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Risk, Return, and Diversification for Private Equity and Venture Capital General and Limited Partners

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What tools can GPs and LPs rely on?

- Public securities investors rely on liquid arms-length pricing and abundant public information to perform rigorous time-series and cross-sectional analysis of their asset class

- Private investors have no such toolset at their disposal
  - Data is scant both due to lack of systematized data collection effort, as well as preference for privacy by general partners to preserve the value of investment ideas
  - There is no unified financial framework for optimal investing under these conditions

- IRR provides approximately accurate "central tendency" performance expectation but fails to give adequate sense of uncertainty of outcomes.
  - Even "De-smoothing" of IRR-based series has significant problems when applied to risk models to capture volatility

If VC/PE were Star Wars

- **C-3PO (The Quant):**

Oh my… the odds of navigating to a good deal through an asteroid field of bad deals are 3730 to 1

- **Han Solo (The Deal Partner):**

Never tell me the odds !!

Combining Intuition and the Quantitative

- **Utility:** Investors like gains and dislike losses

- **Diversification:** LPs like to have many deals so that at least few hit home runs:
  - probability of at least one home run is the sum of the probability of each deal being a success
  - thus the objective is to add as many deals as capital allows in an effort to find at least one diamond in the hay stack

- **Agents:** GPs think about a deal's central expectation but give only secondary, if any, consideration to dispersion of potential outcomes and correlation of the outcomes across deals in the portfolio

- **Models:** Traditional Risk Models focus on dispersion around the central expectation, but don't tell much about manager skill of picking the central expectation

The *Prospector's Distribution*

- We have just acknowledged two sources of uncertainty:
  - One arising from the skill of the manager to identify the average payoff when selecting to invest in any particular deal
  - The other is the dispersion of potential outcomes of the individual deal around the average outcome for the deal, whatever that average may be.

- In essence, the second source of uncertainty is a distribution conditional on the first

- The aberrations around the mean in the second distribution are independent from the mean itself; thus we can easily combine the two distributions into one which we shall call the *Prospector's Distribution*
  - *The analogy in the name is that of a gold prospector – the amount of gold found will be a function of the skill of the Prospector to read the geology and identify a deposit location, and, separately, the natural dispersion of possibilities of how much gold there will be, if any is found*

Deriving the Prospector's Distribution

- *The "second" distribution* – dispersions around a mean - has traditionally accepted to be a normal distribution:
  - Some of the volatility is coming from common risk factors defined by industry, geography, etc.
  - Some of the volatility is coming from idiosyncratic risk

- The "first", or skill-, distribution has not been explored well in the literature:
  - Thus, we can assume the least informed distribution – the uniform distribution for the ability of manager to predict average profitability
  - Alternatively, anecdotal evidence and intuition suggest that private investment for venture capital in particular has significant positive skew (small probability very, high outcomes); the exponential distribution for manager skill will be a good candidate for those cases
- *We can solve the Prospector's distribution parameters for both the uniform and exponential and pick the one with the higher likelihood in the case of each manager*

