll road PPPs where the private party's revenues rely on vehicle numbers. In some PPPs, for example EastLink in Victoria, Cross City Tunnel and NorthConnex in NSW, the physical protection provisions for the private party are limited to direct feeder and egress roads, as well as to changes that specifically affect the toll road (e.g. speed limits). In other cases (e.g. City Link), a broader range of network changes encompassing physical or operational changes can lead to compensation claims.

In the case of NSW Smart Motorways, the state and federal governments are planning to fund the $400 million upgrade to motorways that will entail variable speed limits and signage, extensive ramp metering and better use of on-shoulder traffic.

Together these measures will result in substantially better service outcomes for the motorway customer for traffic flow and improved arrival time, and be financially beneficial to the PPP operator on the adjoining network.

A question in search of an answer is, how could PPP operators responsible for the adjacent motorways be incentivized to make a smart motorway type investment on the entire Sydney ring road?

Regardless of the earlier merits of the original PPP contracts that helped accelerate the building of the Sydney ring road, there was insufficient consideration given to the operational and financial incentives for operators to be continuously improving customer outcomes through innovation and adoption of new technologies.

These challenges are exacerbated by the lengthiness of the toll road contracts – up to 40 years. Current government practice to extend the contract term as a form of compensation for the cost of enhancements made by the concessionaire (such as through acceptance of unsolicited bids from the concessionaire), means it may be a long time before governments could resume full and unfettered operational control over their urban arterial road network: without recourse to paying compensation to PPP toll road concession holders.

More generally, the failure decades ago of previous governments to establish PPP contracts with stronger customer service incentives are keenly felt by motorists and the community today. This highlights the limitations of past PPP contract practices, and the need to continue with a program of ongoing reform of contractual arrangements centered on services and customer outcomes over the long term.

The current road funding model provides little direct relationship between customer use, service standards and fees and charges for use of the network, even in the case of where the PPP can charge motorist full cost recovery.

This situation has been subject to considerable criticism; however, a simple shift to cost reflective pricing in the absence of other

measures, like fully integrated land use and transport planning, is unlikely to overcome the problem of perceived inadequate road space and escalating traffic congestion.

The existence of long-term toll road contracts in major metropolitan areas is likely to further complicate the introduction of broader road user charging owing to the obligation to provide financial compensation in some cases where there are material adverse effects on concession holders.

Governments could either seek to renegotiate the tolling regime on these roads, and provide the owners with the negotiated financial compensation or accept that they will not be able to introduce a comprehensive consistent road user charging regime until the final toll road contract expires, sometime after 2050.

The use of availability PPPs in the road sector (as in Peninsula Link) do not appear to pose the same constraints on operation of the arterial road network. In the case of the Australian rail PPP models, these are essentially 'availability' based and leave the government with much broader options for network governance and pricing reform.

In the Peninsula Link contract, the private partner receives a quarterly availability payment from the state, which it receives in full if all contractual KPIs are met. Changes made by VicRoads to the broader physical road network may affect traffic on Peninsula Link but will not alter the private partner's revenues. If the state seeks to change service level KPIs on Peninsula Link, it will need to negotiate compensation arrangements with the private partner but this should be relatively simple because it does not involve modelling traffic and revenue projections.

Performance-based contracts, such as the NSW stewardship road maintenance contracts, appear to provide a good model for future road service delivery contracts. They are customer focused with simple measurable comprehensive KPIs and with real incentives/sanctions for performance. The contract term is long enough for the service provider to take a longer-term perspective. Not only are the KPIs relatively extensive and well-targeted compared with toll road PPPs, but also the incentives and sanctions are relatively more important in terms of revenue at risk.

Shifting the mindset: play for the long game

This section argues that infrastructure governance should not lock in societies to second best infrastructure. Uncertainty about the future can be a powerful catalyst for innovation and is examined in the context of the Better Infrastructure Futures Framework. A case study on Australian airports concludes the section and is offered as an example of past infrastructure reform that can serve the nation well again in new areas of reform.

Introduction

There is a systemic preference that has emerged in the past 20 years around infrastructure governance.

On the one hand, there is an enormous concentration of effort in the continuity and reliability of infrastructure. While this is important, especially for life sustaining systems such as electricity and water, it has nonetheless come at a cost in the form of 'gold plating' infrastructure, especially in respect of some transport and electricity networks. However, a more subtle and potentially insidious cost has been the emergence of an overly cautious culture that risks stifling innovation.

While there may be sound reasons for this, one concern is that land transport is in need of much further reform to ensure it has access to full range of productivity enhancing options, in particular through tapping the latent capacity in the existing infrastructure through new technology and innovation.

This is an area that is in need of greater scrutiny and critique.

Managing a 'shovel ready' project culture

The planning of infrastructure is a very valuable period for policymakers because designers and engineers have the benefit of exercising the most flexibility in testing concepts and designs with the objective of finding the best and, hopefully, most enduring solution.

Governments can have a tendency to both rapidly conceive and announce major infrastructure projects that at times can be contrary to the long-term skillful planning of their departments. Speed and urgency to complete a project as soon as possible is often linked to the perceived need of policymakers to do so within the electoral cycle to demonstrate a fiscal stimulus is delivering on jobs and growth. While the transaction efficiency of major infrastructure is one dimension of social welfare, it is critical that the same process does not trade off the right scoping and right sizing of the proposed investment using flexible design.

Major projects concerned with building assets for the long term highlight the challenges for policymakers to commission them and ensure they can astutely navigate a very high level of uncertainty in the future. Reflecting these uncertainties in contracts such as PPPs is an onerous task and inevitably requires a range of assumptions to create enough certainty for the contract to be both workable and enforceable.

The longer the asset life, the more important it is to conceive a solution that can respond to uncertainty in the long term. Despite this obvious point, the governance of major projects in infrastructure often inserts assumptions about the future into contract terms with private owner/operators that are simply inflexible and constrain the asset owner to respond to uncertainty over the long life of the asset.

An example of unforeseen developments is in respect of Melbourne CityLink. The original contract was signed in 1995 allowing the concessionaire to increase tolls quarterly by whichever was higher, the inflation rate or 4.5% annually for the first 15 years after completion of the road. This contract was signed during a period when 4.5% annual inflation was not unusual. However, trend inflation had since fallen to around 3% annually making the toll increases well in excess of inflation for an extended period of time. This situation was compounded by a failure to link improved customer service outcomes with the onerous escalation in real prices the community has had to pay to use CityLink.

In response to the millennium drought many states invested in desalination plants as an insurance against future risks to water security in their jurisdictions. All of these were conceived with urgency as dam levels were diminishing. The Victorian

and NSW desalination projects shared common characteristics including very large water production capacity (e.g. Melbourne was set at 150 billion liters of water annually, making it the largest desalination plant in Australia).[16] Both are PPPs where government pays the concessionaire an availability payment irrespective of use plus a volumetric payment.

Insurance policy type investments such as desalination plants make value for money difficult to judge, until they are next called upon. That said, building a smaller plant with options for additional capacity through modular and flexible design may have offered a degree of relief. Another option is to have had the plant producing water at a reduced capacity but on an ongoing basis to help enable dams to release water for environmental flows and improve the health of rivers. Together these may have helped taxpayers secure better value for money.

A certain future risks new opportunities

A culture and expectation has evolved that the provision of infrastructure services is better done in an environment of no surprises. Contractual certainty is highly valued by government and proponents alike because it is more conducive to the mobilization of resources, and the attraction of cost-effective design and financing. While this can create efficiency benefits in the short to medium term, it can have an opportunity cost in the future should it lead to inflexibility and loss of incentive and competence to adapt to changing circumstances.

While the power of contractual certainty can be necessary and attractive to quickly mobilize resources in the early life of a project, these benefits potentially attenuate overtime. For example, inflexible high certainty contractual arrangements that make changes in scope and purpose difficult to achieve also risk creating disincentives for private proponents to not adopt essential behaviors that are abundantly evident in competitive markets. These involve using strategic investment and risk allocation to protect and expand their offering to first survive and then prosper in a changing marketplace.

High certainty contractual arrangements can blunt the willingness of proponents to learn, adapt and repurpose their assets and services as time progresses and circumstances may warrant it. This can be acute not only in the long term, but also in the early stages of project commissioning, particularly in periods of new information that may justify re-scoping, stopping or pausing on a major project.

Infrastructure is often referred to as being 'lumpy', that is it is difficult to break it down into smaller components or modules. While that can be the case, technology and engineering innovation is changing to where flexible design can more easily enable, but does not require, additional capacity.

The economics of flexible design is that it allows the building phase to meet the immediate demand, but with options to add more as growth occurs. On the other hand, inflexible design requires that the build is much larger so that the asset can accommodate future forecast growth.[17]

The difficulty with a project commissioning culture driven by urgency, is that it risks failing to take advantage of smaller but more flexible options. Establishing certainty through contractual arrangements to expedite a project can risk focusing on getting the project built while distracting from a proper exploration of flexible design through a culture that emphasizes future benefits of agility, innovation and adaptation.

Framework for better infrastructure futures

Figure 3 introduces the 'Better Infrastructure Futures Framework' (BIFF) with the intention of helping policymakers, investors and the community to better understand the strategic space of uncertainty and opportunity around long-term infrastructure.

The shaded area that originates from the period of project commissioning forms a conical shape that indicates an expanding strategic space relevant to the operation of infrastructure over time. In other words, the longer it is in time from project commissioning, the greater is the area of both uncertainty to threats and opportunities.

The grey cylinder in Figure 3 extends into the future, and is a stylized representation of an availability based PPP or similar infrastructure contracts that can have a contract term of up to and beyond 40 years. These contracts are robust legal instruments that are intended to be capable of ensuring the government and the private proponent together can continue to provide operations with a relatively high level of certainty. To that end, the owner/operator has the benefit of a number of assurances that insulate it from competitive threats that could disrupt their viability through new entrants and or changes to the environment that could have an adverse impact. By the same token, these uncertainties include but are not limited to shifting demographics, technology, and social preferences that could also imply foregone opportunities.

The point of the BIFF is the benefits of the contractual certainties offered to the concession holder to ensure stable and ongoing operations are attractive in many ways, not least of which is the ability to attract cost-effective debt and equity at project commencement and subsequent refinancing. However, these benefits are not costless, and indeed may have an escalating opportunity cost over time to both investors and the economy.

In fact, the longer the contract period, the greater chance the benefits of contractual certainty at project commissioning may be offset in future decades. This is because the contract may prevent or give little incentive for the concession holder to respond to emerging threats and opportunities. The result is infrastructure that is inflexible and static to its environment and customers.

In terms of long-term infrastructure efficiency, it is argued that the uncertainty and opportunity space denoted by the conical shape must be explored, and wherever possible contested by market actors to avoid the risk of stagnation and lock-in to a second best infrastructure solution. But the presence of a PPP contract can also work to shut down this uncertainty/opportunity space for other providers because of a lack of financial recourse to extract a return in light of the risk of contesting an incumbent PPP.

Should there be opportunities for the concessionaire or new entrants to develop additional products and services to explore this space, the figure shows that the spectrum of uncertainties and opportunities could complement and add value to the core contract, and equally there are threats that could detract from it.

Empowering market actors to engage this strategic space of customers, new services (core-plus) and products are critical to the long-term dynamic efficiency of infrastructure. Finding a way to achieve this without compromising the early stage benefits of certainty needs to be examined more comprehensively in the future.

The different stages of innovation are reflected in a stylized series of concentric circles in Figure 3. Each stage of the innovation process can influence the infrastructure contract to varying degrees.[18] The innovation referred to occurs in the economy and the adjacent systems that can materially affect the contract.

Stage 1: Maintain costs, exploit synergies

At Stage 1 it is more than likely that the focus is on incremental (small scale) innovations concerned with doing things better and faster towards more competitive costs. For physical infrastructure, incremental innovations are closely linked with the day-to-day processes of replacing existing components with new ones rather than replacing like-with-like. Central to the decision whether to innovate is the life and serviceability of the existing asset.

Optimized asset management planning has become a central concern of public and private infrastructure operators and is generally accommodated within say a PPP contract. However, if a contract is so lean, the concessionaire could be financially constrained to invest in asset replacement and there can be a tendency to 'sweat the assets' rather than modernize.

Significant savings and service quality improvements can be achieved through increasing the scale and scope of operation (economies of scale). Examples include consolidation of railway companies in the 19th century or water companies in the 20th century and the emergence of the private multi-utility model in the 1990s. Regulation can affect this type of action and needs to be carefully assessed to ensure the benefits are justified relative to the possibility of loss of competition from greater concentration of asset ownership.

Stage 2: Change the system, harvest new value

At Stage 2 radical innovations involve major changes to the way a system is configured or operates, and are more likely to occur in the medium term. In the case of infrastructure these can be triggered by a shift in relative price by virtue of a regulatory change. The dramatic shift to renewable energy is a case in point, driven by a combination of technology, regulation and prices.

In the 1950s and 1960s the USSR, US and UK did this with the introduction of nuclear power. Other examples of radical innovation are concerned with environmental infrastructure investments, especially in wastewater treatment and solid waste that have largely been driven by new regulations that allowed waste to shift from a cost to a profit center where energy can be produced and sold back into the grid.

Stage 3: Disrupt, energies new and old

Goldsmith refers to Stage 3 innovations as having systemic implications as they open up whole new ways of delivering infrastructure services. The pattern of use may not change overnight as it takes time to build the new networks and the incumbent infrastructure owners and operators have many options to respond and survive. Historical examples include the way railway technology replaced water canals, cars and roads replaced railways, electric lighting replaced town gas or mobile phones replacing fixed lines.

During the industrial revolution, canals were partially complementary to turnpike roads as they only took the heavy freight traffic for bulk materials or bulk manufactured goods off the roads and onto water. Canals were generally not used for short journeys or for passengers. Similarly, the invention of the internet gave a respite to the fixed telecoms operators faced with competition from mobiles as they could offer ADSL services over phone lines.

When the town gas monopolies were faced with being made redundant by the invention of electric lighting, they responded by reinventing themselves as suppliers of gas for cooking and heating. In fact, the survival strategies of 'old' infrastructures faced with new competition can lead to intense price competition that benefits customers along with unleashing a new wave of innovation about how to use the existing infrastructure better.

Stage 4: Start over and do it again

Just as this process began with small improvements and larger ones, all of them are intended to both improve and challenge the incumbent technology and service provider. Regardless of the merits of the incumbent their very presence should serve to invite the next disruptive technology that will trigger the commencement of a new cycle of innovation.

More competitive innovation trumps contractual certainty

Providing contractual certainty to infrastructure concession holders is central to modern PPPs. While PPPs invite intense innovation in the early stages of the project life cycle, they are particularly focused on cost management while ensuring the asset's continuity and availability. Despite these benefits, longer-term issues are at play that the concession holders are possibly less well equipped to manage by virtue of contractual arrangements.

From the perspective of designing infrastructure markets, long-term dynamic efficiency can only be achieved when the market explores the uncertainty and opportunity strategic space shown in Figure 3. When a contract from government prevents this, there needs to be greater scrutiny of the costs and benefits, because of the risk this could present in impediments to structural adjustment of the economy generally, and loss of customer focus and satisfaction specifically. Infrastructure generates a range of externalities, including a wider economic impact to the broader economy, which is why infrastructure governance needs to be comprehensive in its approach towards long-term efficiency.

Historical experience is clear on this point. The 150 years from the mid-1700s in Britain, slightly later in the United States, saw a massive mobilization of resources by the private sector that created the legacy networks of energy, water and transport that continue to shape these economies today.

The great railway companies of Britain and US were driven by enormous financial incentives to shift their land use patterns from their transport, energy and communication infrastructure.

The dividends of these risky endeavors were to secure first mover advantage, especially with respect to land access and customers, along with capturing the land uplift from their improved infrastructure amenity. The period provides important lessons for the stewardship of current infrastructure challenges.

- Firstly competition between the emerging technologies was important in ensuring the nation had the benefit of best of breed infrastructure.
- Competition brought many complications, including haphazard development, duplication and overdevelopment, in some areas and underdevelopment in others. However the upshot of it ensured Britain did not prematurely settle for a second best technology that could have limited its long-term growth potential.
- Despite its shortcomings, competition played an important role in shifting the focus to service outcomes as opposed to basic provision of physical assets. It sharpened the perspective about the function of infrastructure from what it is (the asset), to what it does (the service). It was this outcomes perspective that ensured markets were dynamic, and driven by whichever strategy had the better feature for its customers.

Australian airport reform

Giving permission for greater adaptability, more innovative and better risk management

The mid-1980s to the early 2000s in Australia was an important period of modern infrastructure reform when both state and federal governments created an opportunity to shift away from cumbersome, inflexible and bureaucratic procedures for investing and managing major infrastructure to a more disciplined and an evidence-based regime. This was in the form of the corporatisation of government trading enterprises, especially in the telecommunications, energy and water utilities, which heralded significant improvement in asset management, productivity and customer satisfaction. It was followed by privatisation for some areas, most notably telecommunications and airports, which will be examined in further detail below.

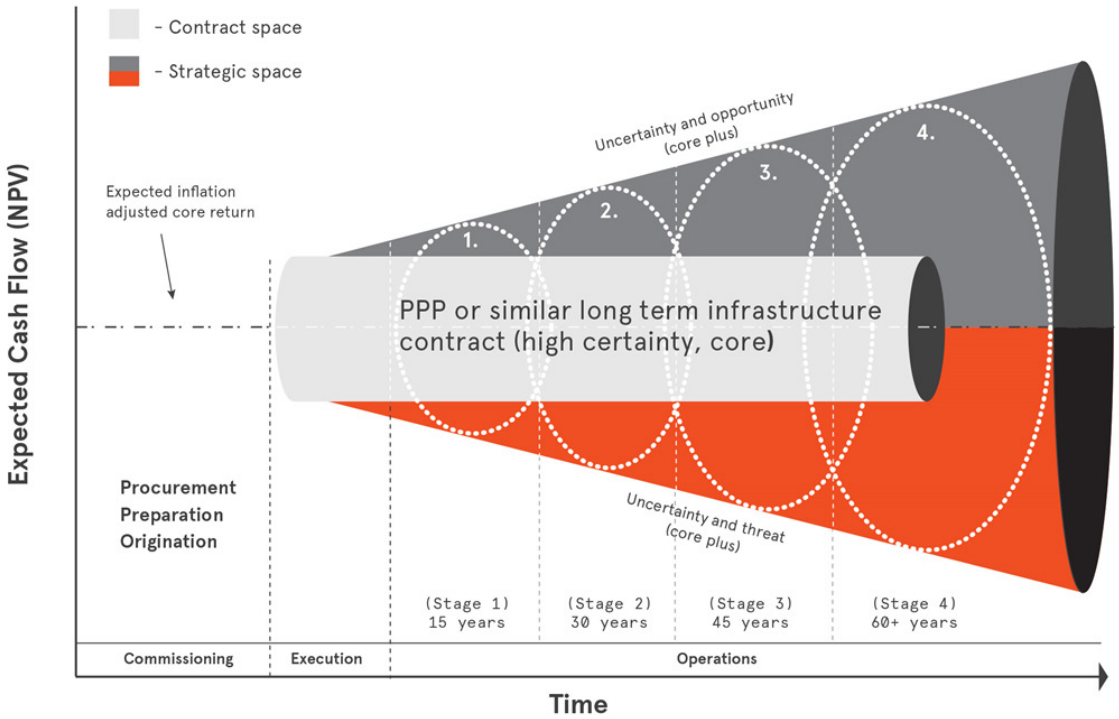
Australia was one of the first nations to reform its airports, and 2016 represents the 20th anniversary of these important public policy initiatives.

View the full report here to read more on airport privatization.*

Final Remarks

Infrastructure is not a low risk activity and it must be managed for the long game; it faces an array of complexities and uncertainties

Figure 3: Better Infrastructure Futures Framework (BIFF)



Stages:

1. Maintain costs, exploit synergies
2. Change the system, harvest new value
3. Disrupt, energise new & old
4. Start over and do it again

Source: Better Infrastructure Initiative

in its future strategic and operating environment. The most effective way of dealing with these is through disciplined balanced sheet management, a strong focus on customer interaction and to use and adapt assets to the maximum benefit of customers and shareholders.

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***Appendix**

http://sydney.edu.au/john-grill-centre/our-research/infrastructure/initiative-publications/shifting-australias-infrastructure-mindset-to-the-long-game.html

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Garry is an active contributor to the debate on infrastructure governance and investment in Australia and globally. He is uniquely placed to challenge and shape the current and future agenda for cities, regional development and the role of government and the private sector in the provision of infrastructure services. Garry is well known for thought provoking presentations, speeches and reports on the future of infrastructure that have been shaped from his unique balance of commercial and government experience spanning Australia, Asia and the OECD.

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Over a 25 year career Gordon has worked in banking and superannuation, as a political adviser and in industrial relations. His previous roles include Director of Investments and Economy at the Association of Superannuation Funds of Australia and Deputy CEO of the Committee of Melbourne. Gordon also works with Inflection Point Capital Management, a UK based investment advisory business and is a Director of the Network for Sustainable Financial Markets and Steering Committee Member for Australian Alliance to Save Energy.

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Glenn has spent much of his career in government – initially in Canberra with the Productivity Commission and Australian Treasury focusing on microeconomic reform matters, and then over 20 years from the late 1980s with the Victorian Government in the infrastructure field in the Treasury, Premiers' and Energy portfolios with experience ranging from policy development to preparation of business cases, assessment of proposals for funding approval, tendering processes, utility reform and the undertaking of privatisations and commercial transactions such as PPPs. Since 2011, Glenn has worked in the private sector as an advisor on infrastructure matters.

Brexit and its Impact on Cross-Border Activity in Europe

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On June 23rd last year, British voters decided that the United Kingdom (UK) ought to leave the European Union (EU) – the successor of a group of European nations it had formally joined back in 1973[1].

Several months down the line a lot of uncertainty remains, and the ways in which the separation is to be achieved are still broadly unknown.

Over the past four decades or so, policy made at an EU level has permeated many areas of legislation in each of the national jurisdictions, in an effort to harmonize the "playing field" within a zone of complete free trade, in which regulatory arbitrage was not to be permitted. From Agriculture to Manufacturing, through to Intellectual Property, the EU's array of topics in which the legislator has been active is extremely wide.

Financial services, of course, have been impacted by those "EU laws", with the regulators of each EU country having to implement those – mutually- (and multilaterally-) agreed – "laws" within their own jurisdictions. As a result of the UK breaking away from the EU, it is, at this stage, still unclear what will happen to all those financial regulations which the UK has adopted over the past many years – including those which, in some cases, were designed for the purpose of allowing financial services to operate across borders within the EU.

How will cross border financial services work in the EU post-Brexit?

The following is attempt to answer this question, from a theoretical perspective at this stage insofar as all the decisions have yet to be made, in the context of a political climate that has been difficult in Europe overall.

Many pieces of EU legislation in the field of financial services currently include the option of operating – including, in many cases marketing – across border or via the opening of a branch in a "host state" within the EU.

A "host state" is an EU country other than the one where a financial services company was initially authorized; the country of authorization is called the "home state". Choosing to operate in that way has been called "passporting" financial services within the EU; that is one of the mechanisms of free trade on which Brexit could have an impact.

Hedge funds will be looked at more specifically, because they are the target of a recent piece of EU legislation called the Alternative Investment Managers Directive (AIFMD), which was published in 2011 but has been implemented in stages since. The AIFMD also includes various passporting options, which could be impacted as a result of Brexit.

1. More, or less, free trade?

Before looking at the specific case of hedge funds, or of financial services even, there is one point one has to bear in mind: among other objectives, the EU regulatory framework aims at "leveling the playing field" in order to enhance competition within the EU. However, it has been acknowledged that many of those in favor of Brexit articulated their own reasons for being dissatisfied with EU policies in either one of the following – somewhat contradictory – two ways:

- Some of those who voted for Brexit were, in fact, in favor of more free market policies and practices, which they felt the EU framework was stifling: they perceived the weight of EU regulations as heavy, anti-business, and preventing rather than enhancing competition. Besides, competition and free-trade in relation to zones outside of the EU (e.g. the United States) also suffered from what has been perceived as an increasingly high regulatory burden, and the creation of a market which has been caricatured by some as "fortress Europe"[2].
- Others, who also voted for Brexit, allegedly did so for completely opposite reasons: to them, free trade represents a danger to the interest of the UK; they rejected the EU for the very reason that they think the UK ought to be protected as a market. Beyond the economic rationale, this group often seeks to protect a culture and an identity; they also object to the free movement of the labor force which the EU allows, as they feels this has a detrimental impact on employment.

There are many examples of aspects of EU legislation that currently either enhance or, on the contrary, restrict the functioning of a free market, including the following:

- Free movement of labor within the EU applies to all sectors of economic activity. As far as financial services are concerned, the City of London – the financial center within Europe – does attract young and highly qualified individuals from all over the continent (and beyond). Those who voted for Brexit may have had in mind sectors other than financial services when they felt non-UK workers ought no longer to be naturally allowed to come and work in the UK; it is nevertheless the case that the "foreign" workforce has been part of the growth of the City, and that the decision to breakaway from the EU will have an impact on that aspect of financial services.
- European hedge funds had, until recently, been kept relatively outside of the scope of financial regulations – coming from national and EU regulators alike. To put this situation into perspective, the rest of the financial services industry has, on the contrary, had to apply rules that had originated in Brussels – the center of the EU institutions – for a long time, from the Markets in Financial Instruments Directive (MiFID[3], applicable to most investment firms) to rules on solvency ratios (for insurance companies). To some, those regulations, including the more recent ones on hedge funds, constitute a barrier to entry into an industry which, as a result, can be seen as less competitive.

2. The passporting of financial services within the EU

In 2005, the Financial Services Authority (FSA, UK financial regulator at the time) issued a Discussion Paper aiming to gather thoughts and data about hedge funds from the industry, starting with the definition of what might constitute a hedge fund. This was an initial step towards the possibility of regulating a sector which was relatively unknown at the time, including by the regulator itself. The financial crisis that was about to start three years later somewhat precipitated the decision of imposing further regulation on hedge funds, which regulators decided partly to blame for the crisis, as far as the systemic risk they presented potentially was concerned. The AIFMD was born as a result; it contains several passporting options.

Other European Directives such as the one on Undertaking for Collective Investments in Transferable Securities (UCITS[4]) and MiFID also contain passporting provisions:

- European "UCITS" are types of investment funds that meet certain criteria (as defined by the various UCITS Directives, the first of which was published in 1985) and can be marketed to retail investors. Unlike hedge funds, UCITS funds have to be incorporated onshore – i.e. in Continental Europe. UCITS funds must follow certain rules (for instance on asset diversification); as a trade off, they may benefit from a "European passport". While that passport did not function well for a while, practitioners have noticed some clear improvement over time: it is now easier than before to sell a UCITS fund incorporated in one EU country to retail investors in another EU country without the need to seek formal approval from the host state(s). It is absolutely unclear at this stage what will happen to that possibility of passporting UCITS funds once the UK leave the EU, especially in the context of many UCITS funds being incorporated in Ireland or Luxembourg, where the tax treatment is deemed to be more favorable, and being sold everywhere across Europe, including in the UK. A non-negligeablenegligible proportion of UCITS funds are incorporated in, or managed from, the UK; those situations are also likely to require some adjustments in the post-Brexit Europe.
- MiFID Directives are revamped versions of the Investment Services Directive[5], initially published in 1993. While deemed constraining by many, these

Directives include passporting provisions, which increased the amount of cross border business in financial services over time within the EU. For instance, within the EU investment banks (to name but one firm type) can operate via the incorporation of one single legal entity, which they are then able to branch out throughout the EU. This possibility, and the ease with which the whole of the European market becomes accessible as a result, could disappear as a result consequence of Brexit; that is one of the reasons why large US banks have said they would relocate their European headquarters away from the UK, and into jurisdictions from where it may still be possible to use the EU passport, post-Brexit.

It is, of course, not easy to envisage what – if anything – might replace the ""EU passport" going forward as far as the UK is concerned. If the latter were to disappear completely, and if the UK were to be treated like a country completely outside of the geographical zone altogether, that would equate to barriers being erected around the UK as far as financial services are concerned. The objective of leaving the EU for the purpose of enhancing free market would, in that case, be defeated absolutely.

More likely outcomes could be as follows:

- Switzerland never joined the EU, and yet has a strong culture of financial services, supported by its relationship with the EU. From a regulatory perspective, this relationship works as follows:

  1. Switzerland has published its own rules which are different from EU rules but in-keeping with them. Among other things, the intention of the legislator has been to "keep its market clean" and avoid attracting companies would have come to Switzerland as a result of refusing to abide by the relatively higher standards of the EU. Doing so was a stated intention in the case of the AIFMD a few years ago, with Switzerland feeling a pressure somewhat to have "its own AIFMD" – its own piece of legislation regulating hedge funds but with a "Swiss finish".

  2. As far as UCITS are concerned, Switzerland also replicated the EU rules; in addition, they provided for an easier way of approving UCITS funds recognized by one of the EU jurisdiction: while this is not quite "passporting", the procedure is more flexible and faster than it would normally be (e.g. for a non-EU / non-UCITS fund).

- Many are currently talking about the UK becoming a lot closer to the US once it becomes unconstrained by the EU legislation. In the minds of many commentators, such an outcome could result in the UK being to keep its pre-eminence in financial services, as a result of the reopening of a channel which, in some cases, had been somewhat restricted by the proliferation of regulations on both sides of the Atlantic in the aftermath of the financial crisis. The new regimes in both countries could influence that outcome.

3. A few words on the AIFMD, the EU hedge fund regulatory framework still in its infancy

As mentioned, it took a while for hedge funds to be regulated in Europe. In the absence of any other reference, the model that was adopted by regulators for the making of the AIFMD was the UCITS Directive. The latter regulates retail funds though, and hence fund managers have argued that its provisions are far too restrictive to be transferable to the management of funds that are designed to appeal to more sophisticated investors. Running a hedge fund in Europe has, over the past few years, become a lot more expensive than it used to be as a result of the AIFMD, and this has created barriers to entry. That aspect could be looked at in parallel with the fact the number of candidates to become hedge fund managers in Europe has risen during that time, a second-order consequence of the financial crisis and its impact on investment banking, including the fact the latter also became more regulated.

The AIFMD contains some passporting options, however these are complex, and they are being implemented in stages, depending on where funds, and their managers, are located. The fact that Brexit came in precisely at a time when the functioning of those passporting rules has not yet been established is adding a further layer of uncertainty since we are working with two moving targets here, the interaction of which might give way to more possibilities than is the case as far as the becoming of the other Directives is concerned.

Given the hostility against the AIFMD in the Anglo-Saxon world – from the point of view of both the cost of running a hedge fund business and the ability to market a product for the purpose of generating revenues – it is likely that Brexit will give way to a relative deregulation of hedge funds. Scaling down the EU regulatory framework currently applicable to hedge funds may not necessarily equate to throwing out the baby with the bathwater:

- As is the case in Switzerland – to a lesser extent perhaps given the timeframe and the prevailing opinions within the countries in question – the UK could keep some form of regulatory framework applicable to hedge funds, in-keeping with the necessity to provide market surveillance and ensure the latter stays "clean".

- Passporting provisions currently soften the fact that having simple conversations – with investors who are sophisticated enough to know what they are doing – has become harder and harder as a result of the new regulation (AIFMD). If those restrictions no longer were in the first place – or, at the very least, if they were fine-tuned – the relative advantage of having passporting provisions may be lessened. Lowering international barriers as far as the marketing of hedge fund products is concerned is not, however, something that can happen unilaterally: the possibility of achieving that outcome would depend, also, on the willingness of other countries, outside of the EU, to offer reciprocity in terms of market access. A lot of work between the UK and the US remains to be done in that context.

References

1. At the time, the "group of European nations" was called the European Economic Community.

2. The phrase was used during the negotiation phase that led up to the making of the AIFMD, from 2009 to 2011. In its initial form at least, the Directive would have been very restrictive as far as the marketing of non-EU hedge funds to EU investors was concerned.

3. https://ec.europa.eu/info/law/markets-financial-instruments-mifid-directive-2004-39-ec_en

4. https://ec.europa.eu/info/business-economy-euro/growth-and-investment/investment-funds_en

5. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52002PC0625

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Marianne Scordel is the Founder of Bougeville Consulting, a consulting firm that assists hedge fund managers in doing business in Europe. She has managed set up and business migration projects since 2012 and her business has received numerous awards since that time, including three from UK national publication Financial News. She has worked in investment banking and was previously a co-chair of the Legal Issue Special Interest Group at CFA UK. She is French, an Alumna of the University of Oxford, and recently relocated to the United States.

Challenging Pension Funds Model Portfolios with Listed Private Equity (LPE)

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Introduction

Pension fund portfolios exhibit major shifts during the last decade with respect to assets and portfolio structure, driven not only by volatile markets but also by regulatory requirements and an enhanced focus on adequate risk measurement.

In search of higher yields, a global trend towards expanded allocation to equities and alternative investments established. Offering a higher risk-return profile, pension funds in smaller markets increased their exposure to equities while decreasing their holdings in bills and bonds (OECD, 2015). Whereas others such as funds in UK reduced their bond and equity positions indicating an expanded allocation to alternative investments (OECD, 2015; Talmod & Vasvari, 2014). Some of the largest pension markets increased their portfolio share in alternative assets more than five percentage points over the period from 2004 to 2014. In the UK, allocation increased by 12.8%, Canadian pension funds increased the share about 8% and funds in Brazil by 8.9%. During the same decade, the US increased the allocation to alternative assets by 4.5% (OECD, 2015). Additionally, those funds in markets with the highest returns in 2014 have switched to alternative investments over the last ten years. The main driver for the allocation shift is that some of the alternative asset classes may exhibit better returns, but also bear higher investment risks than traditional financial assets, hence requiring specialized skills and knowledge of pension fund management (US GAO, 2012).

In Switzerland, pension funds' asset allocations are regulated by the LPP legal framework (BVV2, 2000). The framework not only covers provisions regarding asset categories but also the maximum weights per asset class (BVV2, 2000, art. 54-57). Since its inception in 1985, the LPP framework experienced significant

changes in terms of specification and covered asset classes. One cornerstone to achieve broader diversification was the inclusion of alternative assets. In 1993, the Pictet LPP pension fund reference index consisted mainly of Swiss and international stocks and bonds before the reference index also included private equity and hedge funds in 2005 (Pictet, 1993). The significant change towards alternative assets and the narrower definition of asset classes in the reference index of 2015 give rise to questions regarding portfolio optimization methods and the suitable diversification into alternative assets.

This paper should contribute to the knowledge about listed private equity in the multi-asset portfolio context and the special case of pension funds. The rationale is given by the considerable growth in alternative asset investments of pension funds in the seven largest markets (P7) measured by total pension assets including the US, UK, Japan, Netherland, Australia, Switzerland and Canada (Towers Watson, 2015). The 20% growth in alternative asset investments from 1995 to 2014 has also implications about the importance of pension funds as investors (Preqin, 2011). Thirty-three percent of investments in the top 100 alternative asset managers is made by pension funds. Within this group, private equity funds are the most favored asset type after direct real estate funds (Towers Watson, 2014). However, as there are pension institutions with a preference for liquidity or with a core investment in traditional private equity, which would like to fine-tune the overall exposure with listed instruments, this study mainly focuses on LPE (Brown & Kraeussl, 2012; Cumming, Fleming & Johan, 2011).

Alternative investments, but liquid

This study aims to analyze the model portfolio of the Pictet 2015 LPP-60 index (Pictet, 2015b) in comparison to a portfolio, which follows the general composition of the LPP-60 index and fulfills the LPP weighting requirements but includes an additional asset, listed private equity (LPE).

Given the similarity of LPE to traditional private equity funds' investment strategies, its regulatory treatment as regular stocks with respect to capital requirements and similar characteristics as small cap stocks, LPE could be a beneficial addition to a pension fund's portfolio. Instead of analyzing the influence of LPE on portfolio performance in a mean-variance framework, the applied optimization considers the non-normal return distribution of alternative assets.

The shift towards alternative investments in portfolios of institutional investors mainly considered hedge funds and traditional private equity (see for example Preqin, 2015b; Talmor & Vasvari, 2014; Groh, Liechtenstein & Lieser, 2010; Schneeweis & Martin, 2001).

In 2015, Bain (2015) reported record numbers for private equity with investment values close to USD 250 billion in 2014; a 25% surge in deal values over three years. Part of the capital deployed to participate in the growth of the asset class came from pension funds. Over the last decade, a narrowing gap between target and actual private equity holdings of pension funds could be observed. However, pension funds still have lower holdings in private equity than other institutional investors such as endowments, family offices or sovereign wealth funds (Ang, Ayala & Goetzmann, 2014). Caveats of pension funds towards private equity holdings are directly related to the specifications of limited partnerships (Talmor & Vasvari, 2014). Foremost, its illiquidity and valuation difficulty make the asset class unsuitable for certain institutional investors. The lack of market prices and long-term lock-up of capital also make the determination of optimal portfolio weights more difficult (Woodward & Hall, 2003; see also Woodward, 2004).

Despite the illiquidity, commitment requirements and intransparency, pension funds chose to invest in limited partnerships. In a survey of the US Government Accountability Office (US GAO, 2012), respondents claimed that the reason for the investments were higher risk-adjusted returns than equity. Half of the respondents state that their private equity investments outperformed the equity investments over a five year period. However, pension fund managers note that private equity returns were not shielded from losses during economic crisis. Furthermore, the dependency on co-investors is critized. The ability to actually contribute capital defines the investment strategy and changes due to a lack of capital can be costly (US GAO, 2012). To overcome the before mentioned drawbacks of limited partnerships, e.g. private equity, the inclusion of listed private equity is considered by investors concerned with transparent and regular pricing of their investments (Brown & Kraeussl, 2012; Huss & Zimmermann, 2009). LPE gives the investor the possibility to own a stock of a direct investing fund or fund manager, whose core business, identical to limited partnerships, is to hold investments in private companies. LPE does not require capital commitments, co-investing nor does it apply a lock-up period. Investments can be disposed by a stock sale. Cumming and Johan (2014) analyzed investment behavior among international pension funds and their private equity investments. They note that depending on the mandate, private pension managers have a significantly higher share of funds, which invest in LPE than those that do not. They relate the likelihood of an investment to the size of the investment team and the associated due diligence capacity. Cumming and Johan (2014) also conclude that LPE is a source of diversification and lowers due diligence costs what benefits smaller pension funds the most. Swisscanto (2015), a major Swiss pension fund favors LPE as diversified investments as LPE companies reduce the risks to a considerable extent, while leaving the income opportunities of private equity intact. The LPE investment is attractive because despite its economic allocation to alternative investments, it represents an equity commitment, which is beneficial under risk capital requirements of regulatory accords for pension funds, insurers and banks (Preqin, 2014; IORP, 2014; BIS, 2011; EIOPA, 2015).

Cumming, Hass and Schweizer (2013) presented a benchmark based on the VentureXpert database for venture capital and buyout funds, which is updated monthly and is superior to LPE price indices, transaction based or appraisal value based indices. No weighting restrictions apply except for a 20% threshold to maintain diversification. The authors conducted the optimization based on different risk measures such as lower partial moments, conditional value at risk and variance. In practice, LPE has been

included in institutional investors' model portfolio. The Pictet 2005 reference indices included the LPX50 up to a maximum weight of 7.5% (Pictet, 2005). Pictet removed the LPX50 from the LPP reference indices arguing that daily available price indices only partially reflected the performance of the industry. Despite the high potential, Pictet argued that LPE is not viewed as a separate asset class rather as a sub-category of regular equities (Pictet, 2015b). In contrast, LPEQ, a global association of LPE companies, refers to the fact that some of the LPX50 constituents exhibit a 93% correlation of NAV with unlisted NAV (Preqin, 2015a). Therefore, LPE is not only a proxy for private equity, it is private equity with key advantages such as seasoned portfolios avoiding the J-curve effect and previously mentioned liquidity. LPEQ particularly mentions the liquidity advantage of LPE for defined contribution pension plans which struggle to include alternative assets that lack daily pricing (Preqin, 2015a). Based on the findings about LPE, pension funds' reception of private equity and private equity in the general portfolio context, this work contributes by including LPE in a pension fund's model portfolio. On the one hand, this analysis considers the hybrid characteristics of LPE, its stock-like nature and limited partnerships' related core business by assigning LPE to different investment categories for the optimization. On the other hand, real-world investment limits apply by modeling according to the LPP-60 index provided by Pictet.

Theoretical considerations – The risk is in the tail

For the optimization, return distributions are taken into account. Optimization based on the Markowitz framework only considers mean and variance as objective variables. This bears some drawbacks (Markowitz, 1952). Markowitz optimization, which minimizes variance, assumes that asset returns are normally distributed and the investor has a quadratic utility function (Levy & Markowitz, 1979). With latter, an investor who seeks to maximize the expected portfolio return will only consider mean and variance but not higher moments (Fabozzi, Kolm, Pachamanova & Focardi, 2012). The consequence is that the investor neglects extreme outcomes such as severe losses. The normality of asset return distributions is violated by some asset classes, hence they exhibit higher probabilities to realize returns in the tails of the distribution unlike the assumption that fifty percent of the returns are higher and lower than the mean, which gives the normal distribution its symmetric bell shape (Sharpe, 2007; Favre & Galleano, 2002). In exhibit 1, the histograms of daily returns contrasting with a fitted normal distribution show outliers in and beyond the tails what indicates the positive excess kurtosis and negative skewness of some of the asset returns. Given the previous observations, the assumption of a symmetric return pattern does not hold for certain assets, hence the optimization method must account exactly for that (Xiong & Idzorek, 2010). One measure to consider the skewness and kurtosis of a distribution is Value-at-Risk (VaR), which corresponds to the predicted maximum loss over a pre-specified time period within a given confidence interval (Jorion, 2007).

In the portfolio context, VaR is only of limited use as a risk measure as it is not coherent according to the description offered by Artzner, Delbaen, Eber and Heath (1999). One of the criteria determining the coherence is the subadditivity principle, which does not necessarily hold as the VaR of the entire portfolio can be higher than the sum of the individual assets' VaR for specific portfolio compositions. Moreover, VaR is non-linear what makes optimization of discrete distributions challenging. Additionally, the loss described by VaR gives no indication of the magnitude of a potential loss beyond VaR (Jorion, 2007). The expected tail loss or Conditional Value at Risk (CVaR) overcomes these problems. CVaR is still a simple measure of downside risk, but covers also losses beyond VaR. It gives the average loss of the sum of losses which exceed VaR with a certain probability. It is coherent as shown by Artzner et al. (1999) and Acerbi and Tasche (2001) and is consistent with the mean-variance framework as optimal portfolios based on variance equal optimal portfolios based on CVaR given a normal distribution of asset returns (Uryasev, 2000).

Data and empirical approach

In this study, I follow the approach by Rockafellar and Uryasev (2000) to minimize CVaR as optimization target. To calculate the mean-CVaR efficient frontier, the Pictet LPP-60 portfolio is replicated. As a proxy for stock investments three investable indices are selected. For Swiss equities the Swiss Performance Index (SPI) is included. For international stocks and international small caps, the MSCI World and the MSCI Small Cap are added. Both indices contain stocks of developed countries for liquidity reasons. For the fixed income share of the portfolio, the Swiss Bond Index was added to reflect the performance of Swiss corporate bonds. The BarCap Euro-Aggregate Corporates includes bonds of investment grade quality and therefore has a minimum rating for European Bonds. For sovereign debt of developed countries and emerging markets the Barclays World Government and Barclays Emerging Market Bond Index were added. Corresponding to the sub-indices of the LPP-60 alternative assets are represented by the SXI Real Estate Index and the HFRX Global Hedge Fund Index. The first contains cap-weighted real estate funds listed on stock exchange, the second represents absolute return strategies.

To represent the listed private equity universe, I include an equally weighted buy and hold index of 115 LPE vehicles based on their daily market prices from January 2000 to December 2013. The sample is drawn from Preqin (2012) and the LPX (2015a) universe. In order to put the potential benefits of LPE to a pension fund's portfolio into perspective, the optimization is re-run with holdings in the LPX50 NAV index. This modification allows to contrast risk and return of portfolios with observable market prices and with NAV. As market prices and NAV of most LPE vehicles significantly differ (Lahr & Kaserer, 2010), other optimal portfolios are expected. To complete the analysis, the findings are cross-validated by an optimization of portfolios including LPE based on the NAV of the publicly traded LPE vehicles and portfolios with private equity allocations based on the NAV of limited partnerships. For the NAV of LPE and NAV of unlisted limited partnerships, the LPX50 index and the Thomson Private Equity Buyout index are included.

The mentioned sub-indices have fixed weightings in the Pictet LPP index family. In order to maintain flexibility during the optimization, maximum weightings were included which correspond to the legal constraints imposed by the LPP framework . To replicate the pension portfolio, the following investment caps were introduced:

Weight constraints per asset class

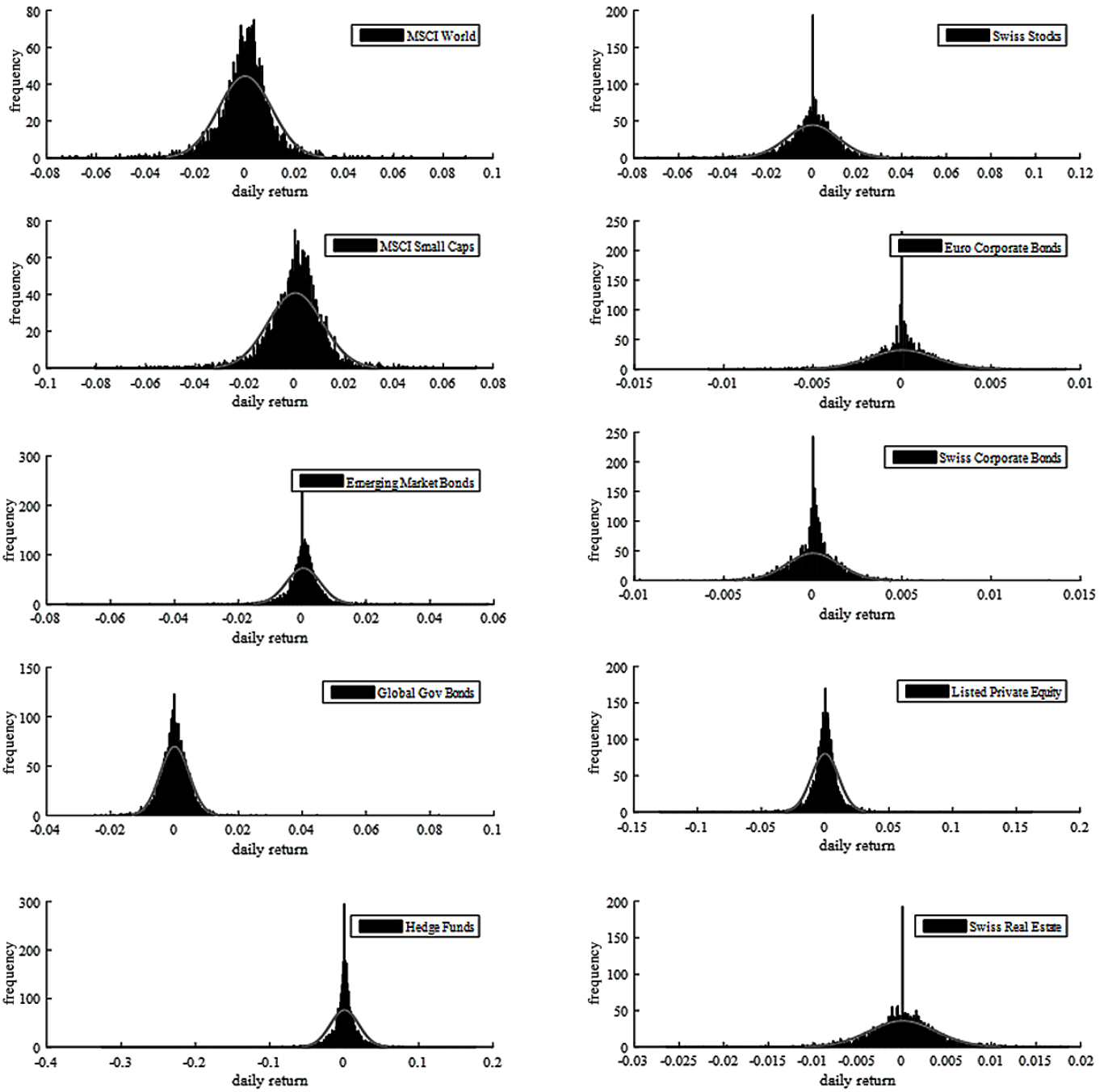

Exhibit 1: This exhibit shows the daily returns and their frequencies over the period of the 1st quarter 2000 through the 4th quarter 2013. The lower four plots show the histograms for bond indices. They exhibit only a few return materializations in the tails. In the mid-section and upper sections three histograms of stock indices and alternative investments/real estate refer the fatter tails.

As LPE is not included in the LPP-60 portfolio, the most reasonable categorization is defined by similarities to the existing LPP-60 asset class definitions. The first and most obvious categorization is into the regular equity bucket. LPE offers ownership rights, which are publicly traded on a stock exchange, therefore fulfilling the criteria of a regular stock. Analyzing the characteristic of LPE stocks more closely, the average company size is similar among the LPE universe identified by Preqin and LPX (LPX, 2015a; Preqin, 2012) Based on the study of Bilo, Christophers, Degosciu and Zimmermann (2005), LPE vehicles have a small market capitalization, which is confirmed by a positive Pearson correlation with the included MSCI Small Caps. Therefore, LPE stocks qualify also as small caps. The core business, holding investments in private companies, also allows categorize LPE as an alternative investment (Swisscanto, 2015). Therefore, LPE can substitute equities (MSCI World, SPI), small caps (MSCI World Small Caps) and alternative investments (HFRX indices).

Hence, to add LPE to the portfolio, we treat it either as a (1) regular stock, as a (2) small cap stock or as an (3) alternative investment . Each scenario (1)-(3) results in a combination

Weight constraints per asset class

	(1) Investment Categories	(2) Index	(3) Pictet LPP-60	(4) Constraint based on LPP-Law (max)	(5) Cumulative Constraint (max)	(6) Applied (Group) Constraint (max)
Bonds	Swiss Corporate Bonds	Swiss Bond Index	10	100	100	100
	Euro Corporate Bonds	BarCap Euro-Aggregate: Corporates	5	100		
	Global Government Bonds	Citi World Government Bond Index	10	100		
	Emerging Market Bonds	BarCap EM LC Government Capped	5	100		
Stocks	Swiss Stocks	Swiss Performance Index	20	50	50	50
	Global Stocks	MSCI AC World	30	50		
	Small Cap Stocks	MSCI Small Cap World	10	50		10
Alternatives	Hedge Funds	HFRX Global Hedge Fund	5	15	15	15
	Private Equity	Market price index of 115 LPE vehicles	0	15		flexible*
Real Estate	Swiss Real Estate	SXI Real Estate Funds	5	30	30	30

Exhibit 2: This table shows the covered investment categories (1) and the indices (2) which represent them. The indices chosen are based on the selected indices of the pictet LPP-60 portfolio. The corresponding weights of the sub-indices are presented in column (3). The individual maximum weights (4) allowed LPP law and the cumulative constraint per asset class (5) lead to the applied weight constraints (6) in the optimization analysis.
***The individual weighting of private equity and the applied cumulative constraint depends on the categorization of LPE.**

weight limit with the respective asset class. Further constraints are imposed. No short positions are allowed and full investment is required.

Methodology

As mentioned earlier, the linearized mean-CVaR optimization (Rockafellar & Uryasev, 2000) is applied for portfolio selection. The CVaR is calculated based on scenarios by simulations of historical return distributions. The following discussion of the methodology follows Rockafellar and Uryasev (2000) and Cornuejols and Tütüncü (2006).

To develop the optimization model, a portfolio of assets with portfolio specification x (portfolio weights) and random events (returns) is considered. This gives a loss function , which does not exceed a certain threshold . For a fixed decision vector , the cumulative distribution function (1) of a loss corresponding to the chosen portfolio specification x is (Tütüncü, 2003):

$$\psi(x,\alpha) = \int_{f(x,y)\le\alpha} p(y)dy \qquad (1)$$

The VaR (2) associated with the portfolio choice x for a specified confidence level α is:

$$VaR_\alpha(x) = \min\{\gamma \in \mathbb{R} : \psi(x,\gamma) \ge \alpha\} \qquad (2)$$

CVaR (3) is therefore the area under the density function which is greater or equal to the VaR divided by 1 minus the confidence level . Working with equation (3) would imply that during optimization VaR has to be calculated first. Simplified by Rockafellar and Uryasev (2000), the calculation of CVaR is detached from the calculation of VaR:

$$CVaR_\alpha(x) = \frac{1}{1-\alpha}\int_{f(x,y)\ge VaR_{\alpha(x)}} f(x,y)p(y)dy \qquad (3)$$

where $f(x,y)$ is still the loss function depending on portfolio weights x and portfolio asset returns y. As CVaR is the average loss beyond VaR, CVaR of a portfolio is at least as large as the VaR, hence a portfolio with a small CVaR will also have a small VaR (Cornuejols & Tütüncü, 2006).