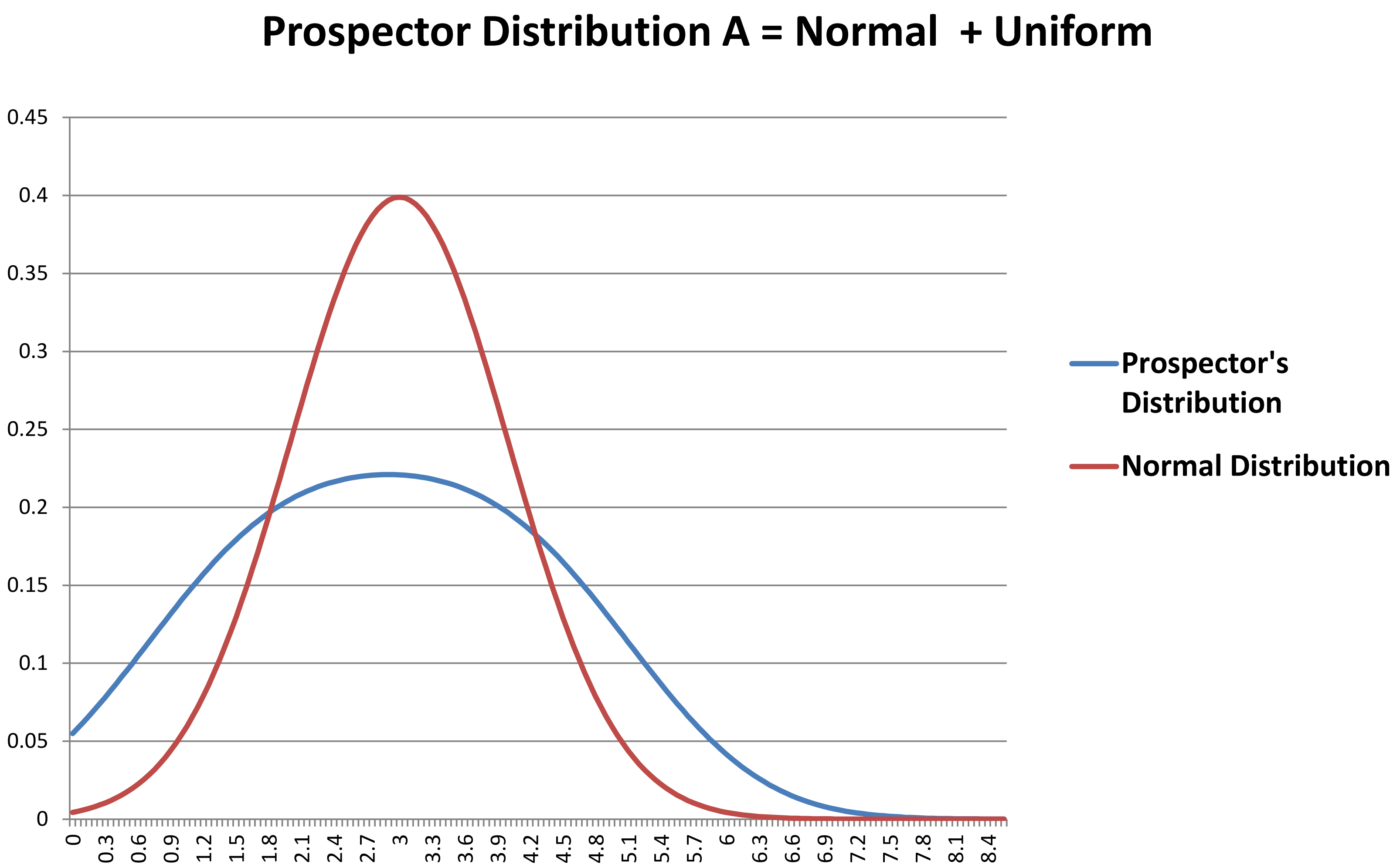
Building the Prospector's Distribution (cont'd)

- The superposition of the *uniform* distribution of manager skill and the normal "difference from the mean" deal distribution will result in a distribution that is unimodal (has a single peak) and descends slowly to the sides (has very fat tails); it will also have positive skew - extreme but low probability gains are more likely than extreme but low probability losses - as outcomes beyond 100% loss will be un-attainable, unless leverage is involved.

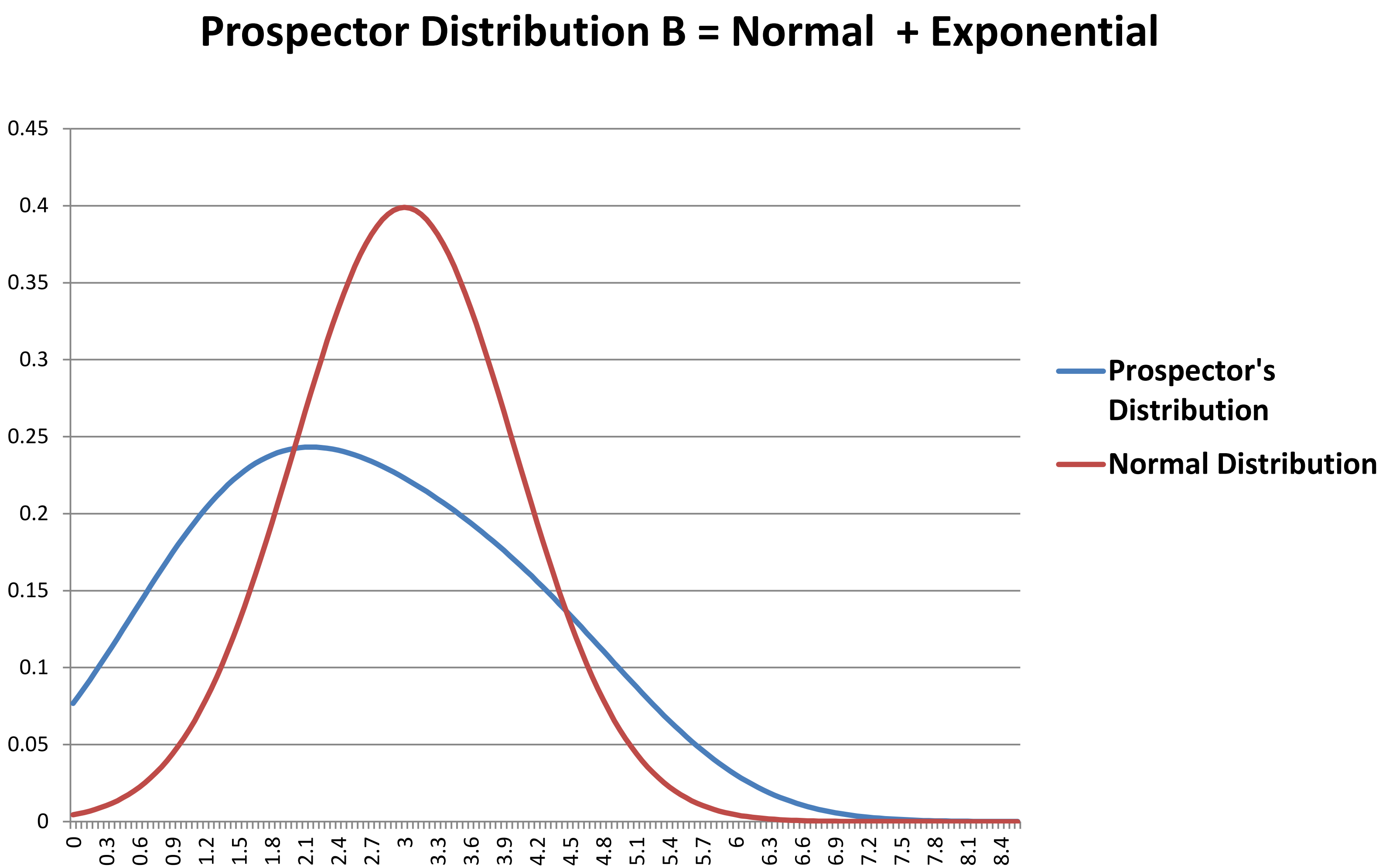
- The superposition of the *exponential* distribution of manager skill and the normal "difference from the mean" deal distribution will result in a distribution that is unimodal, has fat tails and pronounced positive skew

- The result in either case: *we have constructed a distribution which incorporates simultaneously the insights of deal investors and those of traditional risk models*

Prospector Distribution Family



Prospector Distribution Family (cont'd)



Building the Prospector's (cont'd)

- The manager skill distribution aspect can be inferred from past performance of the manager

- The "dispersion around a conditional mean" aspect can be explicitly calculated using a traditional risk model for volatility – CAPM, APT, FF, or a commercial vendor risk model using the portfolio companies and their risk characteristics as they existed during the manager evaluation sample period

- The solution of the parameters of the skill distribution are then overlaid with:
  - The traditional risk model volatility of the particular deal in which the GP explores to invest, that is incremental to the volatility of the existing private equity fund portfolio
  - The traditional risk model volatility of the particular private equity fund in which the LP explores to invest, that is incremental to the volatility of the existing LP's portfolio

Optimal Deal Flow for Illiquid Assets (ODFI)

- The next step is to incorporate the Prospector's Distribution into an optimal investment framework – ODFI
- ODFI received the 2015 annual Best Practitioner Research Award by the American Real Estate Society
- Published and available for detailed review in the Real Estate Finance journal Winter 2016 edition (Belev, Gold)
- Combines fundamental and quantitative tools to derive the criteria by which to select lumpy illiquid investment deals in a multi-asset class setting