Since the calculation of CVaR depends by definition on the calculation of VaR, processing a CVaR optimization is difficult, a simpler auxiliary version is considered (Cornuejols & Tütüncü, 2006; Tütüncü, 2003):

$$F_\alpha(x,\gamma) = \gamma + \frac{1}{1-\alpha}\int_{f(x,y)\ge\gamma} (f(x,y)-\gamma)p(y)dy$$
$$F_\alpha(x,\gamma) = \gamma + \frac{1}{1-\alpha}\int (f(x,y)-\gamma)^+ p(y)dy \qquad (4)$$

Where $a^+ = \max\{a,0\}$

It follows that VaR is to minimize over y. Hence, to minimize CVaR over the portfolio weights, the function F_α (4) must be minimized with respect to portfolio weights and returns. Instead of optimizing the density function $p(y)$, a handier approach is chosen based on scenarios for different *S*:

$$\tilde{F}_\alpha(x,\gamma) = \gamma + \frac{1}{(1-\alpha)S}\sum_{s=1}^{S}(f(x,y_s)-\gamma)^+ \qquad (5)$$

Equation (5) gives the new optimization problem:

$$\min_{x\in X,\gamma} \gamma + \frac{1}{(1-\alpha)S}\sum_{s=1}^{S}(f(x,y_s)-\gamma)^+ \qquad (6)$$

A lower value of γ in equation (6) leads to a higher weighted sum for a small α and a lower weighted sum for large α. The minimum is found when the decrease in the sum is offset by the increase in γ. Then γ corresponds to VaR.

To simplify the problem further, $(f(x,y)-\gamma)$ is replaced by the artificial variable *z* with the constraint that *z* is larger than zero and smaller than $(f(x,y)-\gamma)$.

$$\min_{x,z,\gamma} \gamma + \frac{1}{(1-\alpha)S} \sum_{s=1}^{S} z_s \qquad (7)$$

The main aspect of equation (7) is that not only the portfolio weights are decision variables but also that the quantile level will be optimized. VaR will be calculated as a by-product. The minimization of CVaR leads to almost optimal VaR levels, as CVaR is never smaller than VaR, hence low CVaR portfolios correspond to low VaR portfolios (Andersson, Mausser, Rosen & Uryasev, 2000).

Results and discussion

In this section, I present the results of the multi-asset portfolio optimization. As the histograms in exhibit 1 showed that the included assets exhibit non-normal return distributions, the optimization was based on minimizing CVaR. This approach considers the higher moments of asset returns. The optimization covers the full time period of January 2000 to December 2013 as well as sub-periods before the economic crisis 1st quarter 2000 through 2nd quarter 2007, during crisis 3rd quarter 2007 through 1st quarter 2009 and post-crisis 2nd quarter 2009 through 4th quarter 2013. I compare the results of the LPE sample of 115 vehicles to the results obtained when optimizing with private equity (limited partnerships) and the LPX50 NAV index. The Thomson Private Equity Buyout index is a proxy for traditional partnerships whereas the LPX50 NAV index captures the NAV performance of the 50 largest and most liquid global LPE stocks.

The presentation of the results is structured in subsections depending on the asset type classification of LPE. The first subsection presents the results of the optimization with LPE categorized as a regular stock, followed by the results when categorized as a small cap stock and as an alternative investment.

Portfolio optimization with different LPE categorization

The efficient frontiers presented in the following sections correspond to the most dominate frontier during each of the analyzed sub-periods and the total observation period. Consequently, the best performing portfolios containing LPE allocations measured by their risk and return are compared to the portfolios without LPE allocations.

Optimization with LPE categorized as stock

The findings on LPE categorized as a regular stock is threefold (see exhibit 4).

First, the inclusion of LPE stocks in a portfolio of LPP-60 index holdings does not add value from a CVaR-return perspective. This is based on the location of the efficient frontier for the overall observation period containing portfolios which include a 2.5% allocation to the self-constructed LPE index. The LPP-60 frontier graphically almost matches the frontier with LPE portfolios. Among the efficient frontiers with LPE index allocations, the efficient frontier with a low allocation of 2.5% was the highest. The low allocation is dominant compared to frontiers containing portfolios with higher LPE allocations, but absolutely weaker than portfolios without LPE allocations.

Second, the findings for the total observation period also hold for the pre-crisis period up until 2nd quarter 2007. However, if only the post-crisis period is considered, the tangency portfolio including a 50% LPE holding, yields a 300 bps higher annual return than a portfolio on the LPP-60 frontier with the same CVaR of 15.42% p.a. In general, the 50% LPE frontier dominates the Pictet LPP-60 frontier when accepting more than a CVaR of 9.6% p.a. The findings for the post-crisis period show that after the crisis, LPE exhibits different characteristics compared to the regular stocks represented by the SPI and MSCI World. A look at exhibit 3 shows that the LPE return distribution has clearly fatter tails than those of the MSCI World and the SPI. Despite the slightly positive skewness of the LPE returns, the consideration of the kurtosis leads to neglection of LPE during pre-crisis. The opposite explanation applies to the post-crisis period where a substantial allocation to LPE benefits the portfolio.

The third finding considers the results on the crisis period. The finding that overall and during pre-crisis period portfolios without LPE allocations (e.g. LPP portfolios) dominate those

Distribution moments of portfolio assets

		Bonds				Stocks			Alternative Investments				Real Estate
		Swiss Corporate Bonds	Euro Corporate Bonds	Global Government Bonds	Emerging Market Bonds	Swiss Stocks	Global Stocks	Small Cap Stocks	Hedge Funds	Listed Private Equity (Prices)	Listed Private Equity (NAV)	Trad. Private Equity	Swiss Real Estate
Post-Crisis	Mean	1.35%	3.34%	-1.70%	9.85%	10.17%	14.31%	19.95%	6.65%	15.02%	4.93%	25.41%	2.95%
	95% CVaR	4.67%	6.43%	17.25%	13.16%	36.11%	38.07%	43.88%	6.13%	20.41%	20.55%	46.35%	15.74%
	Skewness	-0.31	-0.38	3.06	-0.75	-0.30	-0.30	-0.41	1.67	-0.02	2.10	-0.14	-0.14
	Kurtosis	6.99	6.2	10.12	46.57	5.98	5.99	6.47	67.9	6.06	31.95	8.4	5.79
Crisis	Mean	0.64%	-4.32%	4.80%	-1.14%	-35.32%	-37.63%	-42.67%	-12.01%	-54.14%	-33.20%	-24.67%	-3.45%
	95% CVaR	0.35%	10.04%	0.60%	35.40%	5.45%	4.51%	4.82%	23.12%	57.25%	51.89	82.19	14.54
	Skewness	0.62	-0.54	0.27	-1.81	0.25	-0.21	-0.41	-7.69	-0.57	-9.73	-0.27	-0.03
	Kurtosis	7.86	4.06	7.94	33.41	7.1	7.32	5.94	92.23	7.3	141.45	7.72	6.72
Pre-Crisis	Mean	-0.37%	0.14%	1.78%	10.99%	3.41%	2.03%	10.20%	6.02%	-1.67%	19.87%	9.42%	1.43%
	95% CVaR	5.20%	6.46%	12.17%	20.83%	42.04%	31.35%	29.83%	6.64%	44.76%	12.64%	75.10%	11.55%
	Skewness	-0.31	-0.33	-0.21	-0.71	-0.21	-0.07	-0.38	2.90	0.29	4.36	-1.23	-0.43
	Kurtosis	6.03	5.11	4.29	10.43	8.27	5.42	4.26	66.08	33.42	35.09	44.51	7.60
Overall	Mean	0.34%	0.67%	0.98%	9.09%	0.86%	1.23%	6.89%	3.98%	-2.57%	4.99%	10.58%	1.33%
	95% CVaR	5.21%	7.00%	15.16%	20.43%	44.82%	41.37%	43.15%	8.53%	40.94%	21.32%	72.95%	13.07%
	Skewness	-0.05	-0.43	1.93	-1.40	-0.11	-0.33	-0.58	-1.37	0.00	-5.78	-0.97	-0.28
	Kurtosis	7.41	5.42	38.80	32.55	9.29	10.32	8.63	93.77	32.92	46.36	36.08	7.01

Exhibit 3: This table shows the annualized moments of the return distributions for each sub-period and the total (overall) observation period.

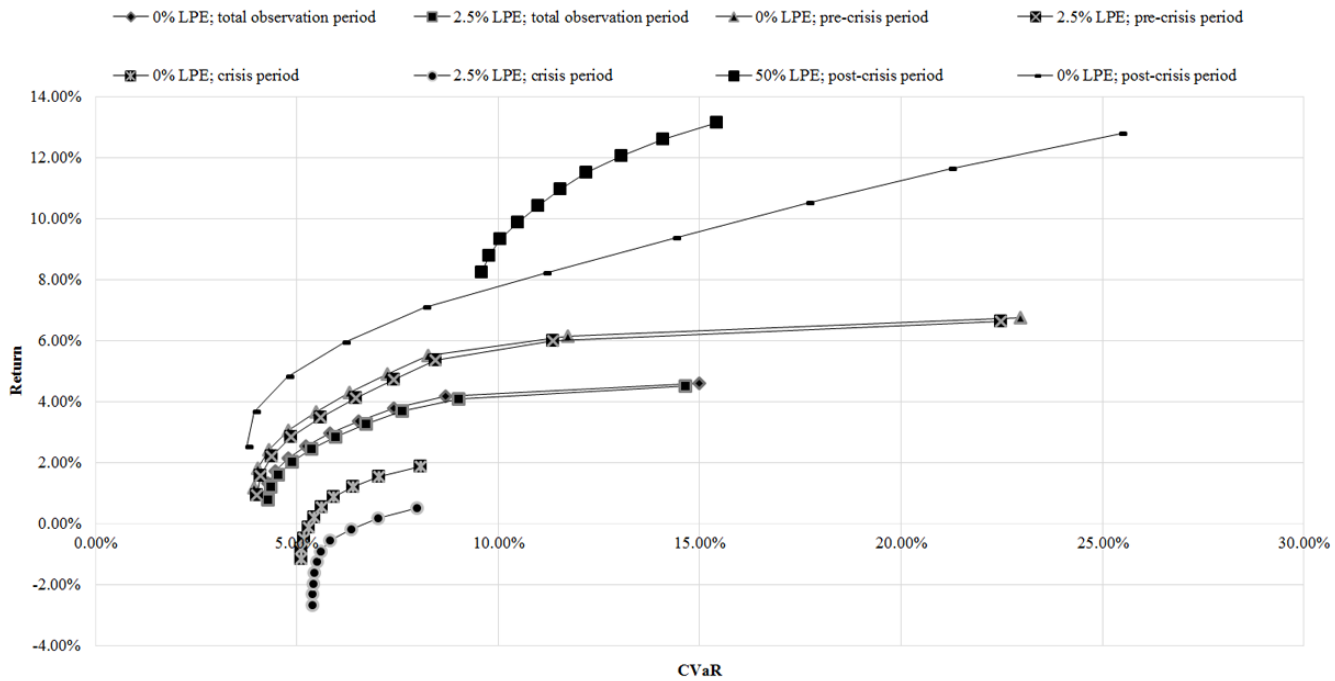

Exhibit 4: This exhibit shows the efficient frontiers for the overall analysed time period from the 1st quarter 2000 through the 4th quarter 2013 as well as for the sub-periods pre-crises (1st quarter 2000-2nd quarter 2007), crises (3rd quarter 2007-1st quarter 2009) and post-crises (2nd quarter 2009-4th quarter 2013). For each time period, an efficient frontier of portfolios containing LPE allocations is presented. For each time period, the chosen frontier is the highest frontier with LPE allocation within the tested range up to the allowed maximum allocation of 50%. For a comparison, the efficient frontier without the LPE allocation is shown only containing indices held by the Pictet LPP-60 reference index. Return and CVaR values are annualized.

with such allocations, accentuates during crisis period. From 3rd quarter 2007 through 1st quarter 2009, LPP and LPE portfolios yield negative returns at low levels of risk. For example, with a 0% LPE allocation, a CVaR of 5.43% is not compensated by a positive return but with a loss of -1.61 percent. Despite the negative returns for low-risk portfolios on both frontiers, portfolios without LPE allocations dominate those with LPE allocations. The tangency portfolio without LPE holdings returns 137 bps with an increase of 7 bps in risk. LPE not only has a bulk of negative returns in the left tail (see exhibit 3) but also shows higher average losses and higher risk than regular stocks.

Optimization with LPE categorized as small cap stock

When assigning LPE to the small cap asset class (see exhibit 5), the findings for the overall, pre-crisis and crisis observation period do not yield significantly different results to the previous analysis (see exhibit 4). A slightly weaker performance of the LPE containing portfolios can be observed. During post-crisis period, the highest efficient frontier allocates 10% to LPE, but does not yield similar returns to the highest efficient frontier with 50% LPE in the stock-replacement optimization. In contrast of the previous scenario, categorization of LPE as regular stock, post-crisis returns for both portfolio types, those with and without LPE, are accompanied by higher risk. The highest risk return portfolios yield 13.61% and 12.77% return with CVaR of 26.79% and 25.44%. This leads to the conclusion that changing the share of actual small cap stocks and replacing it with LPE does not alter the optimal portfolios significantly. In contrast to the previous analysis, the post-crisis results differ as portfolios containing LPE are dominating those without, however to a lesser extent than when the equity portion is substituted.

Optimization with LPE categorized as alternative investment

If the LPP-60 MSCI hedge fund position is replaced with LPE and investments into the SPI, MSCI World and MSCI Small Cap are possible up to 60%, all portfolios for all time segments exhibit a similar risk-return profile than those observed in the small cap-replacement optimization. When comparing to the stock-replacement optimization, portfolios resemble those in the overall, pre- and crisis period and relate to the post-crisis portfolios similarly to those found when replacing hedge funds with LPE. The similar findings for the small cap and alternative investment replacements show that in both cases, the optimal portfolios are determined by the risk and return characteristics of the LPP-60 index holdings and not by the added LPE asset class (see exhibit 5 and 6).

To summarize, the replacement of traditional financial assets and hedge funds covered in the LPP-60 index with LPE does only have a positive effect after the end of crisis, e.g. in the period from 2nd quarter 2009 to the end of 2013. The strongest beneficial effect shows the replacement of regular stocks with a substantial allocation of 50% to LPE. For other time periods and categorization scenarios LPE does not improve optimal portfolios compared to the original LPP-60 portfolio.

To put the findings into perspective and cater to the special properties of LPE with an observable market price and similarity to unlisted private equity limited partnerships, the results of the extended optimization are presented in the following chapter.

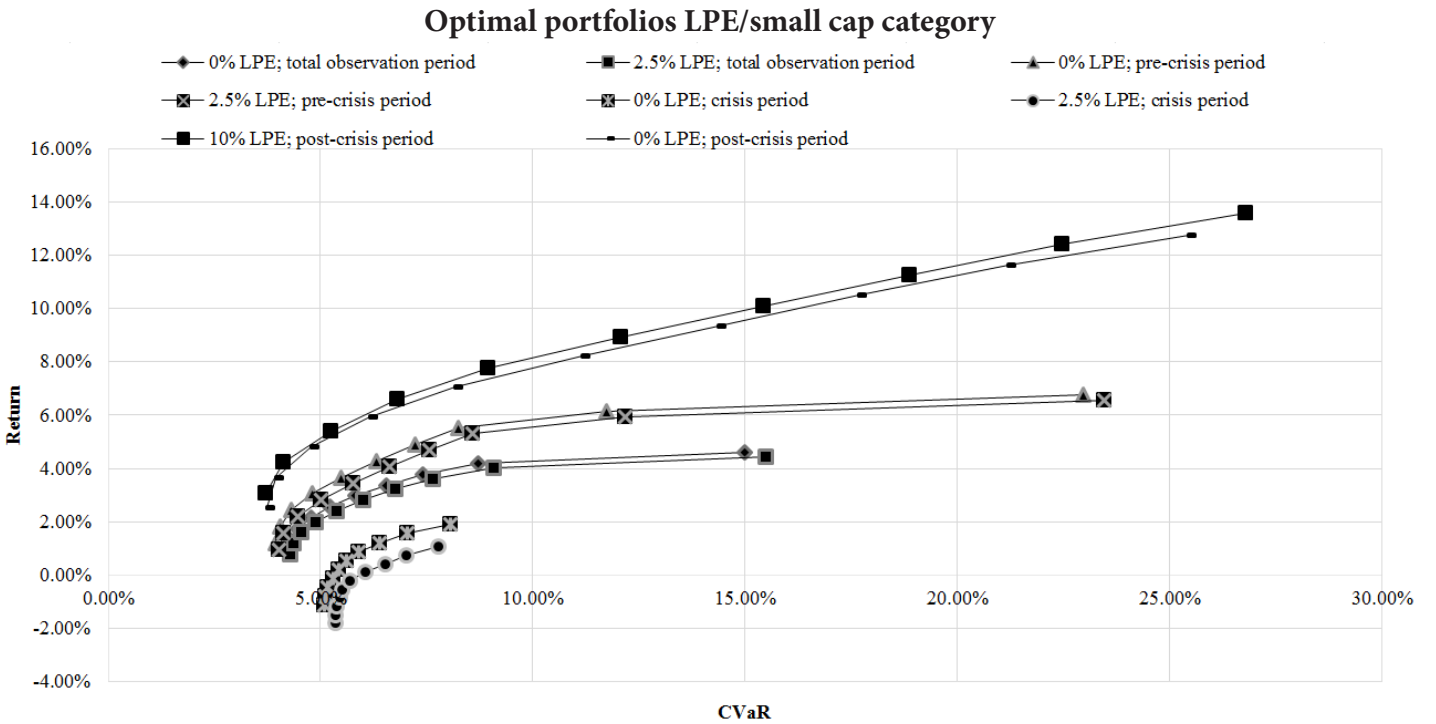

Exhibit 5: This exhibit shows the efficient frontiers for the overall analysed time period from 1st quarter 2000 through 4th quarter 2013 as well as for the sub periods pre-crisis (1st quarter 2000-2nd quarter 2007), crisis (3rd quarter 2007-1st quarter 2009) and post crisis (2nd quarter 2009-4th quarter 2013). For each time period, an efficient frontier of portfolios containing LPE allocations is presented. For each time period, the chosen frontier is the highest frontier with LPE allocation within the tested range up to the allowed maximum allocation of 10%. For comparison, the efficient frontier without the LPE allocation is shown only containing indices held by the Pictet LPP-60 reference index. Retrun and CVaR values are annualized.

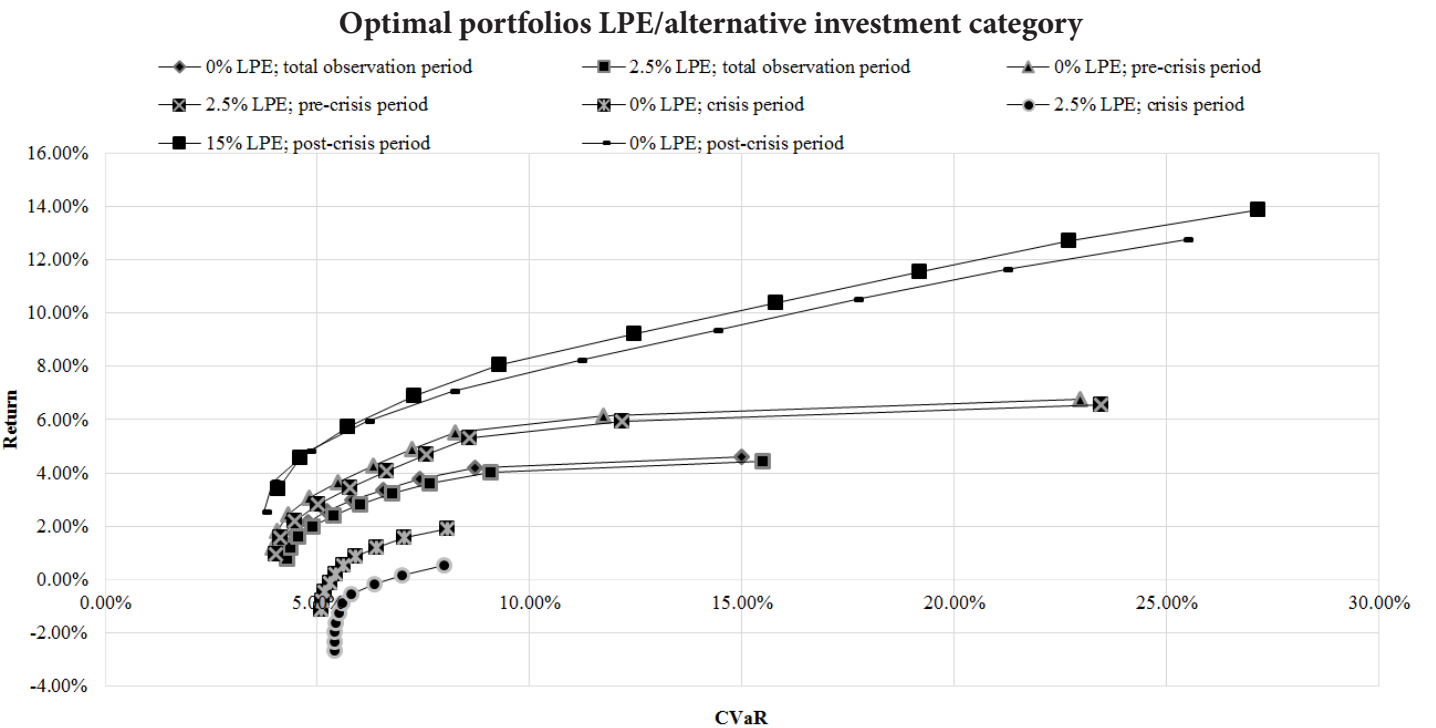

Exhibit 6: This exhibit shows the efficient frontiers for the overall analysed time period from the 1st quarter 2000 through the 4th quarter 2013 as well for the sub-periods pre-crises (1st quarter 2000-2nd quarter 2007), crisis (3rd 2007-1st quarter 2009) and post-crisis (2nd quarter 2009-4th quarter 2013). For each time period, an efficient frontier of portfolios containing LPE allocations is presented. For each time period, the chosen frontier is the highest frontier with LPE allocation within the tested range up the allowed maximum allocation of 15%. For comparison, the efficient frontier without the LPE allocation is shown only containing indices held by the Pictet LPP-60 reference index. Return and CVaR values are annualized.

Portfolio comparison with LPE, LPX50 and Thomson PE allocations

For the first comparison, portfolios for three different weights were compared when investing either in LPE based on market prices (LPE sample), LPE based on NAV (LPX50) and traditional private equity (Thomson Private Equity Buyout index). In this section, the description of the results follows chronological order starting the period before the crisis and discusses the portfolios including three proxies according to their classification as regular stock, small cap stock and alternative investment.

Over the total observation period, LPE could not materially improve pension funds' portfolios. A portfolio in which global and Swiss stocks were replaced with 2.5% LPE yields the best risk-return profile when adding private equity to the model specification. Nevertheless, an unchanged Pictet LPP-60 portfolio exhibits the same risk-return characteristic.

In the next sections, the results for the sub-periods are presented. Regime changes such as the crisis period can influence optimal asset allocations and can show the potential of private equity proxies.

During the pre-crisis period, portfolios holding investments in the LPX50 assigned to the small cap stock and alternative investment portion of the portfolio dominate. Holding portfolios with investments in LPE, hence allocations based on the market price of LPE leads with similar risk but with significantly lower returns. For 15% annual risk (CVaR) a portfolio with 10% LPE holdings returns 8.6% less than the portfolio with the LPX50 holdings. TPE holdings push the frontiers further to the right towards higher risk albeit at the same low return levels as LPE.

The result is not surprising. A look at exhibit 3 shows that the NAV of LPE vehicles not only have higher returns than LPE market prices and traditional private equity, but also higher positive skewness. Additionally, the LPX50 yields strong positive skewness compensating it for the high kurtosis, which otherwise would lead to a reduced representation in the portfolio.

When the indices are assigned to the small cap share or alternative investment share, the findings remain valid for portfolios with LPX50 holdings (see exhibit 8 and 9). LPX50 at low allocations offers the best risk-return relationship, LPE the worst. However, TPE does not increase portfolio risk like in the equity-replacement scenario. The risk-return relationship of TPE and LPE containing portfolios is fairly similar. A direct comparison with the same period analysis but with the proxies categorized as an alternative investment yields similar results. Portfolios with LPX50 holdings compensate with significantly higher returns for the taken risk than portfolios with holdings in TPE or LPE at market prices. Exhibit 3 displays the reason for these findings. The differences of LPE and TPE to LPX50 are striking in terms of higher mean return, lower risk and positive skewness of LPE book value returns (LPX50).