ODFI Steps

- **(1) Fundamental:** Estimate an expectation of average profitability of individual deals in the deal flow, to estimate expected NPV

- **(2) Quant:** capture the incremental impact of proposed investment deals to existing portfolio volatility, based on portfolio theory

- **(3) Quant:** Estimate the expected *downside* impact of the new asset to portfolio performance, based on prior two steps

- **(4) Fundamental:** Risk-adjusted capital budgeting using expected marginal benefit of the particular deals

Step 1: Calculating baseline NPV of new deals

- Estimate expected profitability – this is the job for which deal investors are hired
- When discounting to get NPV, use the risk-free rate
- The reason: we will be subtracting explicitly the expected impact of downside performance from baseline NPV to get to "risk-adjusted" NPV.
- **Fundamental Theorem of Asset Pricing:** Subtracting expected loss will have identical impact to NPV as calculating a risk adjusted discount rate to start with and using it instead of the risk-free rate in discounting

Step 2: Estimating Incremental Volatility

- A tenet of Portfolio Theory is that an asset should always to be analyzed in light of its impact on the portfolio, and not in isolation

- Therefore we are concerned not with the standalone volatility of the new asset, but with its impact to the existing portfolio

- Given a *risk model that transcends liquid and illiquid asset classes*, calculation of the incremental impact of a new asset, or combination of new assets, is a simple algebraic exercise:
  - The difference of portfolio volatility with and without the new assets

- The risk model has to be global and across-asset class if the existing portfolio is global and across-asset class, so incremental impact is captured appropriately.

Step 3: Estimating Downside Impact

- Merton real option analysis has been in existence for a while and with a wide range of applications – from analysis of firms to credit. The key idea:

  Debt – level from which we measure loss – a strike price

  Underlying – the collateral with its value and volatility

  Estimation – done with an option pricing model

- In the same spirit, but different setting, we can use

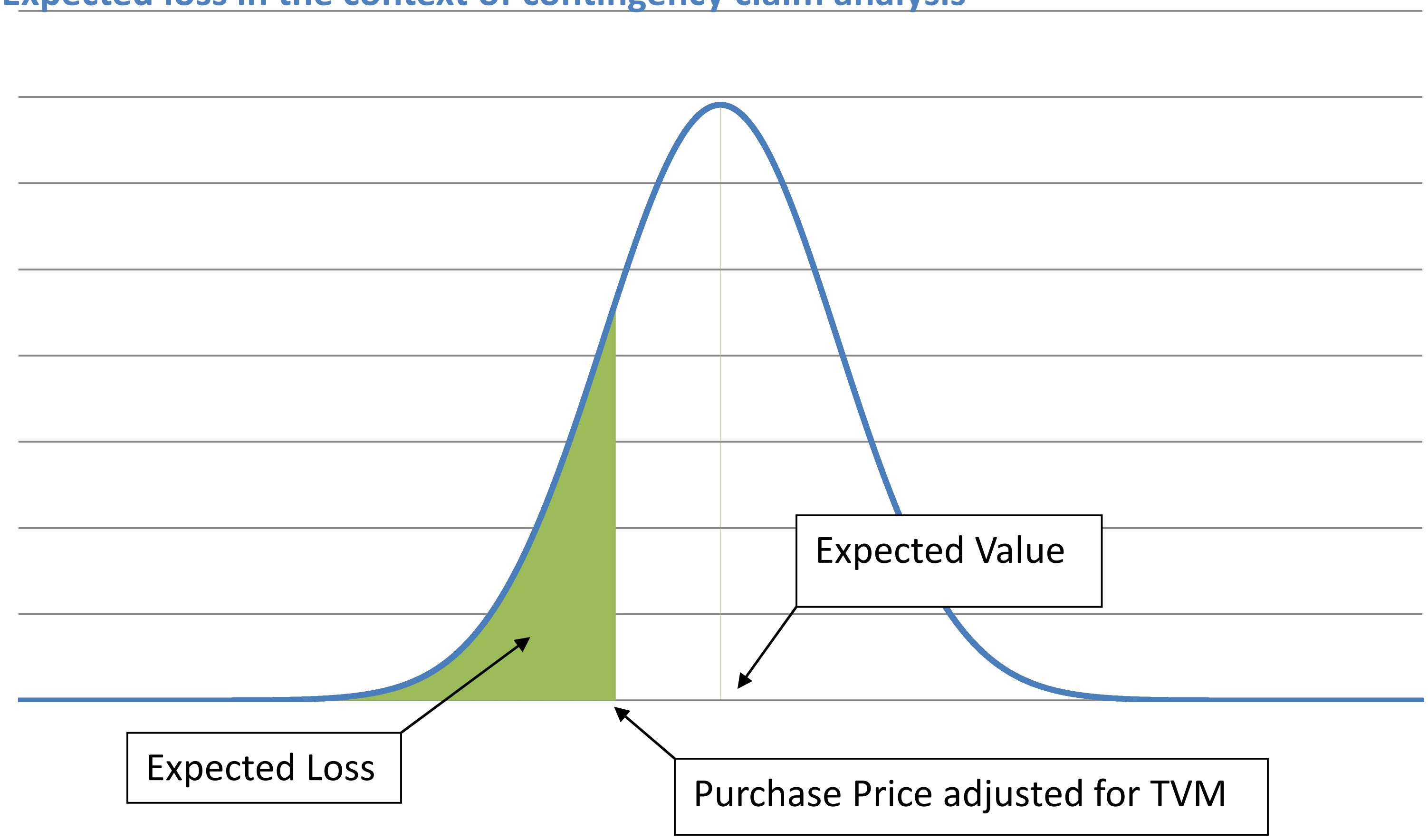
  Offer Price – *level from which we measure loss – a strike price*