The results for the period up to the second half of 2007 clearly indicate, that book values of LPE had a higher probability to achieve significant positive returns even more pronounced than hedge fund returns. This is an important finding, given that hedge fund returns exhibit skewness and excess kurtosis as well and can be a valuable addition to an institutional investor's portfolio (Till, 2004; Favre & Galleano, 2002). But in contrast to hedge funds, the applied index for LPE book values (LPX50) suffers less from survivorship bias and selection bias than a typical hedge fund index (Pictet, 2014; HFR, 2008; Bilo et al., 2005). As LPE is listed

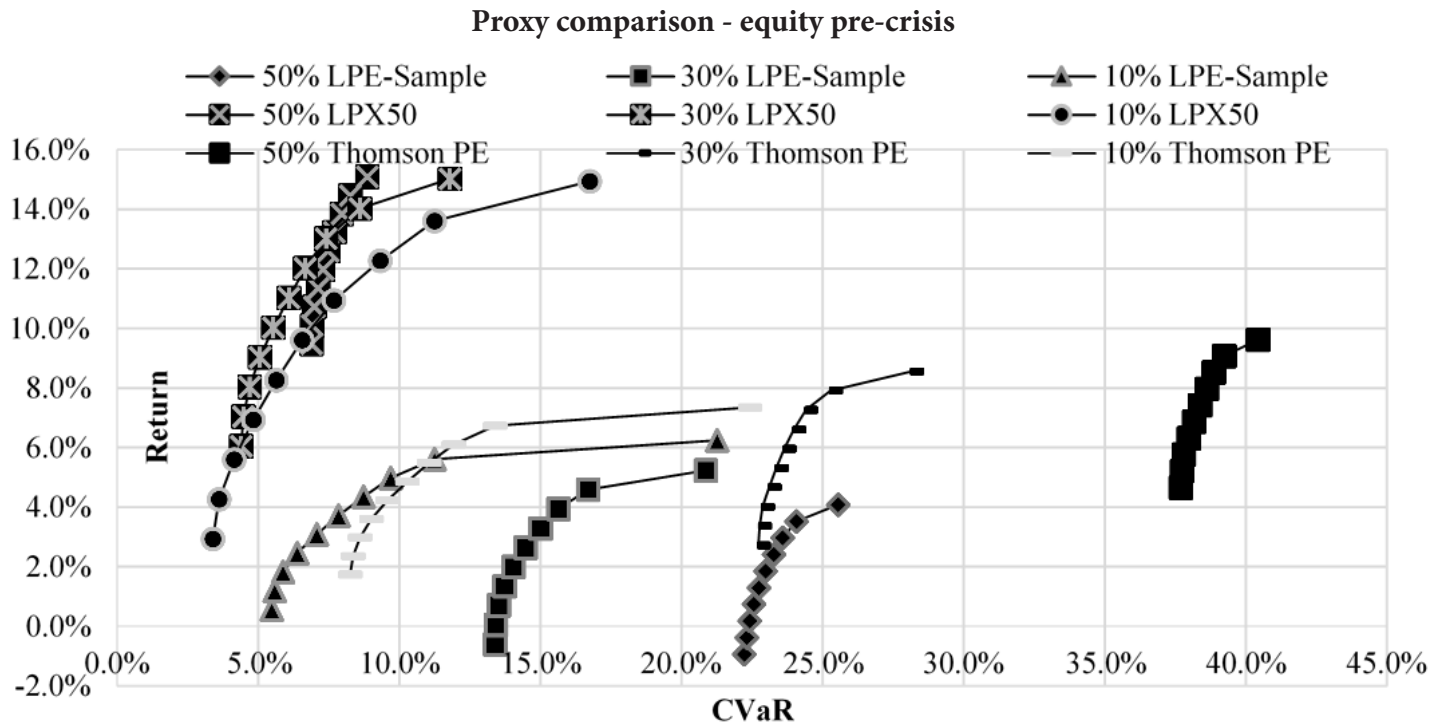

Exhibit 7: This exhibit shows the efficient frontiers for the pre-crisis period with fixed allocations of 10%, 30% and 50% to the self-constructed LPE price index, the LPX50 and the Thompson PE Buyout index. The allocations replace the equity holdings of the portfolio (MSCI World, SPI). Return and CVaR values are annualized.

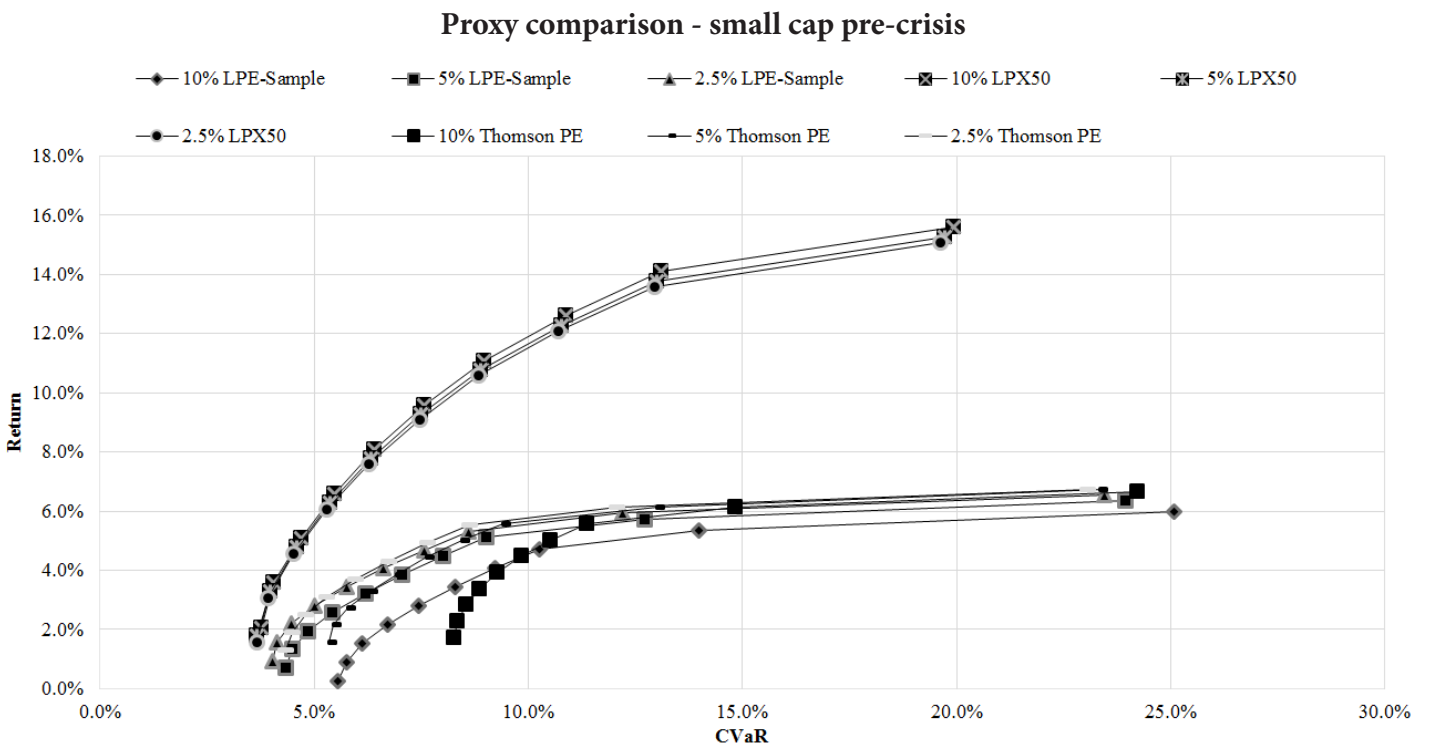

Exhibit 8: This exhibit shows the efficient frontiers for the pre-crisis period with fixed allocations of 2%, 5% and 10% to self-constructed LPE price index, the LPX50 index and the Thomson PE Buyout index. The allocations replace the small cap stock holdings of the portfolio (MSCI Small Cap World). Return and CVaR values are annualized.

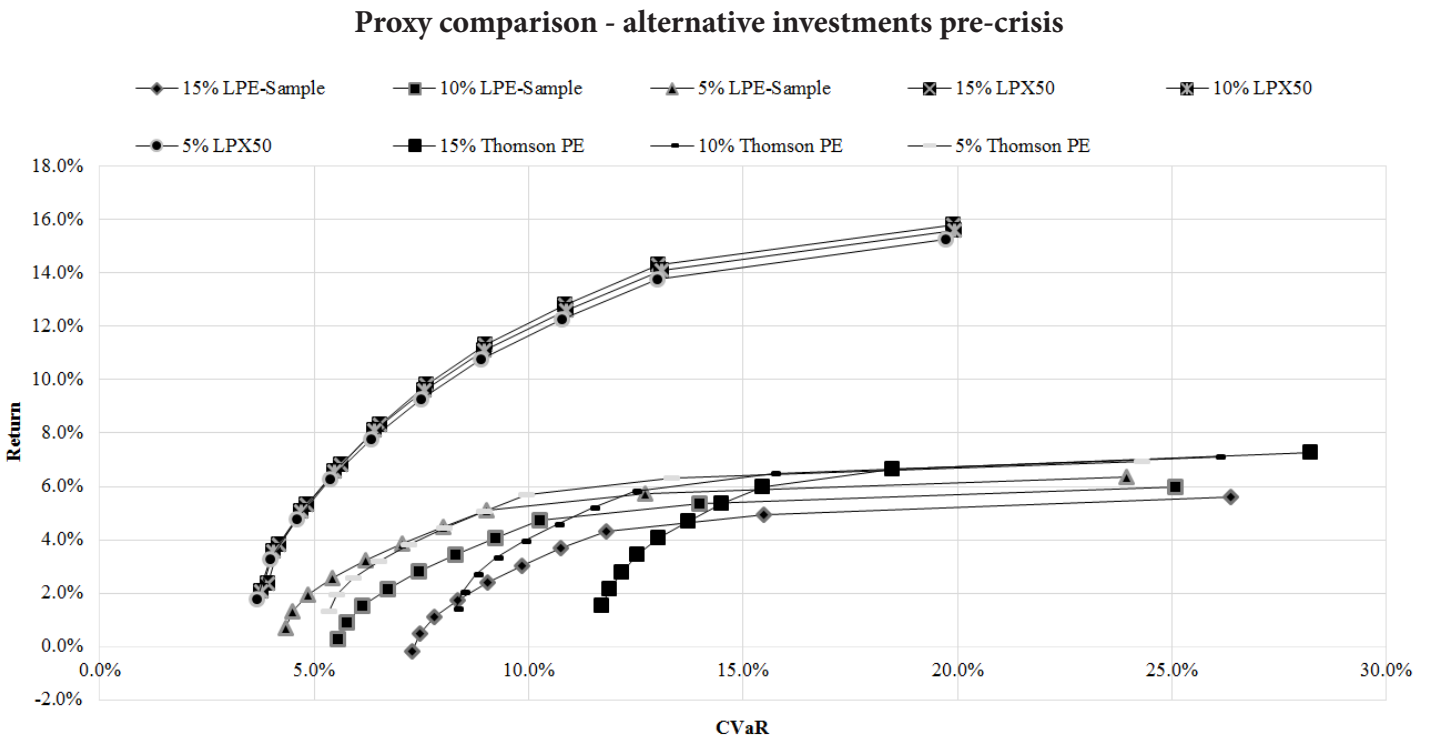

Exhibit 9: This exhibit shows the efficient frontiers for the pre-crisis period with fixed allocations of 5%, 10% and 15% to the self-constructed LPE price index, the LPX50 index and the Thomson PE Buyout index. The allocations replace the hedge fund holdings of the portfolio (HFRX). Return and CVaR values are annualized.

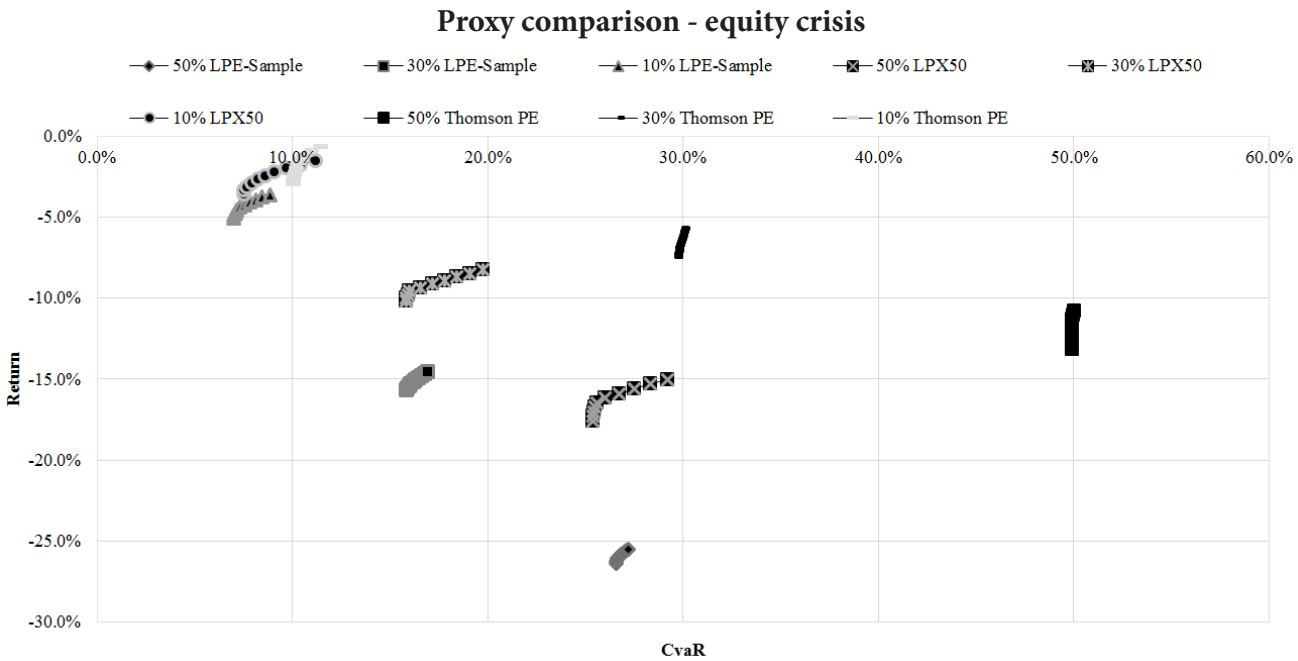

Exhibit 10: This exhibit shows the efficient frontiers for the crisis period with the allocations of 10%, 30% and 50% to the self-constructed LPE price index, the LPX50 index and the Thomson PE Buyout index. The allocations replace the equity holdings of the portfolio (MSCI World, SPI). Return and CVaR values are annualized.

on a stock exchange, reporting and governance requirements lead to higher transparency and reliability of the presented data (LPX, 2015b).

During the crisis, investment possibilities shrinked, leading to short frontiers where the minimum-risk and the tangency portfolio remain close together. For positive allocations to LPE, LPX50 and TPE no positive returns can be achieved in an equity-replacement scenario (see exhibit 10). The best choice is a portfolio with 10% TPE holdings when replacing the equity portion. Traditional private equity lost less in comparison with regard to return and exhibits a smaller change in terms of negative outliers, e.g. skewness compared to previous periods. Contrary to the previous period, LPE holdings based on the book value, e.g. NAV are not a favorable portfolio addition anymore. The highly positive skewness from previous quarters changed to a similarly extreme negative skewness during crisis whereas at the same time returns collapsed.

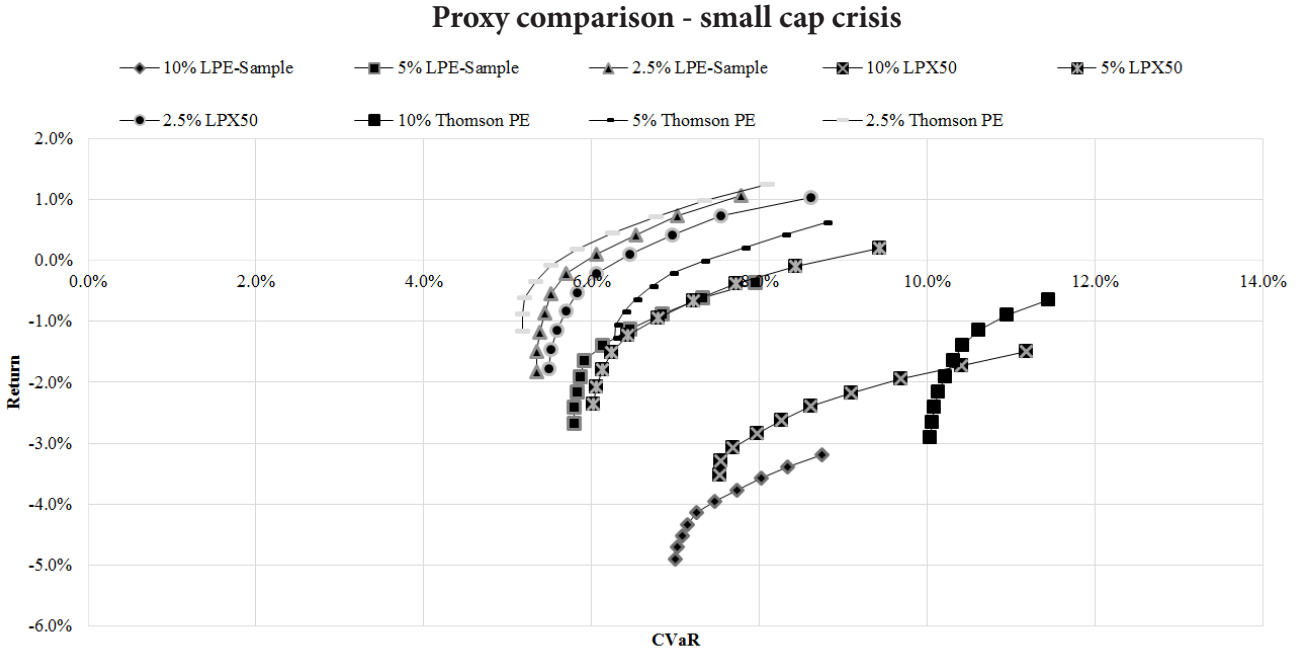

Exhibit 11: This exhibit shows the efficient frontiers for the crisis period with the fixed allocations of 2%, 5% and 10% to the self-constructed LPE price index, the LPX50 index and the Thomson PE Buyout index. The allocations replace the small cap stock holdings of the portfolio (MSCI Small Cap World). Returned and CVaR values are annualized.

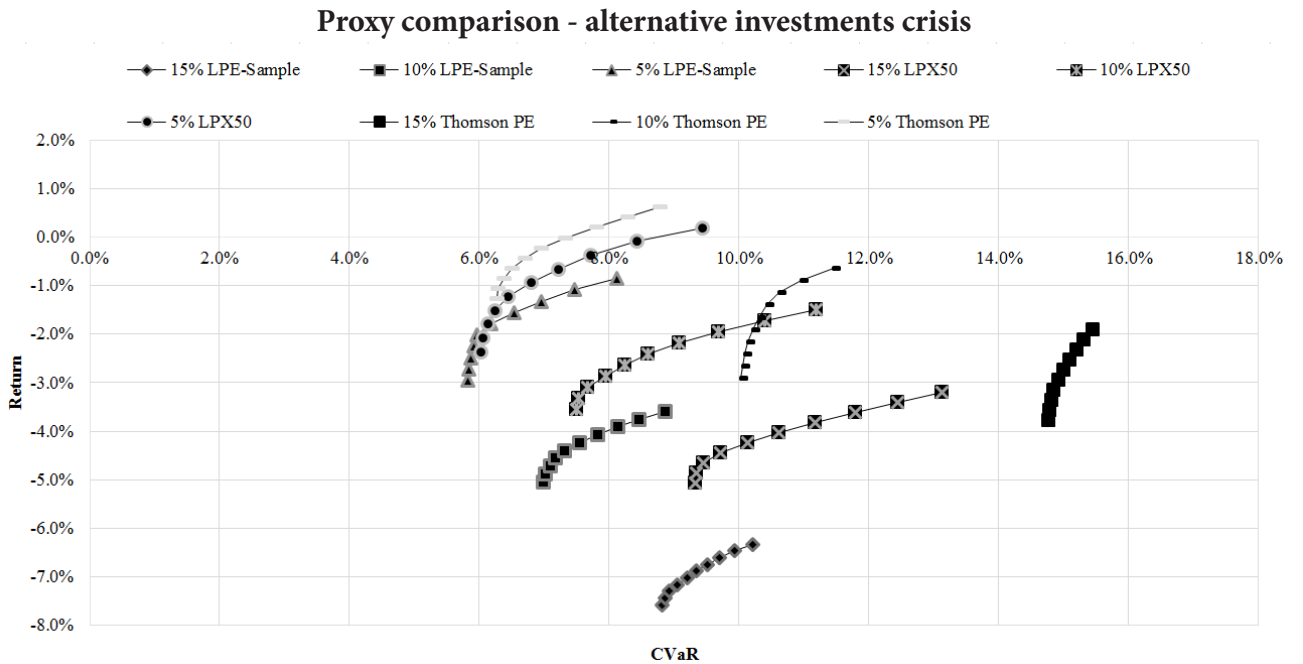

Exhibit 12: This exhibit shows the efficient frontiers for the crisis period with fixed allocations of 5%, 10% and 15% to the self-constructed LPE price index, the LPX50 index and the Thomson PE Buyout index. The allocations replace the hedge fund holdings of the portfolio (HFRX). Return and CVaR values are annualized.

During crisis, TPE is the best substitution for small cap stocks similar to the equity substitution case. But in contrast to the previous analysis, for both cases small cap and alternative investment substitution positive returns are feasible (see exhibit 11 and 12). If categorized as an alternative investment, even an allocation to LPX50 yields a positive return (exhibit 12).

After the crisis, TPE allocations categorized as stock result in the highest efficient frontier (exhibit 13). Due to the far right location, both risk and return are significantly higher than with portfolios containing LPE or LPX50. The highest efficient frontier holding TPE yields an annual return of more than 18.3% at a CVaR of 28%.

For 15% CVaR, LPE holdings of 50% LPE yield 13.1% return p.a., whereas 30% allocations to the LPX50 and TPE offer 9.8% and 11.9% in return (see exhibit 13). Without a target return, from a

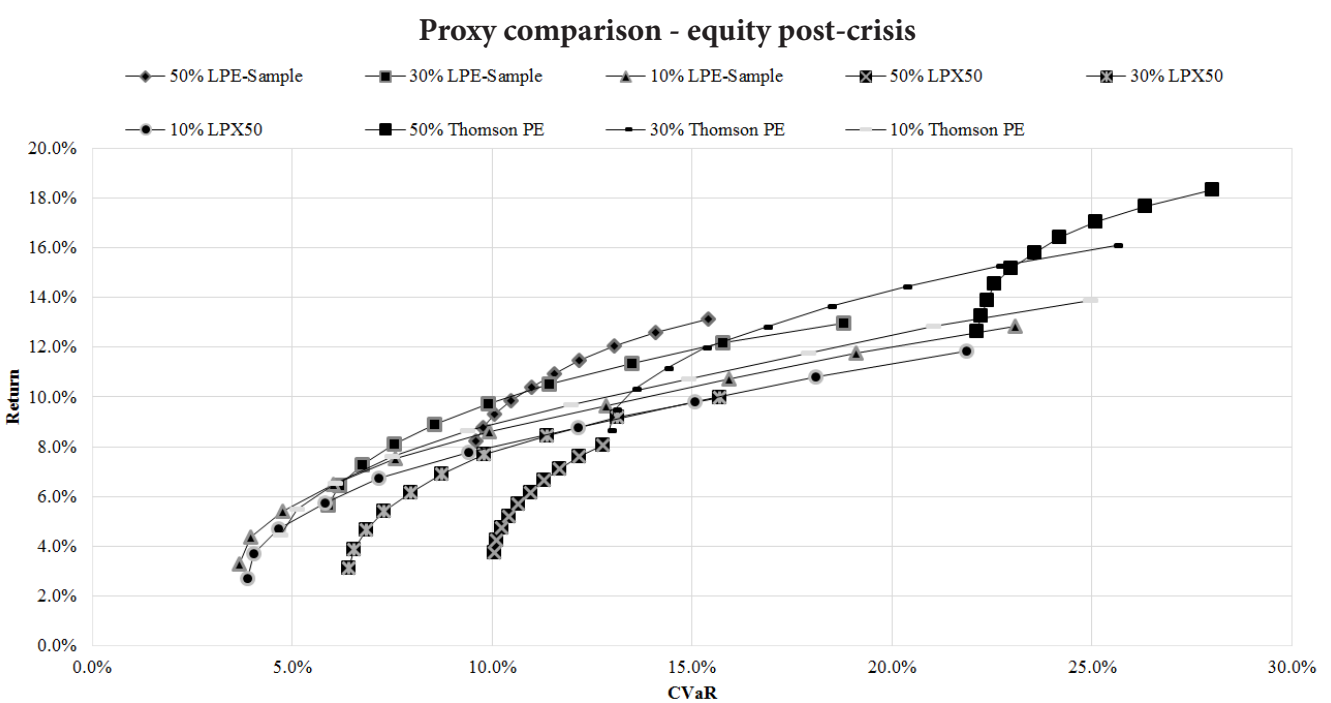

Exhibit 13: This exhibit shows the efficient frontiers for the post-crisis period with fixed allocations of 10%, 30% and 50% to the self-constructed LPE price index, the LPX50 index and the Thomson PE Buyout index. The allocations replace the equity holdings of the portfolio (MSCI World, SPI). Return and CVaR values are annualized.

risk-return perspective, LPE investments leave investors better off. After crisis, more risk-averse and risk-seeking investors can benefit from holding portfolios with LPE allocations. However, with a target return higher than 13.1% p.a., investors must accept annual risk of minimum 18.8% CVaR and shift to mid- and high-range TPE allocations.

Portfolios based on the NAV of LPE lost to LPE and TPE portfolios. Traditional unlisted private equity dominates when included even at a low weight of 10% all variations of LPX50 portfolios. The fact that on each level of risk and with all weight allocations, LPX50 portfolios are dominated by TPE and LPE can be explained by exhibit 1 and exhibit 3. The LPX50 NAV not only has the lowest mean return, but also the highest kurtosis.

In contrast, to previous sub-periods, risk-return ratios increased compared to the other tangency portfolios. For the LPX50 the post-crisis period data shows unfavorable moments compared to pre-crisis values, but LPE and TPE benefit from reduced risk and increased returns. The shift in risk-return characteristics between the LPX50 and TPE and LPE results in new optimal portfolios holding LPE investments at market prices. Optimizations treating proxies as either an alternative asset or a small cap stock highlight again the favorable properties of TPE and the similarities of the distribution moments to LPE (see exhibit 14 and 15). Two findings are noteworthy: First, optimal portfolios and efficient frontiers are closer together, the choice of proxy does lead to different portfolios but with less dispersion than in the stock-replacement scenario. In latter, optimal portfolios differ by the investor's risk taking ability or willingness. Moderate risk takers without a high target return are better off with portfolios containing LPE whereas investors accepting higher risk would ideally invest in a portfolio with traditional private equity. This leads to the second remark: Optimal holdings are clearly identifiable at every level or risk and willingness to take risk. TPE containing portfolios return on average more than portfolios with allocations to LPE and LPX50.