  Underlying – *the PV of illiquid assets future cash flows with their associated volatility*

  Estimation – *done using the same math as an option pricing model*

Step 3: Estimating Downside Impact (cont'd)

Expected loss in the context of contingency claim analysis



Step 3: Estimating Downside Impact (cont'd)

- A buyer in an investment is short a put on the asset underperformance, which the seller of the investor is long.

- Treat the incremental volatility as the effective volatility of the asset underlying the put, (it is equivalent to the volatility as if that asset performance is independent from the performance of the rest of the portfolio). The strike price of the put is the offer price for the new asset

- $\boldsymbol{\sigma_{Imputed}} =$

$$\frac{\sqrt{\omega^2_{New\ Investment} * \sigma^2_{New\ Investment} + 2\omega_{Current\ Port.}\omega_{New\ Investment} * COV_{New\ Investment,Current\ Port.}}}{\omega_{New\ Investment}}$$

- The result from the "option price" calculation is the dollar value an investor assigns to the estimated downside impact if a loss. It agrees with intuition – the higher the offer price (put strike) – the higher the downside potential and risk. Also, the higher the (incremental) volatility the higher the downside risk.

Step 4: Calculating Risk-Adjusted NPV

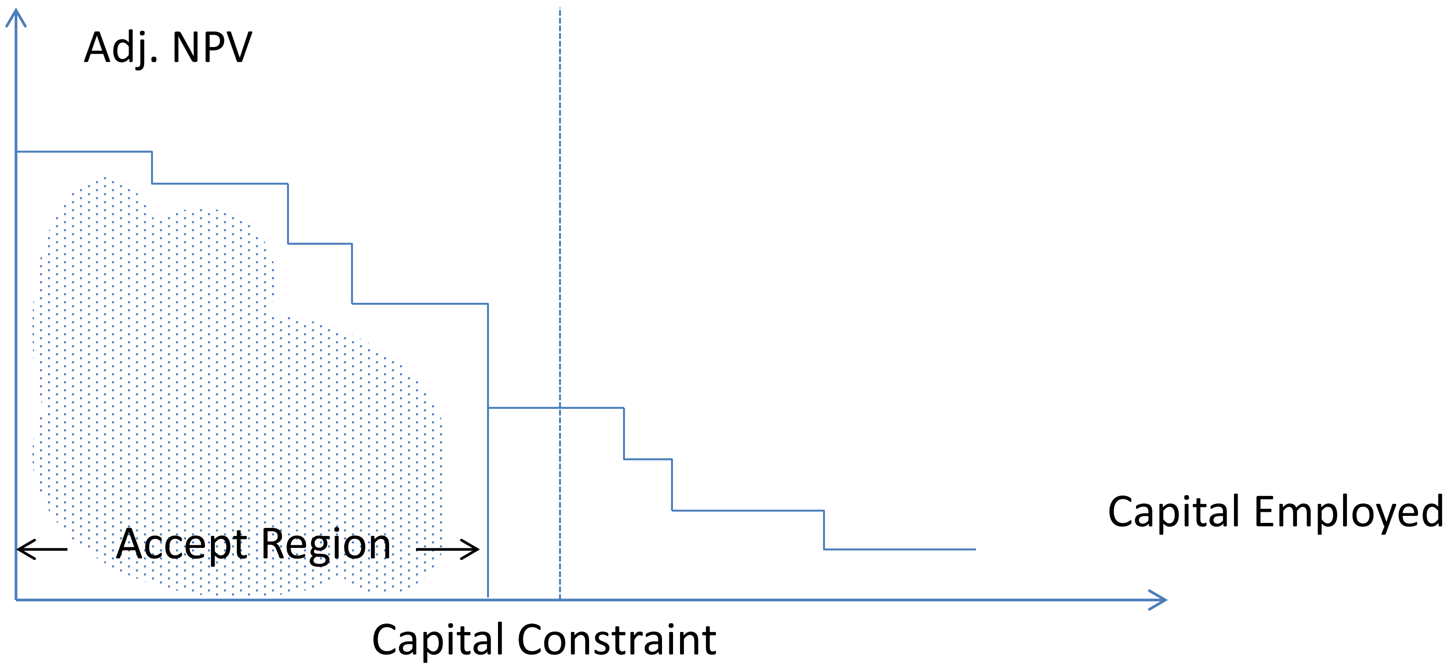
- Subtract the value of the expected loss from the baseline NPV – this is risk-adjusted NPV

- We perform steps 1-4 for each deal under consideration and if several of them exist in any decision period, pick the ones with highest risk adjusted NPV first and continue so until the budget constraint is met.

- The typical number of all assets under consideration in any decision making cycle is such that modern technology makes the turnaround of all calculations involved in this process completely tractable