In summary, the results for the post-crisis period differ in terms of dominance of a specific proxy and the asset, which is replaced by it. The highest dispersion could be found when the three proxies replace the equity portion of the portfolio as variations among higher moments of the proxies and the MSCI World as well as the SPI are large. When analyzing the small cap-replacement scenario, frontiers become less dispersed, market prices of LPE and traditional private equity show similar distribution moments than small cap stocks and dominate portfolios with LPX50 holdings. Lastly, when replacing the hedge fund portion only traditional private equity investments are optimal at every risk level.

The findings previously described are based on the most diversified asset allocations of pension funds within the P7 group and correspond to regulations faced by Swiss pension funds whose pension assets to GDP ratio is similar to the US and the UK (Towers Watson, 2015). Although the results about optimal portfolios were derived by application of investment weight ceilings unique to the Swiss pension fund market (see exhibit 2), the findings can be generalized based on the historical asset allocations of pension funds globally. The pension fund study by Towers Watson (2015) showed that stock allocations of pension funds were less than 50% in 2014, a reduction of 10% and 3% in UK and the US over 5 years. In total, pension funds in the largest markets (P7) held on average 51.25% in stocks from 1995 to 2014, which is similar to the stock position ceiling applied (see exhibit 2). With regard to the other constrained asset groups, namely real estate and alternative assets such as hedge funds and private equity, the cumulative weight ceilings of 15% and 30% are ample constraints given the current allocations to alternative assets of 15% and 29% in the UK and the US. Despite the lack of binding investment ceilings, the pension funds of the largest two pension markets showed similar allocations to the main investment categories.

Conclusion

Exhibit 16 displays the best portfolio choice in terms of proxy per time period:

During pre-crisis period, listed private equity would have been a good addition to an LPP-60 portfolio. No matter the categorization, LPE inclusion with maximum weight led to dominant portfolios. However, this dominance could only be achieved when investing in LPE by holding an investment reflecting the net asset values of the LPE vehicles. Hence, the benefit of holding a liquid investment (by a share purchase in an illiquid industry) cannot be obtained. Nevertheless, the best portfolio from a risk-return perspective has the small cap and alternative investment portion replaced by the LPX50.

During crisis, TPE was the best addition to the portfolio. It yielded significantly better risk-return portfolios than when LPE would have been considered. Nevertheless, an unchanged LPP-60 portfolio is the optimal choice. This finding is in line with Goldwhite (2009) who showed that active strategies such as LPE do not strongly diversify in an environment of rising risk aversion. The dominance of TPE compared to LPE and LPX50 during crisis indicate that traditional limited partnerships displace listed private equity in slumping market environments. Clearly, this should be tested for confirmation under the aspect of valuation difficulties with limited partnerships.

After the crisis, the best altered portfolio replaces the stock investment portion to the full extent of 50% with LPE. As the locations of the efficient frontiers depend widely on the selected proxies, strict optimality is only given up to a certain risk threshold of 15.4% and if no return above 13.1% is targeted. Otherwise, only traditional private equity would fulfill the requirements of higher risk-adjusted returns.

The findings differ from previous results in terms of investor type and corresponding investment restrictions, applied optimization model and derived optimal portfolio weights. Firstly, the results presented are based on the assumption that LPE should be tested as a niche-type of private equity, which due to its hybrid character can be classified into investment groups and should not serve merely as a proxy for private equity in the familiar sense of limited partnerships (Preqin, 2015a; Huss & Zimmermann, 2012; Brown & Kraeussl, 2012). In contrast, Cumming et al. (2013) tested LPE as a proxy for private equity and found that LPE is not suitable to track the performance of traditional partnerships in portfolios as it induces unnecessary volatility, which results in low private equity allocations even if considering only return and volatility. Secondly, the results presented in this paper take into account weight caps on individual investment groups. Such investment constraints were not considered in earlier studies (see Cumming,

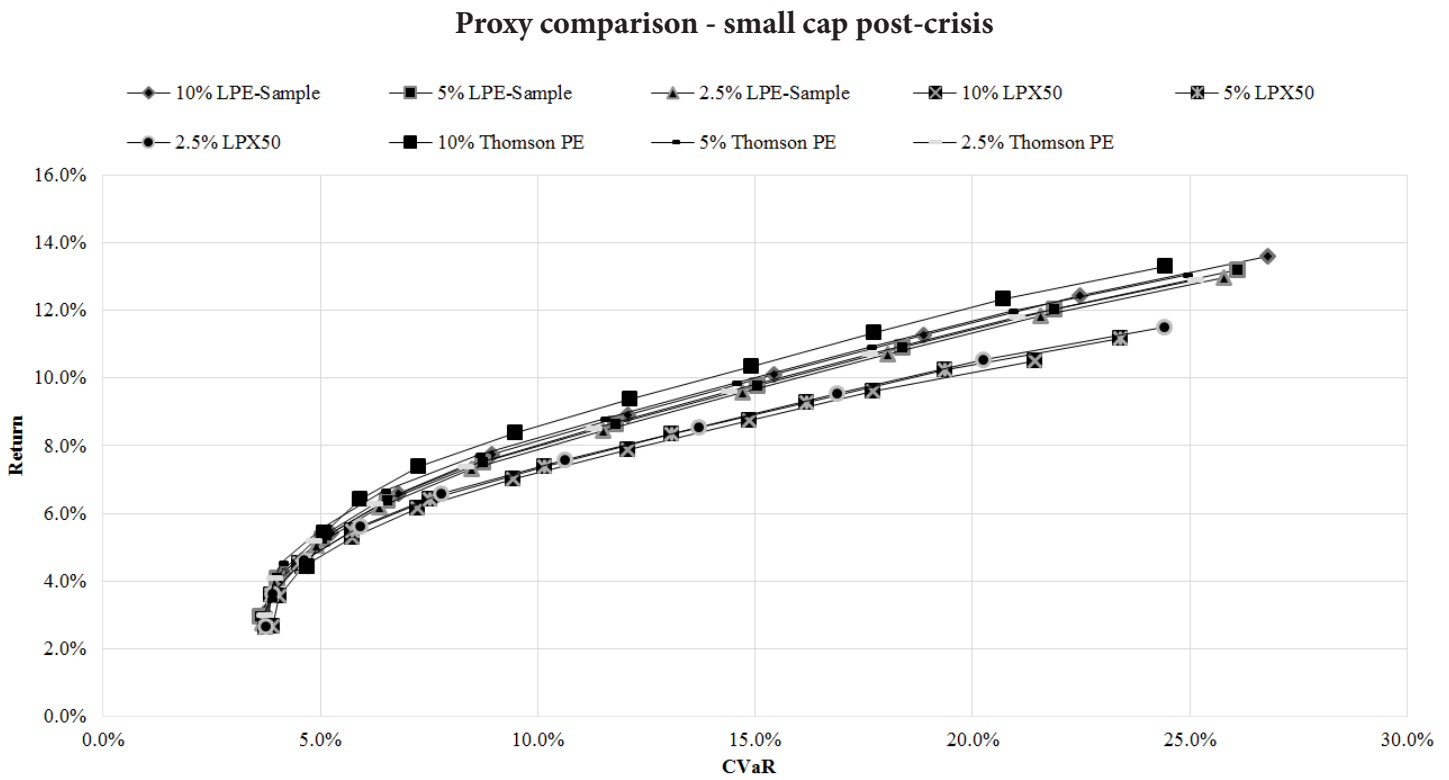

Exhibit 14: This exhibit shows the efficient frontiers for the post-crisis period with fixed allocations of 2%, 5% and 10% to the self-constructed LPE price index, the LPX50 index and the Thomson PE Buyout index. The allocations replace the Small cap stock holdings of the portoflio (MSCI Small Cap World). Return and CVaR values are annualized.

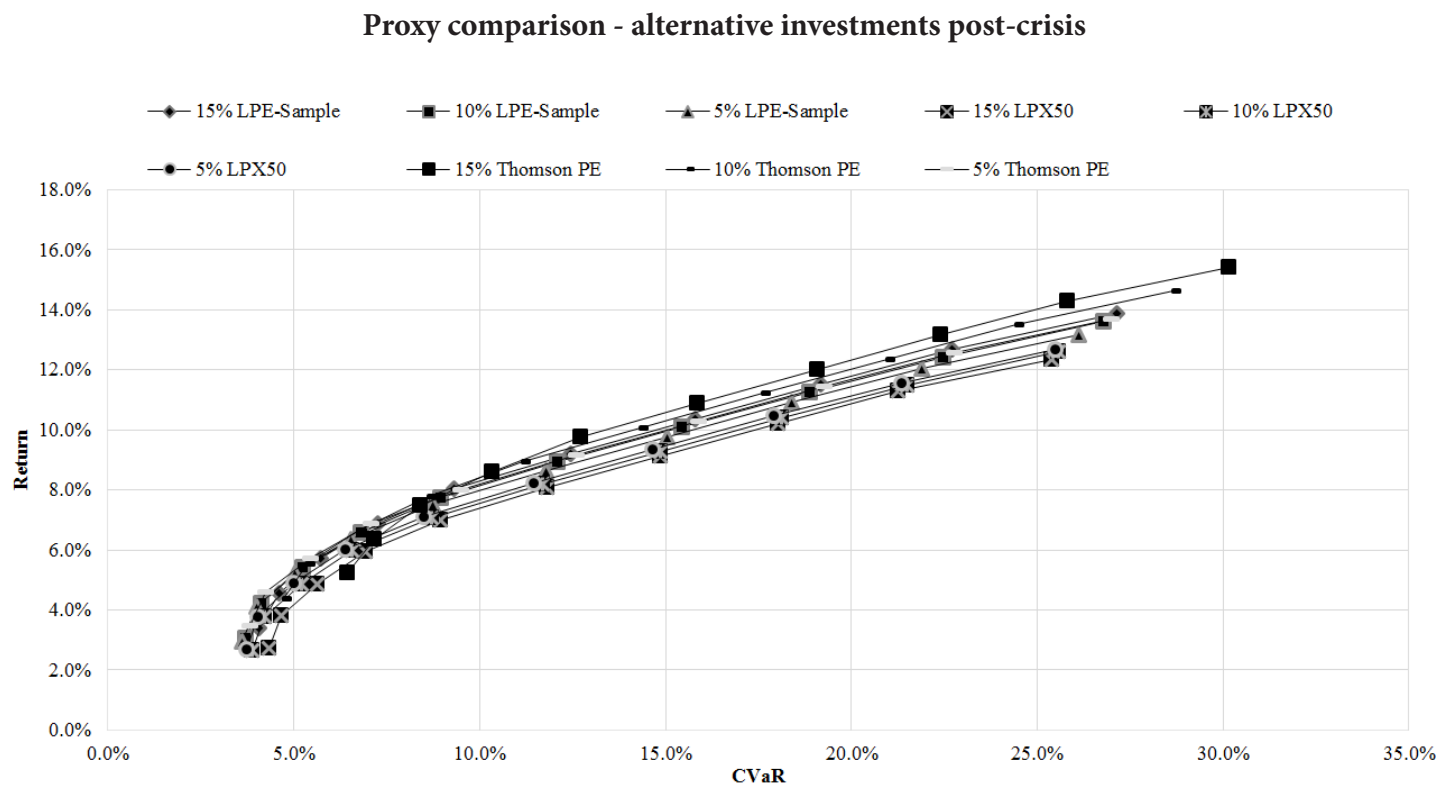

Exhibit 15: This exhibit shows the efficient frontiers for the post-crisis period with fixed allocations of 5%, 10% and 15% to the self-constructed LPE price index, the LPX50 index and the Thomson PE Buyout index. The allocations replace the hedge fund holdings of the portfolio (HFRX). Return and CVaR values are annualized.

Hass & Schweizer, 2014; 2013; Aigner, Beyschlag, Friederich, Kalepky and Zagst, 2012; 2010; Bekkers, Doeswijk & Lam, 2009; Goldwhite, 2009). Aigner et al. (2012) who optimized portfolios consisting of three indices covering global equities, world government bonds and LPE showed that allocations to LPE are strongly driven by an investor's risk aversion (see also Aigner et al., 2010). Contrary to the results presented in this paper, Aigner et al. (2012) do not generalize the optimal LPE weights as they mention the caveat of investment limits for institutional investors regarding alternative investment holdings, but base their analysis on portfolios for unconstrained investors. Thirdly, the portfolios presented in this paper simultaneously consider a realistic number of indices and asset groups and are based on the minimization of CVaR, which adds skewness and tails to the equation. The optimization model applied by Aigner et al. (2012) accounted for higher moments but only considered three broad-market indices. The first-order autoregressive Markov-switching model resulted in moderate allocations to risky assets such as stocks and LPE (up to 32.76%) compared to mean-variance based optimal portfolios (up to 100%) suggested by Bekkers et al. (2009). More specified portfolios considering several asset classes and indices were optimized by Bekkers et al. (2009). However, the chosen optimization framework is based on return variance and does not consider skewness and kurtosis. Bekkers et al. (2009) showed that based on the variance of the tested ten portfolio assets, riskier portfolios contain LPE whose share increases and in the end, LPE ousts bonds, real estate, commodities and stocks. Portfolios consisting entirely of LPE are not feasible in the presented analysis as investment constraints allow for a maximum allocation of 50% when assigning LPE to the stock investment group.

Conclusion

Pension fund managers globally seek to compensate declining performance of traditional financial assets with alternative return sources from hedge funds and private equity. As pension funds in most countries are faced with binding investment constraints in terms of allowed asset classes and maximum weights, not every alternative investment meets the requirements to be included in the portfolio. Listed private equity vehicles as private equity direct investing funds or fund managers provide access to the core business of limited partnerships but with the positive side effect to be a liquid instrument due to public stock market listing.

In this paper, I showed the effects of the addition of listed private equity to a Swiss pension fund model portfolio. This makes the results valid for practitioners, as the model portfolio of the Pictet LPP-60 index is a major reference index for fund managers and adheres to the provisions of LPP law. The approach to base the analysis on the CVaR of portfolio assets caters to the non-normal distribution of asset returns.

The first stage of optimizations only tested the effect of LPE on a pension fund's model portfolio based on their daily market prices without consideration of NAV development or other types of private equity. Empirical results showed that LPE is only a beneficial addition to a pension fund's portfolio in reclining markets as indicated by the post-crisis findings. Specifically, the addition of LPE based on the market prices yields the best results when the LPE investments replaces regular stocks in the portfolio. Under those prerequisites, the weight allocated to LPE should be substantial such as the legally allowed maximum weight of 50%.

Proxy comparison - alternative investments post-crisis

		LPE categorized as:			
		Regular Stock	**Small Cap Stock**	**Alternative Investment**	**without LPE**
Post-Crisis	**Optimal EFF**	50% LPE	10% TPE	15% TPE/2.5% LPE	
	Return	13.10%	13.30%	15.4/13.87%	12.77%
	95% CVaR	15.40%	24.40%	30.2/27.16%	25.44%
	Ratio	0.85	0.55	0.51/0.51	0.5
Crisis	**Optimal EFF**	10% TPE	2.5% TPE	5% TPE	
	Return	-0.50%	1.30%	0.60%	1.89%
	95% CVaR	11.00%	8.10%	8.80%	8.06%
	Ratio	-0.05	0.16	0.07	0.23
Pre-Crisis	**Optimal EFF**	50% LPX50	10% LPX50	15% LPX50	
	Return	8.90%	15.60%	15.60%	6.56%
	95% CVaR	15.10%	19.90%	19.90%	23.45%
	Ratio	0.59	0.78	0.78	0.28
Overall	**Optimal EFF**	2.5% LPE	2.5% LPE	5% LPX50	
	Return	4.50%	4.43%	7.60%	4.60%
	95% CVaR	14.64%	15.50%	28.70%	15.00%
	Ratio	0.31	0.29	0.26	0.31

Exhibit 16: This exhibit shows the efficient frontiers for the post-crisis period with fixed allocations of 5%, 10% and 15% to the self-constructed LPE price index, the LPX50 index and the Thomson PE Buyout index. The allocations replace the hedge fund holdings of the portfolio (HFRX). Return and CVaR values are annualized.

The second stage of optimizations puts LPE in the context of the private equity asset class by testing other types. As one could assume that LPE is only a proxy and potentially not a sufficient one, a comparison to portfolios with traditional private equity and LPE NAV based allocations showed quite the opposite. LPE is a beneficial addition to a pension fund's portfolio albeit not always based on a market price index. The sub-period analysis showed that during the pre-crisis period, portfolios holding LPX50 are substantially better performing on a risk-adjusted basis than the Pictet LPP-60 reference portfolio. Most noteworthy, this finding can be confirmed no matter to which category the LPX50 holding was assigned. The strongest effect on the portfolio is achieved by holding the maximum weight per investment category, hence fully replacing the respective category asset.

During crisis, low allocations to traditional private equity yield the best results of the proxies tested, however leaving the Pictet LPP-60 reference portfolio unchanged was most beneficial.

The results do not surprise based on the distribution parameters of LPE NAV, however, the difference between the higher moments of the LPX50 and TPE is remarkable given that both indices track the performance of private equity entities with the same nature of operations. As due to their listing, LPE vehicles are under scrutiny when it comes to corporate governance and reporting, the same analysis with primary data on limited partnerships might shed light on this specific finding.

In a reclining market environment, all proxies can have a positive effect pension funds' portfolios. Price-based allocations to LPE yield strong results, especially for the stock-replacement scenario. In any case and for each categorization, the portfolio dominate the unaltered Pictet LPP-60 model portfolio.

In summary, the following points can be taken away: In upmarkets and reclining markets, it enhances a pension fund's risk-adjusted portfolio return if the model portfolio altered by private equity allocations. There is no clear indication however, in which investment category private equity proxies would consistently yield the best results. Another component helping to decide in which category to make changes in the asset allocation and based on which type are target returns and risk constraints. A lower willingness to accept risk would indicate allocations to LPE rather than TPE during market recoveries. Furthermore, timing matters in terms of when the model portfolio change should be made. Out-of-sample tests with similar market regime changes would help to build a pattern and strategy for this. Lastly, I showed that LPE adds value to pension fund's model portfolios. This is however arbitrary to the expected benefits flexibility and accessibility to private equity by a share purchase as investor's cannot participate solely in the NAV development unless buying into the LPX50 index. Nevertheless, the good results after crisis indicate future value added of LPE market price indices for pension funds' portfolios.

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A Review of Term Structure Estimation Methods

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Introduction

The term structure of interest rates, or the TSIR, can be defined as the relationship between the yield on an investment and the term to maturity of the investment. Many alternative assets such as real estate, private equity, and hedge fund investments are illiquid with long-term cash flows, without a readily available source for market prices. Thus, a properly estimated term structure of interest rates is essential for obtaining the intrinsic values of these assets. Due to the non-linear convex relationship between asset prices and interest rates, any errors in the estimation of interest rates in a low-yield environment have a larger impact on the intrinsic valuation of these assets. Thus, an accurate estimation of the term structure of interest rates assumes even greater importance in the current low-yield environment with a yield around 1% on the short end, and a 3% yield on the 30-year Treasury bond. Moreover, the TSIR is also relevant for macroeconomic forecasts of short-term rates, and implementation of monetary policy and debt policy by governments (see Piazzesi [2010]).

As noted by Bliss [1997], the TSIR estimation requires making three important decisions. First, one must consider the assumptions related to taxes and liquidity premiums in the pricing function that relates bond prices to interest rates or discount factors. Second, one must choose a specific functional form to approximate the interest rates or the discount factors. Moreover, third, one must choose an empirical method for estimating the parameters of the chosen functional form. This paper focuses on how to estimate the default-free term structure of interest rates from bond data using three methods: the bootstrapping method, the McCulloch cubic-spline method, and the Nelson and Siegel method. Nelson and Siegel method is shown to be more robust than the other two methods. The last two methods can be implemented using the user-friendly Excel spreadsheet prepared by the authors.[1]

The structure of the paper is as follows. First, we review the main concepts about the TSIR, such as discount functions, bond prices, yield to maturity, several definitions of interest rates and a discussion of the shape of the TSIR. Next, we describe three popular term structure estimation methods and point out the clues for a proper usage and their limitations.

1. The Building Blocks: Bond Prices, Spot Rates, and Forward Rates

The TSIR can be expressed regarding spot rates, forward rates, or prices of discount bonds. This section shows the relationship between these concepts.

1.1. The Discount Function

Under continuous compounding, the price (or present value) of a zero-coupon bond with a face value of $100 and a term to maturity of t years can be written as:

$$P(t) = \frac{100}{e^{y(t)t}} = 100\ e^{-y(t)t} = 100\ d(t) \qquad (1)$$

where $y(t)$ is the continuously-compounded rate corresponding to the maturity term t. The function $y(t)$ defines the continuously-compounded term structure based upon zero-coupon rates. The expression $e^{-y(t)t}$ is referred to as the discount function $d(t)$. The typical shape of the discount function is shown in Figure 1. This function starts at 1, since the current value of a $1 payable today is $1, and it decreases with increasing maturity due to the time value of money.

If a series of default-free zero-coupon bonds exist for differing maturities, then it is possible to extract the term structure by simply inverting equation (1) to obtain $y(t)$. However, due to the lack of liquidity and unavailability of zero-coupon bonds for all maturities, the term structure cannot be simply obtained by using zero-coupon bonds such as U.S. Treasury STRIPS.

1.2. Bond Price and Accrued Interest

A coupon bond can be viewed as a portfolio of zero-coupon bonds. Using discount function given above, the present value of each coupon paid t_j periods from today is given by $C \times d(t_j)$, where C is the coupon received. This approach can be used to calculate the present value of all the payments, coupons and face value.

This approach gives us P_0, which is called the *cash price* of a bond, and is the price that purchaser pays when buying the bond. However, bond prices are not quoted as cash prices. The quoted prices are *clean prices*, which exclude the accrued interest. Accrued interest is the interest accumulated between the most recent interest payment and the present time. If t_0 denotes the current time, t_p denotes the date of the previous coupon payment, and t_q denotes the date of the next coupon payment, then the formula for accrued interest is given as:

$$AI = C\left(\frac{t_0 - t_p}{t_q - t_p}\right) \qquad (2)$$

and the bond's quoted price is equal to the present value of the all the payments minus the accrued interest. That is,

$$\text{Quoted Price} = P_0 - AI \qquad (3)$$

Computation of accrued interest requires the *day count basis* used in the market. The day count basis defines how to measure the number of days in a year and as well as the number of days between coupons. Note that it is not the cash price, but the quoted price that depends on the specific day count convention being applied. Any increase (decrease) in the accrued interest due to a specific day count convention used is exactly offset by a corresponding decrease (increase) in the quoted price so that the cash price remains unchanged. Since the TSIR is computed using cash prices, it is also independent of the day count convention used. Of course, it is necessary to know the day count convention to obtain the cash price using the quoted price and the accrued interest.

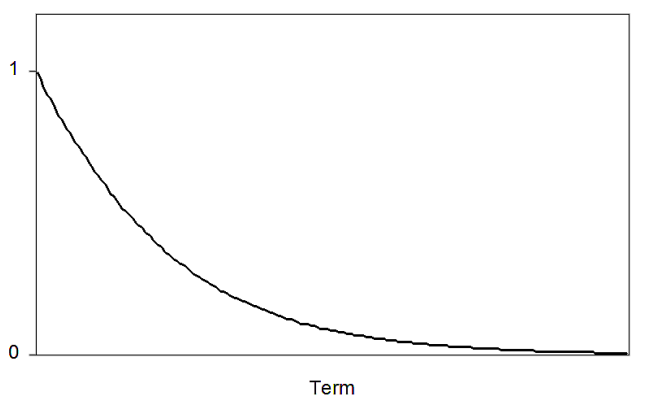

Figure 1: The discount function

1.3. Yield to Maturity

The yield to maturity is given as that discount rate that makes the sum of the discounted values of all future cash flows (either of coupons or principal) from the bond equal to the cash price of the bond, that is:[2]

$$P = \sum_{j=1}^{N} \frac{C}{e^{y \times t_j}} + \frac{F}{e^{y \times t_N}} \qquad (4)$$

Note that the yield to maturity is a complex weighted average of zero-coupon rates. The size and timing of the coupon payments influence the yield to maturity, and this effect is called the coupon effect. In general, the *coupon effect* will make two bonds with identical maturities but with different coupon rates or payment frequencies have different yields to maturity if the zero-coupon yield curve is non-flat. The coupon effect makes the term structure of yields on coupon bonds lower (higher) than the term structure of zero-coupon rates, when the latter is sloping upward (downward).

1.4. Spot Rates, Forward Rates and Future Rates

Zero-coupon rates as defined above are spot rates because they are interest rates for immediate investments at different maturities. The forward rate between the future dates t_1 and t_2 is the annualized interest rate that can be contractually locked in today on an investment to be made at time t_1 that matures at time t_2. The forward rate is different from the future rate in that the forward rate is known with certainty today, while the future rate can be known only in future.

Consider two investment strategies. The first strategy requires making a riskless investment of \$1 at a future date t_1, which is redeemed at future date t_2 for an amount equal to:

$$1 \times e^{f(t_1,t_2)(t_2-t_1)} \qquad (5)$$

The variable $f(t_1,t_2)$ which is *known today* is defined as the continuously-compounded annualized forward rate, between dates t_1 and t_2.

Now consider a second investment strategy that requires shorting today (which is the same as borrowing and immediately selling) a \$1 face value riskless zero-coupon bond that matures at time t_1 and investing the proceeds from the short sale in a riskless investment maturing at time t_2. The proceeds of the short sale equal $P(t_1)$, the current price of \$1 face value riskless zero-coupon bond that matures at time t_1. This investment costs nothing today, requires covering the short position at time t_1 by paying \$1, and receiving the future value of the proceeds from the short sale. Since both riskless investment strategies require \$1 investment at time t_1, and cost nothing today, the value of these investment strategies at time t_2 must be identical. That is, they must offer the same compounded rate of return. This observation can be used to calculate the forward rate that is implied by the term structured observed today. Therefore, the compounded forward rate of return between two future dates t_1 and t_2 is given by:

$$f(t_1,t_2) = y(t_2) + \frac{y(t_2)-y(t_1)}{t_2-t_1}t_1 \qquad (6)$$

The above equation implies that if the term structure of zero-coupon rates is upward (downward) sloping, then forward rates will be higher (lower) than zero-coupon rates. For a flat term structure, zero-coupon rates and forward rates are identical and equal to a constant.

In general, forward rates can be computed for any arbitrary interval length, and each length implies a different term structure of forward rates. To avoid this indeterminacy, the term structure of forward rates is usually defined using instantaneous forward rates. *Instantaneous forward rates* are obtained when the interval length becomes infinitesimally small.

Mathematically, the instantaneous forward rate $f(t)$, is the annualized rate of return locked-in today, on money to be invested at a future time t, for an infinitesimally small interval. The instantaneous forward rates can be interpreted as the marginal cost of borrowing for an infinitesimal period beginning at time t. By the same token, the annualized time t zero coupon rate can be shown to be equal to the average of all forward rates between now and time t:

$$y(t) \approx \frac{1}{t}\sum_{i=0}^{N} f\left(t_i, t_i + \Delta\right) \qquad (7)$$

The above equation gives a relationship between zero-coupon rates and forward rates. It implies that the zero-coupon rate for term t is an average of the instantaneous forward rates beginning from term 0 to term t. Since averaging reduces volatility, this relationship suggests that forward rates should be in general *more volatile* than zero-coupon rates, especially at the longer end.[3]

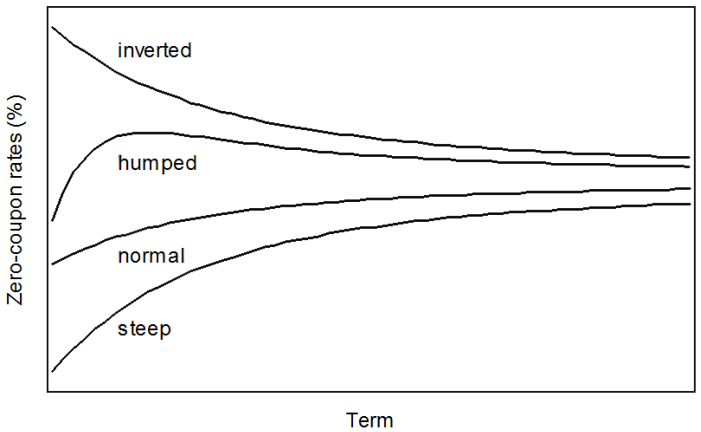

Figure 2: Basic shapes of the term structure

1.5. The Shape of the Term Structure of Interest Rates

Estimation of the term structure involves obtaining zero-coupon rates, or forward rates, or discount functions from a set of coupon bond prices. Generally, this requires fitting a functional form that is flexible in capturing stylized facts regarding the shape of the term structure. The TSIR typically takes four different shapes given as the normal shape, the steep shape, the humped shape and the inverted shape. Figure 2 shows these four typical shapes.

The normal shape is indicative of an economy that is normally expanding. That is, the term structure tends to be sloping upwards, reflecting the fact that longer-term investments are riskier. A higher risk implies a higher risk premium and hence, a higher interest rate. The steep shape of the term structure typically occurs at the trough of a business cycle, when after many interest rate reductions by the central bank, the economy seems poised for a recovery in the future. The inverted shape of the term structure typically occurs at the peak of a business cycle, when after many interest rate increases by the central bank, the economic boom or a bubble may be followed by a recession or a depression. Finally, the humped shape typically occurs when the market participants expect a short economic recovery followed by another recession so that there are different expectations at different terms. It could also occur when moving from a normal curve to an inverted curved or vice versa.[4]

It is also worthy to highlight that whatever the shape, the TSIR tend to be horizontal at longest maturities. The reason for this is twofold. First, although investors can hold different expectations about the future of interest rates for the short, medium, and long terms, their long term their expectations are more diffused, which makes it difficult to establish differences between different long rates. Second, risk premiums tend to be more stable for longer terms. This stylized fact should be considered when estimating the TSIR.

2. Three Methods for Term Structure Estimation

First attempts to estimate the term structure relied on fitting smooth functions to the yields to maturity of bonds using regression analysis. However, this approach was unsatisfactory due to its limitation in identifying the zero-coupon yields, and

in dealing with the coupon effect. The seminal work of J. Huston McCulloch in 1971 suggested a new method based on quadratic splines, which focused directly on estimating zero-coupon yields and discount factors. Much research has extended the work of McCulloch in the past four decades. Methods for TSIR estimation must find a way to approximate the spot rates, or the forward rates, or the discount function. This requires fitting a parsimonious functional form that is flexible in capturing stylized facts regarding the shape of the term structure. A good term structure estimation method should satisfy the following requirements:

- The method ensures a suitable fitting of the data.
- The estimated zero-coupon rates and the forward rates remain positive over the entire maturity spectrum.
- The estimated discount functions, and the term structures of zero-coupon rates and forward rates are continuous and smooth.
- The method allows asymptotic shapes for the term structures of zero-coupon rates and forward rates at the long end of the maturity spectrum.

The commonly used term structure estimation methods are given as the bootstrapping method, the polynomial/exponential spline methods of McCulloch [1971, 1975] and Vasicek and Fong [1982], and the exponential functional form methods of Nelson and Siegel [1987] and Svensson [1994]. Extensions of the above methods are given as the error weighing models such as the B-spline method of Steely [1991], the penalized spline methods of Fisher, Nychka and Zervos [1995] and Jarrow, Ruppert, and Yu [2004], and the constrained B-spline method of Poletti and Moura [2009], among others.[5] In this paper, we focus on the three most commonly used term structure estimation methods: the bootstrapping method, the McCulloch polynomial cubic-spline method, and the Nelson and Siegel exponential-form method.

2.1. Bootstrapping

The bootstrapping method consists of iteratively extracting zero-coupon yields using a sequence of increasing maturity coupon bond prices.[6] This method requires the existence of at least one bond that matures at each bootstrapping date.

To illustrate this method, consider a set of K bonds that pay semi-annual coupons. The shortest maturity bond is a six-month bond, which by definition does not have any intermediate coupon payments between now and six months, since coupons are paid semi-annually. Using the 6-month zero coupon rate, the price of this bond is given as:

$$P(0.5) = \frac{C_{0.5} + F_{0.5}}{e^{y(0.5)0.5}} \qquad (8)$$

where $F_{0.5}$ is the face value of the bond payable at the maturity of 0.5 years, $C_{0.5}$ is the semi-annual coupon payment at the maturity, and $y(0.5)$ is the annualized six-month zero-coupon yield (under continuously-compounding). The six-month zero-coupon yield can be calculated by taking logarithms of both sides of equation (8), and simplifying as follows:

$$y(0.5) = \frac{1}{0.5}\ln\left[\frac{F_{0.5} + C_{0.5}}{P(0.5)}\right] \qquad (9)$$

In order to compute the 1-year zero-coupon yield, we can use the price of a 1- year coupon bond as follows:

$$P(1) = \frac{C_1}{e^{y(0.5)0.5}} + \frac{F_1 + C_1}{e^{y(1)}} \qquad (10)$$

where F_1 is the face value of the bond payable at the bond's 1-year maturity, C_1 is the semi-annual coupon, which is paid at the end of 0.5 years and 1 year, and $y(1)$ is the annualized 1-year zero-coupon yield. By rearranging the terms in equation (10) and taking logarithms, we get the 1-year zero-coupon yield as follows:

$$y(1) = \ln\left[\frac{F_1 + C_1}{P(1) - \frac{C_1}{e^{y(0.5)0.5}}}\right] \qquad (11)$$

Since we already know the six-month yield, $y(0.5)$ from equation (9), this can be substituted in equation (11) to solve for the 1-year yield. Now, continuing in this manner, the six-month yield, $y(0.5)$, and the 1-year yield, $y(1)$, can be both used to obtain the 1.5-year yield, $y(1.5)$, given the price of a 1.5-year maturity coupon bond.

Following the same approach, the zero-coupon yields of all of the K maturities (corresponding to the maturities of the bonds in the sample) are computed iteratively using the zero-coupon yields of the previous maturities.

The zero-coupon yields corresponding to the maturities that lie between these K dates can be computed by using linear or quadratic interpolation. Generally, about 15 to 30 bootstrapping maturities are sufficient in producing the whole term structure of zero-coupon yields. Instead of solving the zero-coupon yields sequentially using an iterative approach as shown above, one can used the matrix approach to solve for all K zero coupon rates simultaneously. Appendix 1 discusses this approach.

The bootstrapping method has two main limitations. First, since this method does not perform optimization, it computes zero-coupon yields that exactly fit the bond prices. This leads to over-fitting since bond prices often contain idiosyncratic errors due to lack of liquidity, bid-ask spreads, special tax effects, etc., and hence, the term structure will not be necessarily smooth as shown in Figure 2. Second, the bootstrapping method requires ad-hoc adjustments when the number of bonds is not the same as the bootstrapping maturities, and when cash flows of different bonds do not fall on the same bootstrapping dates.[7] The next two methods overcome these difficulties by imposing specific functional forms on the term structure.

2.2. Cubic-spline method

Consider the relationship between the *observed* price of a coupon bond maturing at time t_m, and the discount function. As discussed before, the price of this bond can be expressed as the present value of each coupon payment using zero coupon rates:

$$P(t_m) = \sum_{j=1}^{m} CF_j \cdot d(t_j) + \varepsilon \qquad (12)$$

where CF_j is the total cash flow from the bond (i.e., coupon, face value, or both) on date t_j (j = 1,2,…,m). Since bond prices are observed with idiosyncratic errors, we need to estimate some functional form for the discount function that minimizes these errors. We face two problems in doing this. First, the discount functions may be highly non-linear, such that we may need a high-dimensional function to make the approximation work. Second, the error terms in equation (12) may increase with the maturity of the bonds, since longer maturity bonds have higher bid-ask spreads, lower liquidity, etc. Due to these, estimation of the discount function using approaches such as least squares minimization, generally fits well at long maturities, but provides a very poor fit at short maturities (see McCulloch [1971] and Chambers Carleton and Waldman [1984]).

The spline method addresses the first issue by dividing the term structure in many segments using a series of points that are called *knotpoints*. Different functions of the same class (polynomial, exponential, etc.) are then used to fit the term structure over these segments. The family of functions is constrained to be continuous and smooth around each knot point to ensure the continuity and smoothness of the fitted curves, using spline methods. McCulloch pioneered the application of splines to term structure estimation by using quadratic polynomial splines in 1971 and cubic polynomial splines in 1975. The cubic spline method remains popular among practitioners and is explained in Appendix 2.

As regard limitations, a potential criticism of the cubic-spline method is the sensitivity of the discount function to the location of the knotpoints. Different knotpoints result in variations in the discount function, which can be sometimes significant. Also, too many knotpoints may lead to overfitting of the discount function. So, one must be careful in the selection of both the number and the placing of the knotpoints.

Another shortcoming of cubic-splines is that they give unreasonably curved shapes for the term structure at the long end of the maturity spectrum, a region where the term structure must have very little curvature. Additionally, the OLS regression used for the estimation of the parameters in equation (26), gives the same weights to the price errors of the bonds with heterogeneous characteristics, such as liquidity, bid-ask spreads, maturity, etc. Other functions can be used for optimization to overcome this limitation but at the cost of precluding the use of OLS techniques.[7]

Finally, the choice of polynomials as basis functions is also controversial. It is argued that the shape of the discount function estimated using cubic splines is usually reasonable up to the maturity of the longest bond in the dataset but tend to be positive or negative infinity when extrapolated to longer terms. This implies that it is possible to generate unbounded positive or negative interest rates. Moreover, although the use of polynomial splines moderates the wavy shape of simple polynomials around the curve to be fitted, this shape might not disappear completely and hence, the fitted discount function might wave around the real discount function introducing a significant variability in both spot and forward rates. Despite these shortcomings, the use of polynomial splines to estimate the TSIR is widespread in the financial industry.

2.3. Nelson and Siegel Model

An alternative approach that overcomes many of the shortcomings of spline techniques is the methodology of Nelson and Siegel. The Nelson and Siegel [1987] model uses a single exponential functional form over the entire maturity range. Nelson and Siegel suggest a parsimonious parameterization of the instantaneous forward rate, which is then used to give a simple representation of the zero coupon curve:

$$y(t) = \alpha_1 + (\alpha_2 + \alpha_3)\frac{\beta}{t}\left(1 - e^{-t/\beta}\right) - \alpha_3 e^{-t/\beta} \qquad (13)$$

The Nelson and Siegel model is based upon four parameters. These parameters can be interpreted as follows:

- $\alpha_1 + \alpha_2$ is the instantaneous short rate, i.e., $\alpha_1 + \alpha_2 = y(0) = f(0)$.
- α_1 is the consol rate. It gives the asymptotic value of the term structure of both the zero-coupon rates and the instantaneous forward rates, i.e., $\alpha_1 = y(\infty) = f(\infty)$.
- The spread between the consol rate and the instantaneous short rate is $-\alpha_2$, which can be interpreted as the slope of the term structure of zero-coupon rates as well as the term structure of forward rates.
- α_3 affects the curvature of the term structure over the intermediate terms. When $\alpha_3 > 0$, the term structure attains a maximum value leading to a concave shape, and when $\alpha_3 < 0$, the term structure attains minimum value leading to a convex shape.
- $\beta > 0$, is the speed of convergence of the term structure towards the consol rate. A lower β value accelerates the convergence of the term structure towards the consol rate, while a higher β value moves the hump in the term structure closer to longer maturities.

Figure 3 illustrates how the parameters α_1, α_2, and α_3, affect the shape of the term structure of zero-coupon rates (given a

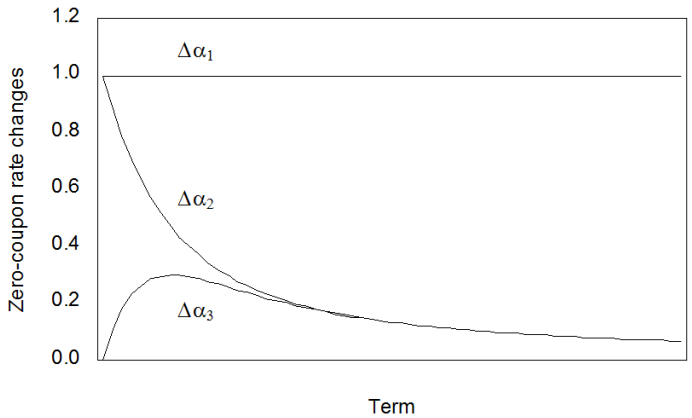

Figure 3: Influence of the alpha parameters of Nelson and Siegel on the term structure of zero-coupon rates

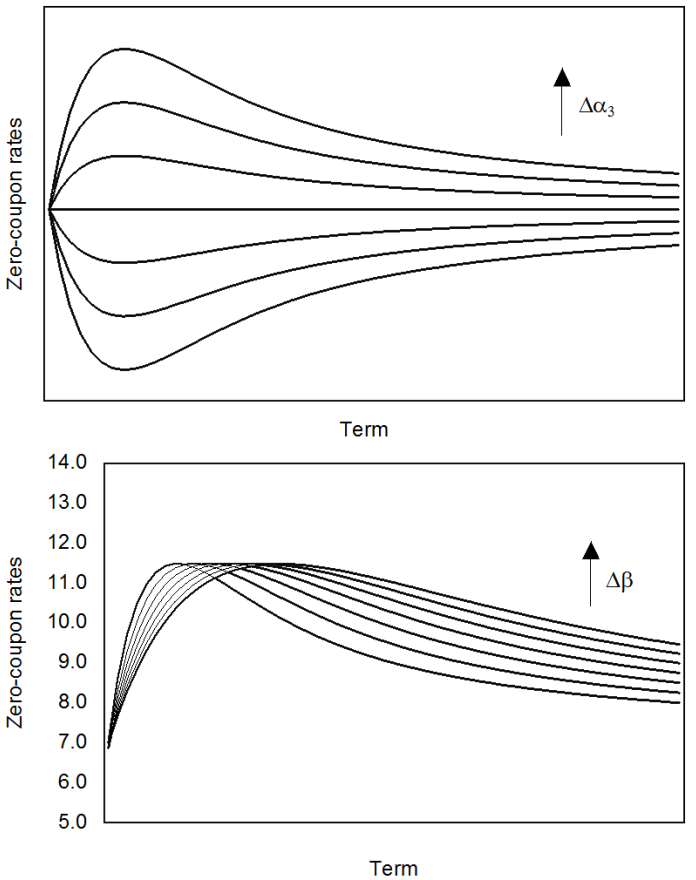

Figure 4: Influence of the curvature and hump positioning parameters of Nelson and Siegel

constant $\beta = 1$). A change in α_1 can be interpreted as the height or parallel change, a change in α_2 can be interpreted as the slope change (though this parameter also affects the curvature change slightly), and a change in α_3 can be interpreted as the curvature change in the term structure of zero-coupon rates.

Figure 4 demonstrates that Nelson and Siegel method is consistent with a variety of term structure shapes, including monotonic and humped, and allows asymptotic behavior of forward and spot rates at the long end. For illustrative purposes, the consol and instantaneous rates have been set at the same level.

The discount function associated with the term structure in (13) can be used to obtain a pricing formula for a coupon-bearing bond, as follows:

$$P(t_m) = \sum_{j=1}^{m} CF_j e^{-\alpha_1 t_j - \beta(\alpha_2+\alpha_3)\left(1-e^{-t_j/\beta}\right)+\alpha_3 t_j e^{-t_j/\beta}} \qquad (14)$$

where t_m is the bond's maturity and CF_j is the cash flow of the bond at time t_j.

The parameters in this equation can be estimated by minimizing the sum of squared errors between the left hand and right hand sides of equation (14) subject to the following constraints:

$$\begin{aligned} &\alpha_1 > 0 \\ &\alpha_1 + \alpha_2 > 0 \\ &\beta > 0 \end{aligned} \qquad (15)$$

The first constraint in equation (15) requires that the consol rate remain positive; the second constraint requires that the instantaneous short rate remain positive; finally, the third constraint ensures the convergence of the term structure to the consol rate.

Since the bond pricing equation (14) is a non-linear function, the four parameters are estimated using a non-linear optimization technique. As non-linear optimization techniques are usually sensitive to the starting values of the parameters, these values must be carefully chosen.

Despite this computational difficulty, the Nelson and Siegel model, and its extended version given by Svensson [1994], have a prominent position among term structure estimation methods. The smoothness of the estimated curves for both spot rates and forward rates, the asymptotic behavior of the term structure over the long end, and their robustness to outliers and errors in market data are the main advantages these methods compared to spline methods. In fact, as reported in BIS [2005], most Central Banks use these methods for term structure estimation. Also, in recent years, these models are attracting the interest of researchers in the area of interest modelling and portfolio risk management. Matzner-Løber and Villa [2004] and Diebold and Li [2006], for example, reinterpret them as modern three-factor models of level, slope and curvature factors in the most pure tradition of Litterman and Scheinkman [1991] and Bliss [1997] and obtain empirical evidence in favor of them. Moreover, Christensen, Diebold and Rudebush [2011] provide theoretical foundations for the model by obtaining the affine arbitrage-free dynamic term structure version of the model, which only differs in the existence of a yield-adjustment term, and Krippner [2013] shows that Nelson and Siegel model can be interpreted from the perspective of Gaussian affine term structure models. Finally, Gürkaynak, Sack and Wright [2007] provide the estimates of the US TSIR at a daily frequency from 1961 to present time using the Nelson and Siegel specification for the period before 1980 (due to the lack of long term bonds) and the extension of Svensson [1994] afterwards.

3. Conclusion

Interest rates play a central role in valuation of financial assets and for making macroeconomic policy. However, they are not directly observable, and should be estimated from the market prices of government securities with different maturities. Many alternative assets such as real estate, private equity, and hedge fund investments are illiquid with long-term cash flows, without a readily available source for market prices. Thus, a properly estimated term structure of interest rates is essential for obtaining the intrinsic values of these assets. In the current low-yield environment, an accurate estimation of the term structure of interest rates assumes even greater importance due to the non-linear convex relationship between asset prices and interest rates. This paper focuses on three commonly used term structure

methods, given as the bootstrapping method, the McCulloch cubic spline method and the Nelson and Siegel method. We give a mathematically rigorous illustration, explaining the foundations of the methods, deriving the main equations, and pointing out the advantages and disadvantages of each method.

Appendix 1

The following matrix approach can be used for obtaining a direct solution for the bootstrapping method. Consider *K* bonds maturing at dates $t_1, t_2, \ldots, t_K$, and let CF_{it} be the total cash flow payments of the ith (for i = 1,2,3,…,*K*) bond on the date t (for $t = t_1, t_2, \ldots, t_K$). Then the prices of the *K* bonds are given by the following system of *K* simultaneous equations:

$$\begin{pmatrix} P(t_1) \\ P(t_2) \\ \vdots \\ P(t_K) \end{pmatrix} = \begin{pmatrix} CF_{1t_1} & 0 & \cdots & 0 \\ CF_{2t_1} & CF_{2t_2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ CF_{Kt_1} & CF_{Kt_2} & \cdots & CF_{Kt_K} \end{pmatrix} \begin{pmatrix} d(t_1) \\ d(t_2) \\ \vdots \\ d(t_K) \end{pmatrix} \qquad (16)$$

Note that the upper triangle of the cash flow matrix on the right-hand side of equation (16) has zero values. By multiplying both sides of equation (16) by the inverse of the cash flow matrix, the discount functions corresponding to maturities $t_1, t_2, \ldots, t_K$ can be computed as follows:

$$\begin{pmatrix} d(t_1) \\ d(t_2) \\ \vdots \\ d(t_K) \end{pmatrix} = \begin{pmatrix} CF_{1t_1} & 0 & \cdots & 0 \\ CF_{2t_1} & CF_{2t_2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ CF_{Kt_1} & CF_{Kt_2} & \cdots & CF_{Kt_K} \end{pmatrix}^{-1} \begin{pmatrix} P(t_1) \\ P(t_2) \\ \vdots \\ P(t_K) \end{pmatrix} \qquad (17)$$

The above solution requires that the number of bonds equals the number of cash flow maturity dates.[8] The zero-coupon rates can be computed from the corresponding discount functions using equation (1).

Appendix 2

Consider a set of *K* bonds with maturities of $t_1, t_2, \ldots, t_K$. years. The range of maturities is divided into *s*-2 intervals defined by *s*-1 knot points $T_1, T_2, \ldots, T_{s-1}$, where $T_1 = 0$ and $T_{s-1} = t_K$. A cubic polynomial spline of the discount function $d(t)$ is defined by the following equation:

$$d(t) = 1 + \sum_{i=1}^{s} \alpha_i g_i(t) \qquad (18)$$

where $g_1(t), g_2(t), \ldots, g_s(t)$ define a set of s basis piecewise cubic functions and $\alpha_1, \ldots, \alpha_s$ are unknown parameters that must be estimated.

Since the discount factor for time 0 is 1 by definition, we have:

$$g_i(0) = 0 \qquad i = 1,2,\ldots,s \qquad (19)$$

The continuity and smoothness of the discount function within each interval is ensured by the polynomial functional form of each $g_i(t)$. The continuity and smoothness at the knotpoints is ensured by the requirement that the polynomial functions defined over adjacent intervals (T_{i-1}, T_i) and (T_i, T_{i+1}) have a common value and common first and second derivatives at T_i. The above constraints lead to the following definitions for the set of basis functions $g_1(t), g_2(t), \ldots, g_s(t)$:

Case 1: $i < s$

$$g_i(t) = \begin{cases} 0 & t < T_{i-1} \\ \dfrac{(t-T_{i-1})^3}{6(T_i - T_{i-1})} & T_{i-1} \le t < T_i \\ \dfrac{(T_i - T_{i-1})^2}{6} + \dfrac{(T_i - T_{i-1})(t-T_i)}{2} + \dfrac{(t-T_i)^2}{2} - \dfrac{(t-T_i)^3}{6(T_{i+1} - T_i)} & T_i \le t < T_{i+1} \\ (T_{i+1} - T_{i-1})\left(\dfrac{2T_{i+1} - T_i - T_{i-1}}{6} + \dfrac{t - T_{i+1}}{2}\right) & t \ge T_{i+1} \end{cases} \qquad (20)$$

Case 2: $i = s$

$g_i(t) = t$

Substituting equation (18) into equation (12), we can rewrite the price of the bond maturing at date t_m as follows:

$$P(t_m) = \sum_{j=1}^{m} CF_j \left(1 + \sum_{i=1}^{s} \alpha_i g_i(t_j)\right) + \varepsilon \qquad (21)$$

By rearranging the terms, we obtain:

$$P(t_m) - \sum_{j=1}^{m} CF_j = \sum_{i=1}^{s} \alpha_i \sum_{j=1}^{m} CF_j g_i(t_j) + \varepsilon \qquad (22)$$

The estimation of the discount function requires searching of the unknown parameters, $\alpha_1, \alpha_2, \ldots, \alpha_s$, that minimizes the sum of squared errors across all bonds. Since equation (22) is linear with respect to the parameters $\alpha_1, \alpha_2, \ldots, \alpha_s$, this can be achieved by an ordinary least squares (OLS) regression.

The above approach uses $s-2$ number of maturity segments, $s-1$ number of knotpoints, and s number of cubic polynomial functions. An intuitive choice for the maturity segments may be short-term, intermediate-term, and long-term, which gives three maturity segments of 0 to 1 years, 1 to 5 years, and 5 to 10 years, four knot points given as, 0, 1, 5, and 10 years, and five cubic polynomial functions.

McCulloch recommends choosing knotpoints such that there are approximately equal number of data points (number of bonds' maturities) within each maturity segment. Using this approach, if the bonds are arranged in ascending order of maturity, i.e., $t_1 \le t_2 \le t_3 \ldots \le t_K$, then the knot points are given as follows:

$$T_i = \begin{cases} 0 & i = 1 \\ t_h + \theta(t_{h+1} - t_h) & 2 \le i \le s-2 \\ t_K & i = s-1 \end{cases} \qquad (23)$$

where h is an integer defined as:

$$h = INT\left[\frac{(i-1)K}{s-2}\right] \qquad (24)$$

and the parameter θ is given as:

$$\theta = \frac{(i-1)K}{s-2} - h \qquad (25)$$

McCulloch also suggests that the number of basis functions may be set to the integer nearest to the square root of the number of observations, that is:

$$s = Round\left[\sqrt{K}\right] \qquad (26)$$

This choice of s has two desired properties. First, as the number of observations (bonds) increases, the number of basis functions increases. Second, as the number of observations increases, the number of observations within each interval increases, too.

Footnotes

1. The software is available at www.fixedincomerisk.com/web/software.html clicking on the link IRR 1. A Practical Guide to Term Structure Estimation with Excel in the Guides Software section.

2. When compounding is discrete, each exp(yt) is replaced by $(1+y/k)^{tk}$. Since cash price is used in equation (4), sometimes the discount rate is also called the "adjusted" yield to maturity.