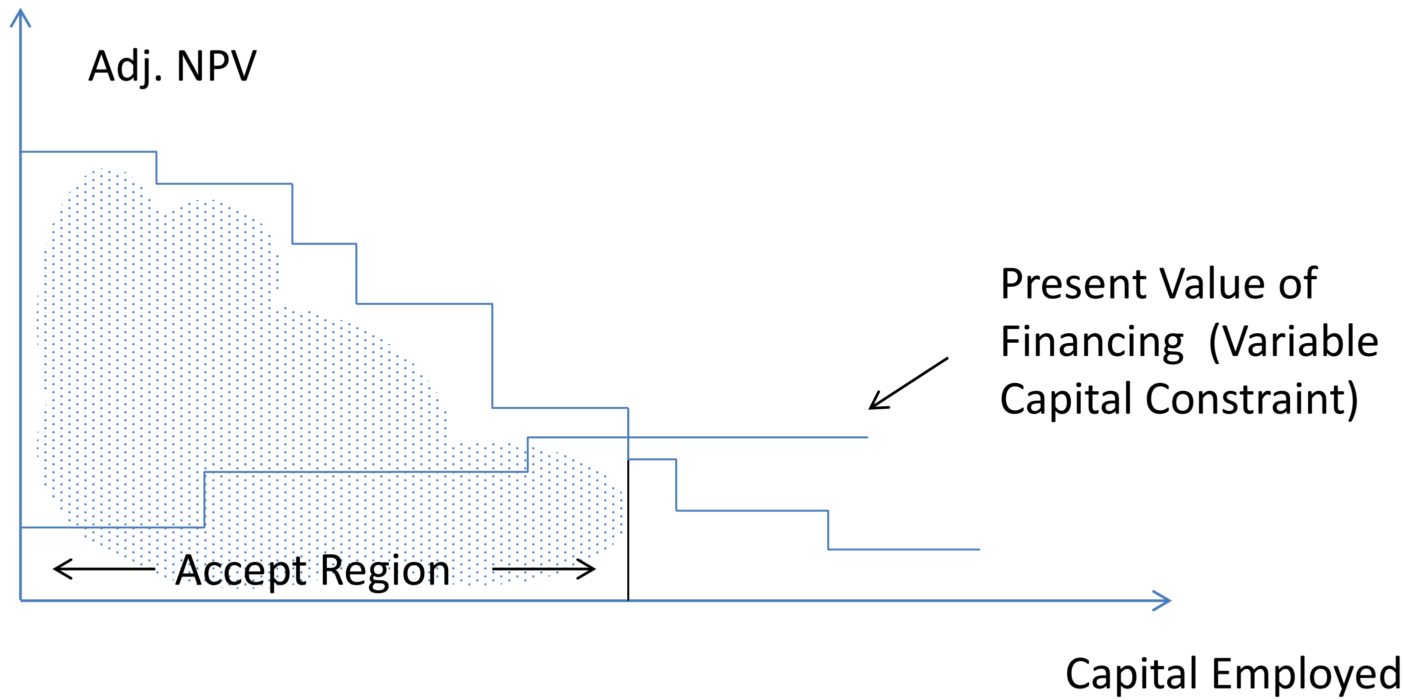
Step 5: Capital Budgeting

- We sort all investment possibilities by Risk-Adjusted NPV in descending order
- The cutoff point will be the acceptance threshold for possibilities



Step 5: Capital Budgeting (cont'd)

Increasing cost of capital due to borrowing will contribute to increasing present value of financing cash flows (discounted at the risk-free rate), presenting a dynamic capital constraint



ODFI in Practice

Investment	PV Cash Inflows (mill dollars)	Offer Price (mill dollars)	PV (per dollar Invested)	NPV (per dollar Invested)	Time Horizon	Imputed Volatility	CCA Drawdown Value per dollar invested	Adjusted NPV (per dollar invested)	Cumulative Investment (mill dollars)	Cumulative Budget Constraint (mill dollars)
Investment 3 (***Company X***)	36.8	23.6	1.6	0.56	15	23.5	0.07	0.49	23.6	50
Investment 6 (***Retail prop.***)	17.6	12.1	1.5	0.45	15	16.3	0.04	0.42	35.7	50
Investment 5 (***Electric Distr.***)	14.8	9.9	1.5	0.50	15	29.3	0.11	0.39	45.6	50
Investment 3 (***Timberland***)	25.3	17.0	1.5	0.48	15	30.0	0.12	0.36	62.6	50
Investment 1 (***Company Y***)	14.8	11.0	1.4	0.35	15	18.3	0.05	0.30	73.6	50
Investment 7 (***Private Debt***)	28.6	22.0	1.3	0.30	15	20.0	0.07	0.23	95.6	50
Investment 8 (***Office prop.***)	11.0	8.8	1.3	0.25	15	15.8	0.05	0.20	95.6	50
Investment 2 (***Warehouse***)	23.6	20.9	1.1	0.13	15	15.0	0.05	0.08	95.6	50

Risk Factor Models: are IRRs a suitable input?

- A lot of literature has been dedicated to the suitability of IRR as a central measure of profitability – *our observations do not add anything to the pro- and con- arguments in this area*