3. An excellent visual exposition of the difference in the volatilities of the zero-coupon yields and those of the instantaneous forward rates is given in the excel file TSIRmovie.xls available at www.fixedincomerisk.com/web/software.html clicking on the link Term Structure Movie.

4. The shape of the term structure is also explained by other variables not related to expectations such as liquidity premium, market segmentation, etc. Alternative term structure hypotheses have assigned different roles to these variables. For a brief discussion about the main hypothesis, see Nawalkha, Soto and Beliaeva [2005], pp. 52-55.

5. The method used to estimate the TSIR not only affects these estimates, but also any data derived from them. Diaz, Jareño and Navarro [2011] report this for estimates of interest rate volatility.

6. Usually, not all the bonds that trade in the market at a given time are used for the estimation of the TSIR. The bond selected must cover a wide spectrum of maturities, should have an enough degree of liquidity and their prices shouldn't incorporate high distortions due to tax effects or other market frictions. Usually, these requirements are fulfilled by the establishment of filtering criteria for determining the bonds that qualify for inclusion in the sample.

7. In fact, there are many alternative error-weighing schemes which might lead to more robust estimates of the term structure. For example, Bliss [1997] suggests weighting each bond price error by the inverse of the bond's duration as a way to improve the fitting of long interest rates, which might be poor. This is due to the fact that in absence of a weighting scheme for pricing errors, the quality of the fit of the term structure decreases with maturity. To understand this, consider the relationship between prices, yields and maturities. A same change in price implies a much greater change in yield in short-term bonds compared to long-term bonds. Therefore, following a price error minimization criterion in the estimation will make interest rates corresponding to long-term bonds to be over-fitted at the expense of shorter-term interest rates. Other approaches include the use of penalty functions, as in Fisher, Nychka and Zervos [1995] or Jarrow, Ruppert, and Yu [2004].

8. For example, when two or more bonds mature on the same bootstrapping maturity, the estimated spot rates resulting from using each of these bonds are usually averaged. In the opposite case, when no bond exists at a required bootstrapping maturity, a common practice is to estimate a par yield curve (that is, the yield to maturities of bond priced at par) using simple regression models that make the yields to maturity on current bonds depend on a series of bond characteristics including the coupon rate and the time to maturity. Then, the yields on par bonds are estimated by assuming that the coupon rate of each bond equals its yield to maturity.

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Can Non-Accredited Investors Find and Invest in the Next Unicorn?

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Unicorns is a term used to describe private venture-capital backed startup firms valued at over $1 billion. Stanford (2015) reports that 2015 may well be remembered as the year of the unicorn. He identifies 47 companies reaching unicorn status in 2015 from the United States (US) and 28 from outside the US. Nearly $33 billion was invested in unicorns in 2015 and Stanford reports the median deal size of $158 million. Not all the money raised was from venture capital however as Stanford notes that Fidelity, Wellington Management and T. Rowe Price put money into 23 unicorns combined in 2015.

The results from unicorn investing are of relevance in light of the new rules regarding crowdfunding. One can look at the experience from the current unicorns and infer what may happen for investors who are early stage investors under the new rules. On October 30, 2015, the Securities and Exchange Commission (SEC) approved rules that allow all investors to invest and receive equity stakes in startup businesses via crowdfunding. For the first time, private company issuers are able to solicit investments in their securities using public advertising, and permit investment by both accredited and non-accredited investors. Prior to this change only accredited investors (investors whose net worth exceeds $1 million or who earn more than $200,000 a year) could participate in equity crowdfunding. The possibility of non-accredited investors participating in equity based crowdfunding began with the passage of the 2012 Jumpstart Our Business Startups Act (JOBS Act). This latest SEC rule change under the Title III portion of the JOBS Act opens the way for private startup companies to raise money from a wide range of investors in return for equity or other securities. Mary Jo White, the SEC chair since April 2013, stated in her speech to the 41st Annual Securities Regulation Institute in Coronado, CA that crowdfunding is "the start of what promises to be a period of transformative change in capital formation."

Taylor [2015] indicates Title III is overdue because the Joint Small Business Credit Survey Report for 2014 reports small businesses continue to struggle to obtain their desired capital through traditional methods. In addition, small loans that startups and small businesses desire are very difficult to obtain. Taylor believes equity based crowdfunding is superior to the traditional debt based funding startups traditionally get. Equity based crowdfunding does not require collateral to receive funds and it doesn't increase the firm's chances of bankruptcy. This may create a moral hazard problem leading business owners to take on too much risk but the added risk may also allow business owners the opportunity to discover new ways to innovate their products or business models. Taylor further argues that only time will tell if equity crowdfunding will work to fund small businesses.

By examining the performance of the 144 unicorns listed in The Wall Street Journal (WSJ), we show why non-accredited investors will be interested in investing in startup firms. We examine unicorn investors to determine who has been the most successful in picking unicorns and from those results we infer how non-accredited investors might fare as they invest in startups. Clearly, the new rules have only recently seen implementation so only time will tell whether investors can indeed find the next unicorns. In addition, we examine what might be the best strategies for non-accredited investors to use equity crowdfunding and how equity crowdfunding may be tweaked to create a better investing environment.

Title III of the JOBS Act – Non-accredited Equity Crowdfunding

The Jump-Start Our Business Start-Ups Act (JOBS) was enacted into law on April 5, 2012. The law was enacted to help facilitate capital raising for smaller companies by easing the regulatory burdens imposed by Federal securities law. The JOBS Act amended the Securities Act of 1933, providing an exemption, for the small businesses, from registration for the offer and sale of securities in connection with crowdfunding transactions similar to that provided to accredited investors (for more information on the crowdfunding exemption, see Walsh [2015]). It has taken the SEC over three years, but the final rules regarding Title III of the JOBS Act were finally adopted on October 30, 2015 allowing business enterprises to raise capital through crowdfunding initiatives. The new rules will become effective on May 16, 2016. The long delay in implementing Title III by the SEC has been concerns about letting non-accredited investors make investments in illiquid and risky equity and whether there is sufficient regulation regarding equity crowdfunding.

The new rules will allow companies to raise up to one million dollars over a twelve month period without having to comply with the Securities Act's registration requirements. The transaction has to be conducted through a broker or funding portal registered with the SEC. The amount a single investor can invest cannot exceed either $2000 or five percent of the annual income or net worth of the investor if either the annual income or the net worth of the investor is less than $100,000, and ten percent of the annual income or net worth of such investor if either the annual income or net worth of the investor is equal to or more than $100,000. The maximum amount of equity that can be sold to a single investor shall not exceed $100,000. There is no limit on the number of investors that may participate in a crowdfunding offering. There are certain companies that are not eligible to crowdfund under Title III of the JOBS Act. These would include non-US companies, public companies, investment companies and any company with any person that is subject to federal and state disqualifiers. Companies conducting a crowdfunding offering will be required to disclose certain information in an offering statement on Form C filed with the SEC and this statement is to be shared with prospective investors. Information about officers and directors as well as owners of 20 percent or more of the company would need to be disclosed. The issuer would need to provide a description of the company's business and the use of the proceeds from the offering. A description of the financial condition of the company would also be needed. Further information required includes the price to the public of the securities being offered, the target offering amount, the deadline to reach the target offering amount, and whether the company will accept investments in excess of the target offering amount.

Companies that have filed a Form C to do a crowdfunding offering must file an ongoing annual report on Form C-AR with the SEC after the offering is completed. In the offering documents the company would be required to disclose information in the financial statements depending on the amount offered and sold during a 12 month period. For offering amounts of $100,000 or less, the company must provide GAAP financial statements for the two most recently completed fiscal years of operations, and filed income tax returns for the most recently completed fiscal year. In both cases, the statements and tax returns need to be certified to be true and complete by the issuer's principal executive officer. If the target offering amount is more than $100,000, but less than $500,000, financial statements must be provided and reviewed by an independent public accountant. For issues of more than $500,000, reviewed financial statements must be provided by the issuer which was a departure from the SEC's original request for audited financial statements. Issuing companies would be required to amend the offering document to reflect material changes and provide updates on the company's progress toward reaching the target offering amount. Companies relying on the crowdfunding exemption to offer and sell securities would be required to file an annual report with the SEC and provide it to investors.

Kinds of Equity Offerings on Internet-based Platforms

Title III joins two other exemptions that were created by the JOBS Act regulating security crowdfunding. Title II lifted the ban on general solicitation for certain Regulation D offerings and Title IV, known as Regulation A+ because it expanded the existing Regulation A exemption. Under Regulation D, accredited investors have invested through equity based platforms since 2011. The JOBS Act simply accelerated the growth of equity crowdfunding.

Title II of the JOBS Act, which has been in effect since September 23, 2013, lifted the prohibition on publicly soliciting investments for private securities under Regulation D, Rule 506(c). Only accredited investors can participate in Rule 506(c) offerings but up to 15 non-accredited investors can participate in the traditional Rule 506(b), where general solicitation is still banned. The new feature of Rule 506(c) is the ability of issuers to advertise, allowing investors to more easily search for placements that suit their needs. Crowdnetic's ,Q3 2015 Report identified 6,063

private offerings that have recorded capital commitments of approximately $870.0 million over the second year of Title II. This is compared to the 4,712 private offerings that had received capital commitments of $385.8 million through the end of the first year of Title II activity representing growth of 28.7% in the number of offerings and a growth of 125.5% in the amount of recorded capital commitments. These figures represent the performance of offerings under Rule 506(c). Rule 506(b) offerings are not included which would list crowdfunding platforms, and Crowdnetic indicates that it is likely that the numbers of 506(b) offerings and the amount of capital raised are higher than that of 506(c) offerings. Crowdnetic states that business owners can now take their concept or product directly to the crowd to validate viability instead of relying solely on traditional angel investors and venture capitalists. Raneri [2015a] indicates Rule 506(c) has stricter requirements to verify investors' accredited status, which appears to hold back many issuers from taking advantage of the opportunity to reach more investors.

Final rules under Title IV of the JOBS Act were passed March 25, 2015 and went into effect June 19, 2015. Title IV allows an unlimited number of accredited and non-accredited investors to invest in Regulation A+ offerings. Freedman and Nutting [2015] say Title IV is ideal for growth and later stage companies that want to file so called mini-IPOs. Raneri [2015b] states the SEC created an intermediate capital formation step on the road to going public that could be very beneficial for companies and investors. However, Title IV is not viewed as being good for seed stage startups since compliance costs are projected to be high for the amount of capital being sought in smaller offerings. The Regulation A+ exemption was expanded from a $5 million raise limit to a $50 million limit but divided into Regulation A+ Tier 1 raising up to $20 million and Tier 2 up to $50 million. Before the JOBS Act, Regulation A issuers could sell unrestricted securities to non-accredited and accredited investors. The expanded Regulation A+ still lets non-accredited investors participate but limits their annual investment in offerings above $20 million to 10 percent of their income or net worth. All investors can invest an unlimited amount in Tier 1 offerings up to $20 million. In addition, Tier 2 preempts blue sky review so there is no need for approval by every state in which the offering is made. Tier 1 will still require blue sky review. Regulation A+ offerings are referred to as mini-IPOs as issuers are required to go through a scaled down registration process and file an offering circular with the SEC which is a prospectus like document. Again, Freedman and Nutting believe seed stage and startup companies will not use the Tier 1 part of Regulation A+ mainly because offerings still require blue sky review and compliance which is probably going to be too costly and time consuming. Raneri believes Regulation A+ will allow founders and early stage investors to get some liquidity from having their money tied up for years. He feels this is important because more and more companies are delaying IPOs because of the cost and regulatory burden.

Other options include equity crowdfunding through intrastate securities exemption. Under the Section 3(a)(11) of the Securities Act of 1933, issuers with headquarters in a particular state may sell securities to all investors who live in that state. Coverman [2015] shows that as of November 1, 2015, 29 states and the District of Columbia have such exemption in place. Some of these exemptions are variations of Title III of the JOBS Act, in terms of the dollar limits on capital raising, and investment limits for non-accredited investors.

Freedman and Nutting [2015] report that as a result of the various ways private securities can be listed online, entrepreneurs and investors are confused about the differences between the exemptions and platforms where you find these offerings. Similar to Freedman and Nutting, Exhibit 1 shows the differences, from an investor's point of view, between the four kinds of equity offerings that investors eventually will find on online offering platforms. There is lots of speculation about equity crowdfunding and how equity offering platforms will work. It would appear the natural progression of capital raising will be using Title III or intrastate securities exemption for early seed stage startups, moving to Regulation D for early growth stage companies that are expanding, and then Regulation A+ for pre-IPO later growth. Using Title III for the seed stage seems reasonable. Examining the dollar amount invested in seed rounds of private venture-backed firms over the past five years from FactSet Mergerstat shows the average invested to be $1.72 million and the median is $1.3 million out of 1,363 firms. As we will show later, investors will be interested in the equity crowdfunding because of the potential returns.

UK Experience

Equity crowdfunding and its success will be measured based on the returns investors receive from their investments. The United Kingdom (UK) has had a longer history then the US with equity crowdfunding that started with the crowdfunding site, Crowdcube in 2011. Similar to changes sought by the JOBS Act of 2012, equity crowdfunding in the UK was started to grow the funding of small and medium sized enterprises. AltFi Data [2015] a data aggregator of equity crowdfunding published a report on equity crowdfunding from 2011 through June 30, 2015 using the five most significant online platforms based on origination volume. These include, Crowdcube, Seedrs, SyndicateRoom, CrowdBnk and Venture Funders. There were 431 investment crowdfunding rounds from 367 companies. The UK report indicates that crowdfunding has revolutionized the funding of small and medium sized enterprises involving both professional and small retail investors. It is reported that 62% of crowd funding investors describe themselves as retail investors with no previous investment experience.

Andrew [2015] indicates equity crowdfunding is regulated by the Financial Conduct Authority (FCA) in the UK. The FCA regulates the equity platform rather than the risk profile of the company investors are investing in. Platform marketing must be fair and not misleading, risks should be highlighted and systems must be in place to separate funds coming in the platform, and the platform must have adequate capital reserves. Who can invest via equity crowdfunding is similar to what the US will have May 15, 2016 and include: retail clients who are advised, retail clients classified as corporate finance contacts or venture capital contacts, retail clients certified as sophisticated or high net worth, or retail clients who confirm that they will not invest more than 10 percent of their net investible assets. One aspect that is different about crowdfund investing in the UK from the US is the tax incentive given in the UK to invest in small and medium sized companies. UK investors are given a subsidy in the form of tax

Exhibit 1: Different Kinds of Equity Offerings on Internet-based Platforms

	Online Launch	Capital Raise Limit in 1 Year	Investor Status	Investment Limit	Intermediary Required
Title IV Reg. A+ Tier 1	June 19, 2015	$20 million	All Investors	No limit	No
Title IV Reg. A+ Tier 2	June 19, 2015	$50 million	All investors	Depends on income/worth	No
Title II Reg. D Rule 506(b)	September 23, 2013	No limit	Accredited investors and 15 non-accredited investors	No limit	No
Title II Reg. D Rule 506(c)	September 23, 2013	No limit	Accredited investors only	No limit	No
Intrastate Equity Crowdfunding	December 8, 2011 Georgia was first	Typically $1 to $2 million	All investors	Depends on income/worth	Varies with each state
Title III Equity Crowdfunding	May 16, 2016	$1 million	All investors	Depends on income/worth	Yes, online portals

breaks to encourage innovation and job creation. The Enterprise Investment Scheme (EIS) and Seed Enterprise Investment Scheme (SEIS) schemes give tax relief (30% and 50% respectively) on the amount of funds invested. AltFi Data reports over 90% of the crowdfunding campaigns were EIS/SEIS eligible. EIS and SEIS are subject to a three year minimum holding period with the relief clawed back if shares are disposed within the minimum holding period.

The report projects that amount of equity capital going to UK companies through crowdfunding will reach 140 million pounds in 2015. The growth in equity crowdfunding has been 129% since 2011. One benefit a company gets from crowdfunding is creating a brand by the recruitment of a number of small investor supporters. AltFi Data believes this relevant word of mouth will continue to increase the sector diversity of equity crowdfunding. They show the size of the crowdfunding campaigns is increasing through time as well.

In general there is a perception that all companies that use crowdfunding to access capital are startups. The AltFi Data report shows that the majority of companies in the UK using equity crowdfunding have been established for several years. They report the average age of companies that raised funds from the crowd in 2015 was 3.32 years and the overall age from 2011 was 2.91 years. One of the goals of the JOBS Act of 2012 was to create jobs. The UK report indicates that average increase in headcount at the companies raising funds from the crowd is 83%. The UK companies receiving funds appear to be in better shape financially after their fundraising as shown in the report by the Experian Delphi credit scores. The Experian Delphi score is examined for each crowdfunded company before and after the crowdfunding campaign. The average Delphi score improves significantly in the 24 months post financing.

Over 80% of the UK companies that crowdfunded between 2011 and 2013 are still around. The AltFi Data report quotes an October 2014 report by the insurer RSA that found 55% of UK Small and Medium sized Enterprises did not survive five years. Investing in small and medium sized companies is not done with the expectations of achieving instantaneous returns. It is still too early to tell if the crowd of inexperienced investors exhibits collective wisdom in what companies to fund. The AltFi Data report recommends platform transparency. Crowdfunding platforms should allow investors the ability to easily track just how many companies have failed and what is the overall proportion of success to failure. As a retail investor dominated market, platforms should do their utmost to ensure that investors are fully appraised of the likelihood of them backing a successful campaign. A unique feature of crowdfunding platforms in the UK, which started with crowdfunding site SyndicateRoom, is the ability of the inexperienced crowd investor to invest in and with professionally led opportunities.

Results

Exhibit 2 provides information regarding the 144 private venture-backed companies listed in the WSJ (see Austin, Canipe and Slobin [2015]) as having valuations over $1 billion. Also in Exhibit 2 is an estimated annualized return for each firm using data from FactSet Mergerstat and the valuation reported in the WSJ. To calculate the annualized return, the date and dollar amount of each investment round prior to the firm's public valuation is obtained from FactSet Mergerstat. Using data from Jensen, Marshall, and Jahera [2014], it was estimated that when private companies went public, venture capitalists/angel investors who had funded rounds of financing, owned around 60% of the public company at the time of the IPO. The valuation of these companies was smaller (average valuation at IPO was $650

million) but the median rounds of funding, 5, is the same as the private companies listed in Exhibit 2. PitchBook.com reports the percentage stake in a company investors are willing to take for a round of funding has been dropping. In the fourth quarter report in 2014, 4Q 2014 U.S. Venture Industry Report, the median stake investors required for seed funding was 23% of the firm. The median for Series A was 28%, Series B was 23%, Series C was 17% and for Series D and beyond is was 12%. Using these figures and knowing the median rounds of funding was five for our sample from Exhibit 2, investors should have around 69% of the company value after the financing rounds. Therefore, the value of the company after investors have provided funding will be estimated to be 60% for this study. Winkler [2015] interviewing Bill Gurley, who is a venture capitalist for Benchmark and is known as one of Silicon Valley's top technology deal makers, stated that when Benchmark talks to their limited partners about private companies, they discount the companies 40% as well.

The estimated annualized firm return prior to the public valuation date is then calculated by using the dates and amounts of the equity funding from FactSet Mergerstat with the valuation listed in the WSJ cut 40 percent. The calculation is done using the XIRR function of Microsoft Excel. An annualized return for the S&P 500 over the same time period for the private firms is calculated for comparison purposes. All of the firms, except Lazada Group, have a higher estimated annualized return than the S&P 500 return over the same time period. The average annualized return for the investors in the private companies is 5,355.43% (median is 119.19%) while for the S&P 500 it is only 10.49%. Eleven unicorns have annualized returns above 1000%. These are estimated returns and do not reflect the differences in returns between seed investors and the different series investors. Seed investors in the firm would have annualized returns that would be higher than that reported since they are the first to invest and hold a better stake in the company than series investors. The same would be true of first series investors such as series A, if the firm has several rounds of funding. Keep in mind these returns reflect private companies that have made it through the startup phase. Gage [2012] reports research done by Shikhar Ghosh who finds 3 out of 4 startups fail. This failure rate is much higher than that reported by The National Venture Capital Association who estimate that 25% to 30% of venture backed businesses fail. Needless to say, the returns for the sample are high.

Exhibit 2 shows 21.17% of the unicorns were started by founders that had previous experience starting a firm. In addition, 83.33% of the founders have remained active in running their company. For those unicorns that report the total size of their board and management team on FactSet Mergerstat, the total size is around 12 with average tenure of 4.30 years. Exhibit 2 shows there are around 5 members to the board and around 45% of the members are independent from management. Unicorns have on average 12.02 investors and 11.51 of the investors are classified as active. Exhibit 2 points out that the average age of the unicorns is 8.44 years and the average amount of equity that has been invested is $450 million based on available information from FactSet Mergerstat.

Exhibit 3 examines the investors in the unicorn companies reported in the WSJ. Sequoia Capital has invested in the most unicorns, investing in 27 of the 144. Unfortunately, the amount invested in each unicorn by investor is not known because FactSet Mergerstat lumps all investors in the same seed or series together with the total dollar amount of each round of funding. Interestingly, there were 414 different investors that invested in only one unicorn. Although not shown in Exhibit 3, the investors that have invested in the most seed rounds coincide fairly well with the list of investors in Exhibit 3. The top three investors in seed rounds were Sequoia Capital investing in 9 of the unicorn seed rounds, Accel Partners investing in 11 seed rounds, and SV Angel investing in 9 seed rounds. Given the dollar limits of how much money can be raised and invested each year by non-accredited investors, seed investing might be the initial way non-accredited investors participate in equity crowdfunding. If non-accredited investors are allowed to invest with accredited investors, it may make sense to invest with the investors that have done it before such as the top firms listed in Exhibit 3.

Exhibit 2: Summary Statistics of Unicorn Companies

Variable	Number	Mean	Median	Minimum	Maximum
Experienced founder	137	21.17%	0	0	1
Active founder	144	83.33%	1	0	1
Total size Board/Management	128	11.85	11	1	39
Number on Board	114	4.95	5	1	12
% Board Independent	113	45.13%	0	0	6
Age of firm	143	8.44	8	1	28
Average Tenure	125	4.30	4	0	13
Latest valuation (billions)	143	3.59	1.5	1	51
Number of investors	136	12.02	11	1	63
Number of active investors	136	11.51	10	0	56
Rounds of funding	142	4.86	5	1	12
60% return (%)	120	5355.43	119.19	8.59	472908.16
Excess return vs. S&P (%)	120	5344.94	107.65	-13.22	472926.44
Total Equity per FactSet (billions)	124	0.45	0.27	0.002	6.01

Exhibit 3: Frequency of Investors in Privately-held Billion Dollar Club Members

Rank	Investor	Frequency	Percentile	Cumulative number of investments	Cumulative percentile
1	Sequoia Capital	27	2.29	27	2.29
2	Accel Partners	19	1.61	46	3.90
3	Kleiner Perkins Caulfied & Byers	18	1.53	64	5.42
4	Tiger Global Management	18	1.53	82	6.95
5	Andreesen Horowitz	17	1.44	99	8.39
6	Google Ventures	15	1.27	114	9.66
7	Wellington Management	14	1.19	128	10.85
8	T Rowe Price	13	1.10	141	11.95
9	Temasek Holdings	13	1.10	154	13.05
10	Fidelity Investments	12	1.02	166	14.07
11	Goldman Sachs Ventures	12	1.02	178	15.08
12	Institutional Venture Partners	12	1.02	190	16.10
13	New Enterprise Associates	12	1.02	202	17.12
14	SV Angel	12	1.02	214	18.14
15	DST Group	11	0.93	225	19.07
16	Founders Fund	10	0.85	235	19.92
17	Greylock Partners	10	0.85	245	20.76
18	Khosla Ventures	10	0.85	255	21.61
19	Various (4)	9	3.05	291	24.66
23	Various (3)	8	2.03	315	26.69
26	Various (7)	7	4.16	364	30.85
33	Various (13)	6	6.61	442	37.46
46	Various (7)	5	2.96	477	40.42
53	Various (14)	4	4.75	533	45.17
67	Various (27)	3	6.86	614	52.03
94	Various (76)	2	11.89	766	64.92
170	Various (414)	1	35.08	1180	100.00

Exhibit 4 lists where the unicorns are located and the general industry each unicorn is associated with. The vast majority of unicorns in the US are located in California and New York and the location of the most unicorns outside the US are in China. The industry the majority of unicorns are in or related to is the technology industry. The top three industry groups listed are packaged software, internet software/services and information technology.

In Exhibit 5, the unicorn excess returns (return for the unicorn less the return for the S&P 500 over the same time frame) are divided into quartiles with quartile 1 representing unicorn excess returns above 197.97%, quartile 2 and 3 having excess returns greater than 56.08% but less than 197.97%, and quartile 4 has unicorn excess returns that are less than 56.08%. Unicorn variables from Exhibit 2 are than compared across quartiles to test for differences in the quartiles. First, the median excess return of quartile 1, is significantly larger than the other three quartiles. The unicorns with the largest excess returns have some characteristics that are significantly different than the other quartiles. The total size of the board/management is significantly smaller and the age of the firm is significantly less in quartile 1 than the other quartiles. Comparing quartile 1 to quartile 4, the average tenure of the board/management is significantly larger in quartile 4 and quartile 4 has significantly more rounds of funding than quartile 1. It would appear the longer the unicorn is around, the unicorn's excess return starts to fall. Stanford [2016] reports that given market volatility, oil prices, and fears of overly frothy private valuations, investors that would like to cash in on their private investments by taking a company public are having to wait given the conditions. He indicated a number of unicorns expected to make a public exit in 2015 waited. There appeared to be a rise in what some refer to as private IPOs. A private IPO is a late-stage funding round above $40 million. Stanford reports the number of private IPOs rose to a high of 135 in the third quarter of 2015 and there have been 44 deals of $40 million or

Exhibit 4: Billion Dollar Club by Industry and Locations

Location	Number	Percentage of Total	Industry	Number	Percentage of Total
California	56	39.1	Packaged Software	39	27.3
New York	10	7.0	Internet Software/Services	30	21.0
Massachusetts	6	4.2	Information Technology	11	7.7
Utah	4	2.8	Catalog/Specialty Distribution	8	5.6
Illinois	3	2.1	Financial	7	4.9
Florida	2	1.4	Misc. Commercial Services	7	4.9
Connecticut	1	0.7	Biotechnology	5	3.5
Georgia	1	0.7	Commercial Printing/Forms	4	2.8
New Jersey	1	0.7	Medical Services	3	2.1
Texas	1	0.7	Specialty Stores	3	2.1
Washington	1	0.7	Advertising/Marketing	2	1.4
Washington DC	1	0.7	Aerospace & Defense	2	1.4
Total U.S.	87	60.8	Computer Processing	2	1.4
China	24	16.8	Data Processing Services	2	1.4
India	7	4.9	Movies/Entertainment	2	1.4
Germany	5	3.5	Specialty Telecommunications	2	1.4
United Kingdom	5	3.5	Wholesale Distributors	2	1.4
Singapore	3	2.1	Apparel/Footwear	1	0.7
South Korea	2	1.4	Broadcasting	1	0.7
Sweden	2	1.4	Computer Peripherals	1	0.7
Canada	1	0.7	Food Distributors	1	0.7
Czech Republic	1	0.7	Life/Health Insurance	1	0.7
France	1	0.7	Personnel Services	1	0.7
Hong Kong	1	0.7	Pharmaceuticals	1	0.7
Israel	1	0.7	Retail Trade	1	0.7
Luxembourg	1	0.7	Semiconductors	1	0.7
Netherlands	1	0.7	Technology Services	1	0.7
Taiwan	1	0.7	Telecommunications Equipment	1	0.7
Total International	56	39.2	Tools & Hardware	1	0.7
Total	143	100.0	Total	143	100.0

Exhibit 5: Independent variables by return quartile

Variable	Number	Mean	Median	Minimum	Maximum
Quartile 1 (Excess return greater than 197.97%)					
Experienced founder	28	28.57%	0	0	1
Active founder	30	83.33%	1	0	1
Total size Board/Management	25	8.64	9	2	25
Number on Board	20	4.15	4	1	8
% Board Independent	19	15.79%	0	0	2
Age of firm	30	5.8	5	2	12
Average Tenure	25	3.0	2	0	6
Latest valuation (billions)	30	4.84	1.8	1	51
Number of investors	30	12.13	8.5	2	63
Number of active investors	30	11.70	8.5	0	56
Rounds of funding	30	4.27	4	2	9
Excess return vs. S&P (%)	30	21127.29	529.51ǂǂǂ	198.27	472926.44
Total Equity per *FactSet* (billions)	30	0.55	0.27	0.002	6.01
Quartiles 2 and 3 (Excess return greater than 56.08 and less than 197.97%)					
Experienced founder	60	23.33%	0	0	1
Active founder	60	96.67%	1**	0	1
Total size Board/Management	58	13.09***	12***	2	39
Number on Board	53	5.13	5	1	12
% Board Independent	53	43.40%	0	0	4
Age of firm	60	8.70***	8***	3	21
Average Tenure	58	4.19	4	1	13
Latest valuation (billions)	60	4.06	1.7	1	46
Number of investors	60	12.70	12	1	35
Number of active investors	60	12.52	12	1	35
Rounds of funding	60	4.95	5	1	9
Excess return vs. S&P (%)	60	108.46	107.65	56.39	197.67
Total Equity per *FactSet* (billions)	60	0.45	0.27	0.03	2.60
Quartile 4 (Excess return less than 56.08%)					
Experienced founder	30	13.33%	0	0	1
Active founder	30	90.00%	1	0	1
Total size Board/Management	30	14.93***	15***	1	27
Number on Board	29	5.90**	6	1	11
% Board Independent	29	68.97%	0	0	6
Age of firm	30	12.37***	11.5***	5	28
Average Tenure	30	5.90***	6***	1	13
Latest valuation (billions)	30	1.81	1.2	1	12
Number of investors	30	13.97	13	2	31
Number of active investors	30	12.73	12	2	29
Rounds of funding	30	6.50***	6.5***	2	12
Excess return vs. S&P (%)	30	35.57	40.38	-13.22	55.77
Total Equity per *FactSet* (billions)	30	0.35	0.28	0.06	1.28

***** Significantly larger than quartile 1 at the 1% level and 5% levels, respectively.
ǂǂǂ Significantly larger than the other quartiles at the 1% level.

more completed in the first month of 2016. The problem he states for unicorn investors is these late round fundings cut into the returns that were thought to be over a hundred times the return on investment.

Conclusion

Equity crowdfunding gives ordinary investors the potential ability to invest in the early stages of high-growth firms. Investors have complained that this early investing has disappeared in public offerings due to costly regulatory mandates such as Sarbanes-Oxley and Dodd-Frank forcing companies to grow larger before going public. We have shown the reward for early stage investing is the potential for large returns but one of the problems of early stage investing is the potential for fraud because the non-accredited investors lack experience. Other issues associated with equity crowdfunding are the lack of liquidity and the risk. The SEC is limiting the amount of funding a non-accredited investor can do to reduce the exposure to risk but there is still the illiquidity issue.

Since non-accredited crowdfunding has not started yet in the US, it is too early to tell how popular equity crowdfunding will be with non-accredited investors and whether fraud will be an issue. Examining the UK experience, equity crowdfunding is growing and it appears it will change how small companies will capitalize themselves. Since non-accredited investors don't have experience investing in private companies, US equity crowdfunding platforms should follow the lead of UK platforms and allow non-accredited investors to co-invest with accredited investors. Given that one of the goals of the JOBS Act is to create job growth, the US may want to consider giving a tax break to investors that invest in startups similar to the UK. Another example would be the Shanghai market where Jie, Areddy, and Areddy [2016] report that to spur investment firms to take more risk on early stage tech startups, the Shanghai market is offering subsidies of up to 30 to 60% of financial losses incurred by investors.

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VC-PE Index

A Look at North American Private Equity as of Q1 2017

Mike Roth
Bison

Private equity has experienced six straight years of strong fundraising, which has propelled the industry to new heights. Over the last five years, private equity has raised more than $2.6 trillion. What is fueling this rise? How are managers responding to this influx of capital?

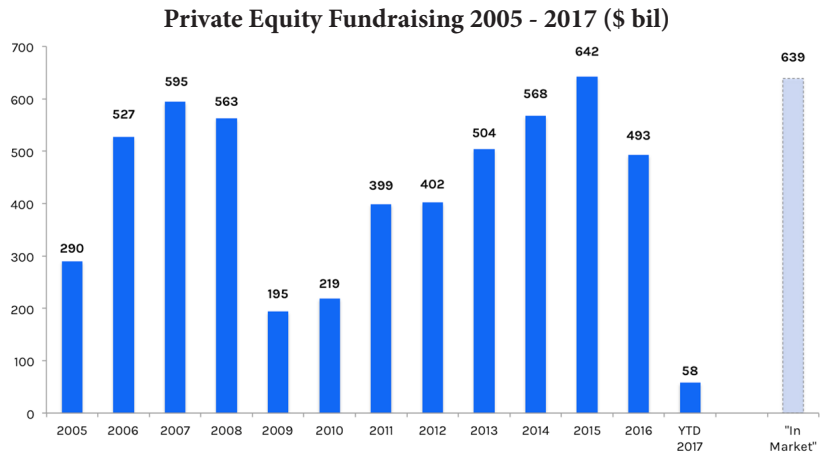
When the book is finally closed on 2016 fundraising, we will have a fourth straight year with more than $500 billion raised. Couple that with the 2,800 funds currently seeking close to $640 billion and it is easy to see that markets that demand but also competition for capital is at all time highs in the industry.

What is fueling this growth?

There are certainly exogenous factors at play which are driving the industry's growth, including disappointing returns in other asset classes and new sources of capital in Asia and the Middle East that are large contributors to the strong fundraising market.

If we dig into industry-specific dynamics, we will see that the strong exit markets are at the heart of what is fueling strong fundraising.

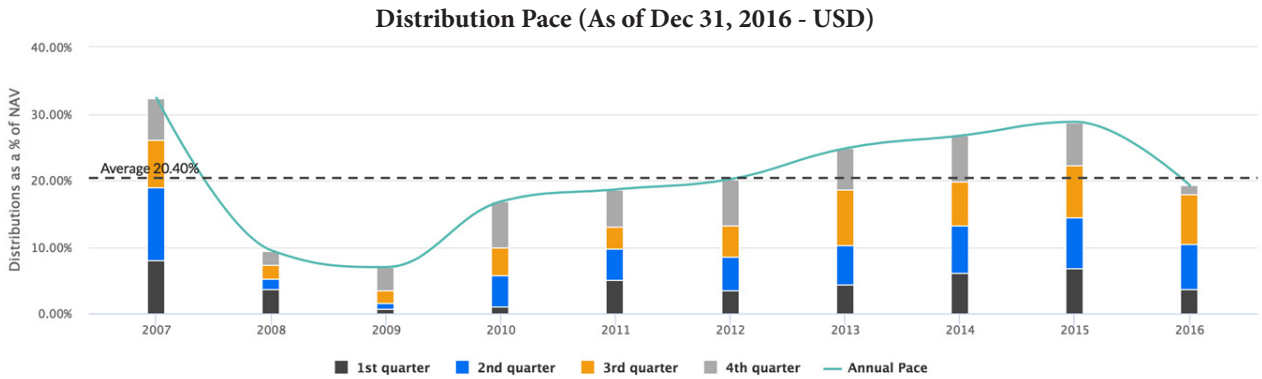
Based on what our clients have been saying, Q4 2016 was an incredibly strong quarter for distributions. This means 2016 will be the fourth

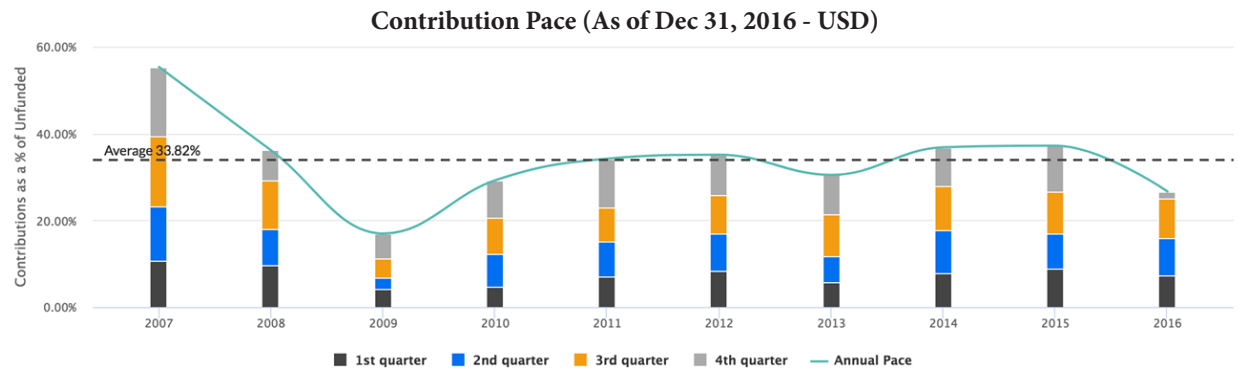


consecutive year of strong, above average exit activity. Looking closely at the above chart, we can see that this bull market got its start in Q4 2010. Q4 2010 was a strong quarter for exits, representing more than 40% of 2010's exit activity, and it represents the start of the upward trend in exit markets.

How are GPs responding to this influx of capital?

Despite the record setting commitments, GPs have remained relatively disciplined. As the chart below indicates, the annual investment pace has fluctuated around the 10-year average of 38% of unfunded commitments.





This contrasts with the bubble that came to a halt in 2008. During the 2005 - 2007 vintage years, GPs invested more than 55% of their available unfunded commitments each year. An unprecedented amount of capital was put to work in a short period of time.

While deal activity has been healthy up until now, the growing supply of dry powder begs the question of "How long will this last?" Either GPs will continue to let dry powder swell while they wait for a buying opportunity or they will succumb to the unspoken pressure to deploy capital and start doing deals that are reminiscent of the 2004 - 2007 boom. Using our market data to approximate the amount of dry powder industry-wide, we estimate there is $1.4 trillion waiting to be deployed.

Wrapping up

Private equity is in the midst of its longest streak of strong fundraising - six straight years of at least $400 billion raised. Relatively strong returns, new pools of capital and sustained strength in exit markets indicate to us there is at least another year, if not two, of runway left in the current golden age. The area to watch for any signs of overheating will be the investment pacing. If deal activity starts to pick up, that will be a sign that GPs have decided to put their money to work rather than accumulate dry powder. In that situation, LPs will want to perk up and pay extra attention to where their GPs are investing in case things start to get carried away.

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Mike Roth is the Research Manager at Bison and oversees the data collection and content production. Before Bison, Mike spent six years on the investment team at SVG Advisers. There, he conducted research and due diligence on buyout and venture capital funds in the Americas. Mike received his BA in Economics from Boston College and is a CFA Level III candidate.

MSCI Global Intel Report
Property Income Risk & Performance

Max Arkey
MSCI Real Estate

National Market - USA

As of 2016 Q3, more than a third of U.S. leases tracked by MSCI were set to expire in less than 40 months. Nearly 60% of the underlying contracted rents in these leases were tied to office assets, two-thirds of which were located in CBDs. Timing matters for these expiring leases, especially for contracts ending in the next two to three years, a period when U.S. domestic and foreign policy priorities could experience transition. For institutional investors, uncertainty — whether upside or downside — requires careful management of risks to the income stream. The analysis of the CBD office sector in these pages covers the four primary dimensions of risk in IRIS (MSCI's property income risk and performance service): concentration, lease length, market conditions, and tenant credit.

Sector Focus - CBD Office

Two of every five dollars held by institutional investors in U.S. non-residential rental contracts could be traced to CBD offices as of 2016 Q3. And within this property type, nearly half (48%) of assets were located within the big three CBDs of the Northeastern corridor: New York, Boston, and Washington. The average CBD office lease in the U.S. was set to expire in 5.6 years, making it only a few months longer than the 5.2-year average for the overall U.S. commercial market. If expiring leases were to roll to current market rents, investors could reasonably expect a 4% premium on their CBD office allocations, with rents in this property type rising by 19.1%, on average, above current contracts (versus a 14.8% rise in rents for the all-sector average).

USA: National Overview As Of September 2016

THE FOUR MAJOR COMPONENTS OF REAL ESTATE INCOME RISK*

		CONCENTRATION	TERM	MARKET	CREDIT
		CONTRACTED RENT *% of national market*	REMAINING LEASE TERM *years (weighted)*	% GAIN / LOSS TO LEASES *market vs contract rent*	TENANT RISK LOW / MED / HIGH
	ALL PROPERTY	100.0%	5.2	14.8%	
BY EXPIRATION	2016	3.4%	—	25.8%	
	2017	9.9%	—	13.6%	
	2018	11.1%	—	8.9%	
	2019	10.8%	—	10.7%	
	2020	10.7%	—	15.4%	
	2021 and beyond	54.1%	—	16.1%	
BY LOCATION	LA/OC/Riverside	13.5%	4.9	14.2%	
	SF Bay Area	11.6%	4.7	27.1%	
	NY/NNJ/LI	11.3%	6.4	31.5%	
	Chicago	10.1%	6.3	11.6%	
	Washington DC	8.3%	5.6	0.5%	
	Boston	7.1%	5.4	15.0%	
	South Florida	4.2%	4.4	11.9%	
	Seattle	4.1%	5.1	18.7%	
	Houston	3.4%	5.3	16.2%	
	Atlanta	3.3%	6.2	3.8%	
BY SECTOR	CBD Office	38.0%	5.6	19.1%	
	Industrial	20.6%	4.3	7.1%	
	Retail	20.4%	6.0	18.4%	
	Suburban Office	20.3%	4.5	11.0%	
BY TENANT INDUSTRY	Banks/insurance (OFF)	10.5%	4.7	18.1%	
	IT/R&D/consulting (OFF)	6.7%	5.1	11.0%	
	Legal services (OFF)	5.6%	6.3	17.8%	
	Software & media (OFF)	4.0%	5.4	17.2%	
	Manufacturers (IND)	3.9%	4.3	8.4%	
	Wholesale traders (IND)	3.6%	4.3	7.9%	
	Retailers (OFF)	3.4%	6.7	14.1%	
	Medical/dental (OFF)	3.4%	5.6	8.7%	
	Mfg ex-pharma/med (OFF)	3.3%	5.6	26.3%	
	Clothing/fashion (RET)	3.3%	5.1	18.6%	

Source: MSCI (IRIS)

**based on the current status and expiration schedules of actual lease contracts held by institutional owners. This is not a forecast.*

		CONCENTRATION RISK	
		ALL SECTORS	CBD OFFICE
		CONTRACTED RENT *% of national market*	CONTRACTED RENT *% of property sector*
	USA	100.0%	100.0%
BY EXPIRATION	2016	3.4%	3.1%
	2017	9.9%	7.4%
	2018	11.1%	10.3%
	2019	10.8%	9.6%
	2020	10.7%	8.5%
	2021 and beyond	54.1%	61.1%
BY LOCATION	LA/OC/Riverside	13.5%	7.4%
	SF Bay Area	11.6%	11.1%
	NY/NNJ/LI	11.3%	22.0%
	Chicago	10.1%	13.7%
	Washington DC	8.3%	12.8%
	Boston	7.1%	12.9%
	Seattle	4.1%	5.2%
BY TENANT INDUSTRY	Banks/insurance (OFF)	10.5%	19.0%
	Legal services (OFF)	5.6%	12.7%
	IT/R&D/consulting (OFF)	6.7%	11.4%
	Retailers (OFF)	3.4%	7.2%
	Software & media (OFF)	4.0%	6.3%
	Mfg ex-pharma/med (OFF)	3.3%	4.2%
	Accounting (OFF)	1.6%	3.3%
	Medical/dental (OFF)	3.4%	3.1%
	RE sales & leasing (OFF)	1.5%	2.9%
	Public sector (OFF)	1.1%	2.8%

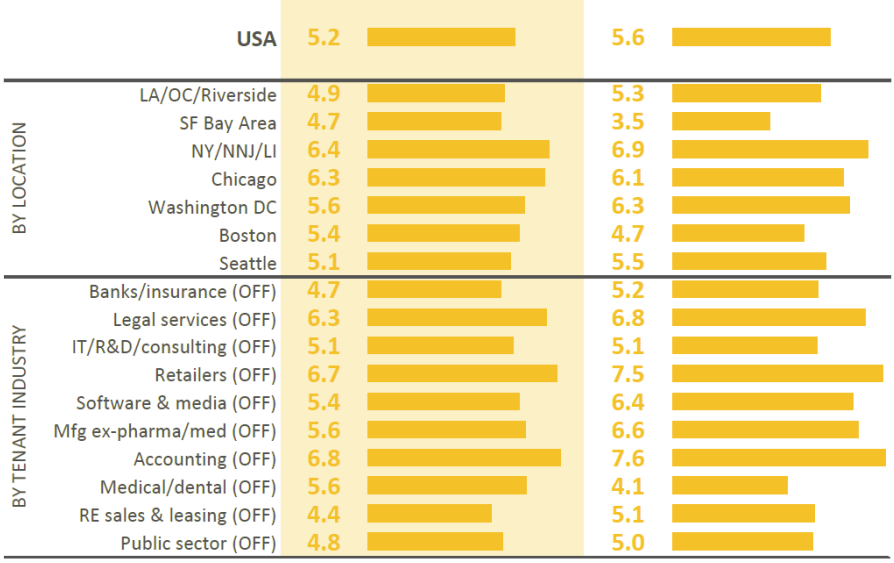
KEY POINTS

- As of Q3 2016, expirations of CBD office leases were back-loaded relative to all U.S. commercial leases, with just over 60% of CBD office leases up for renewal after 2020 compared with an all-sector average below 55%.

- Nearly half (48%) of all institutional investment in U.S. CBD offices could be found in the big three Northeastern markets of New York, Boston, and Washington. The two major California markets (LA and the Bay Area) accounted for less than 20% of the national total.

- The tenant base for CBD offices differs from the overall non-residential market. The top five tenant groups for CBD leases include banks, law firms, consultants, media, and ground-floor retailers. These five groups together account for 57% of all CBD rents, but only 30% of all non-residential rental contracts held by investors.

TERM RISK



based on the current status and expiration schedules of actual lease contracts held by institutional owners. This is not a forecast.

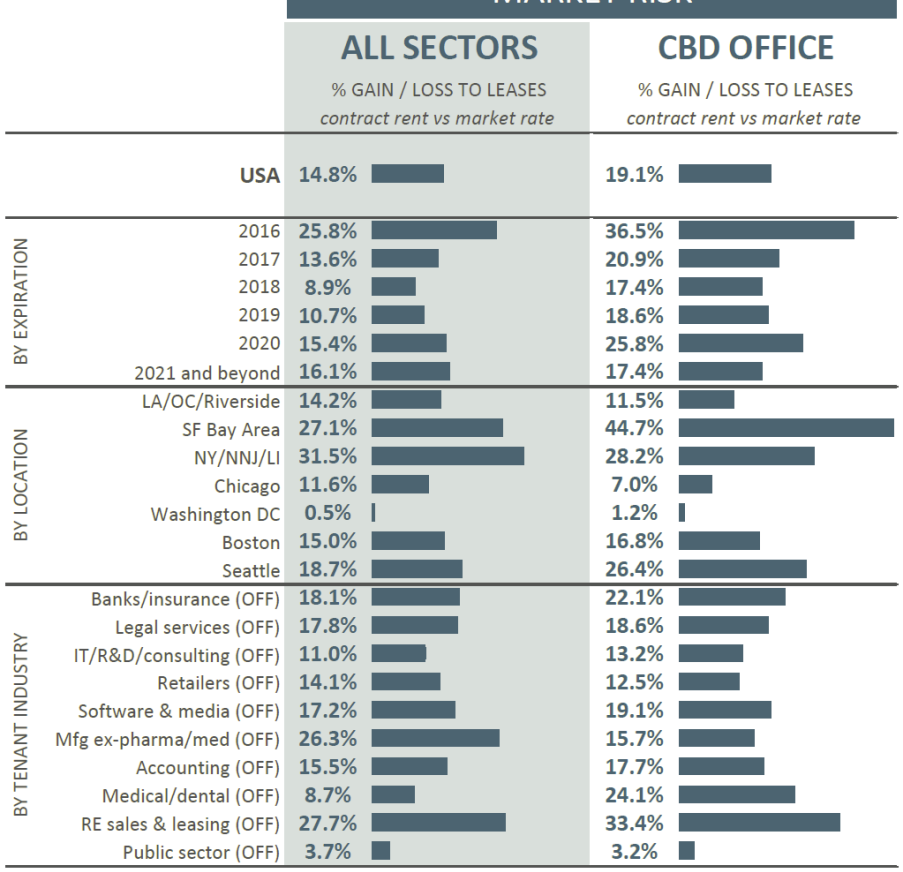
KEY POINTS

- The average commercial lease in the U.S. expires in 5.2 years, with the remaining lease term falling a few months short of the 5.6 year average for CBD offices.

- Of the major CBD markets in the U.S., the Bay Area leases were the most front-loaded with an average remaining lease term of just 3.5 years. New York, Chicago, and Washington were the only CBD markets with an average exceeding six years.

- Financial services firms as a group represent nearly one-fifth (19%) of all CBD leases. The remaining lease terms for these financial tenants averages 5.2 years, somewhat short of the CBD average of 5.6 years.

MARKET RISK

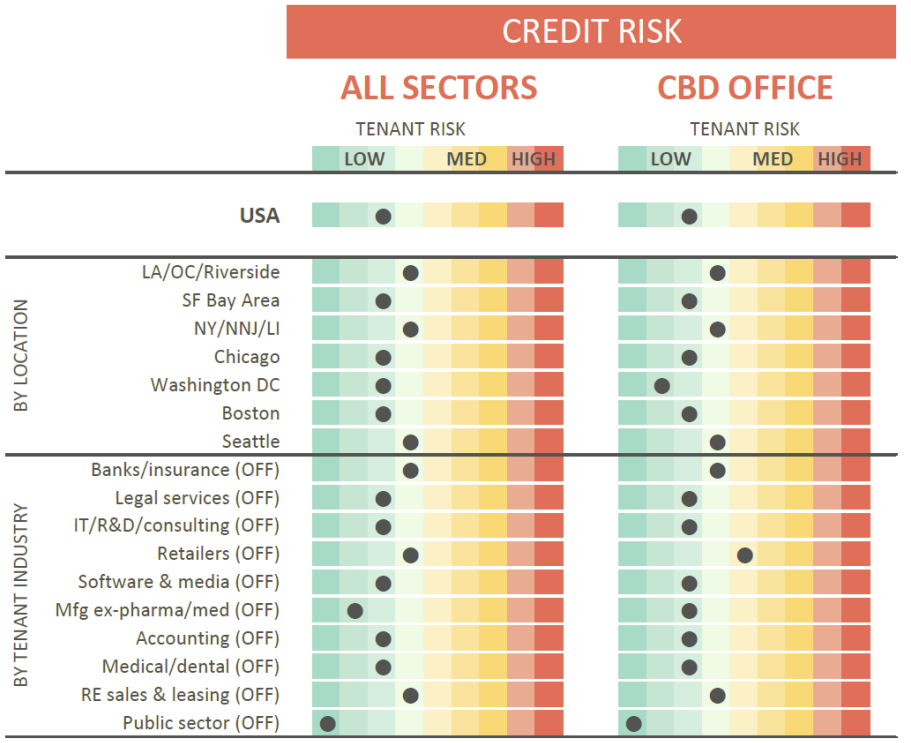


KEY POINTS

- As of Q3 2016, CBD office leases were better placed for rental gains than the all-sector average. If all expiring leases were renewed at current market rents, the average U.S. lease would roll up by 14.8% compared to 19.1% for CBD offices. This CBD premium would be front-loaded, with potential gains on lease renewals occurring over the next five years and then largely aligning with the all-sector average by 2021.

- Potential gains on CBD office lease renewals in the Bay Area New York, and Seattle exceed the national average for this property type. In Washington, however, CBD leases rolling to open market rents would likely produce only marginal gains.

- Across most (but not all) tenant industries, potential gains tended to be higher for CBD offices than for the all-sector average.



Source: MSCI (IRIS) and Dun & Bradstreet

KEY POINTS

- Credit risks at the tenant level can be weighted and rolled up to identify discernible but often nuanced differences when aggregated across geography or tenant industries.

- Credit risks for CBD office tenants showed a degree of minor variation when aggregated to the metropolitan level. Tenants in Los Angeles, New York, and Seattle exhibited modestly higher aggregate risks. Washington, despite its limited potential for rental gains, held the lowest weighted risk score of the major markets, reflecting underlying differences in its local tenant base and distinguishing its risk/return profile among the major markets.

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