- We, however, would argue that IRR's principal shortcoming is that is unsuitable for the creation of volatility models of investment risk:
  - *An IRRs are dominated by the terminal value of a public market exit strategy – IPO or sale to a public company; this could make prior profit aberrations a statistically non-significant gauge of volatility*
  - *The IRR construct is essentially a geometric average. As such the trace from compound volatility to single period risk factors is intractable*
  - ***Attempts to use linear de-smoothing techniques to capture "real" returns will fail due to the above two limitations***

Risk Factor Models and IRR's silver lining

- In 2014 Belev and Qian independently derived the following formula for the variance of **assets** of periodically compounded return over time T consisting of K periods:

$$VCR = [\sigma^2 + (1 + \mu)^2]^k - (1 + \mu)^{2k}$$

- If we start with a public equity equivalent (industry, geography, leverage, etc.) of the particular private company under consideration we will capture a significant amount of the compound variance
- Using the compound IRR-based volatility and the above formula we can back-solve for the specific risk of the investment deal
- **We end up with all aspects of the volatility estimate needed for the "dispersion from the mean" component of the Prospector's Distribution**

Conclusions

- The Prospector's Distribution is a useful way to gauge private equity managers past performance in a manner that has direct relation to their future performance

- GPs get a reliable way to showcase their performance without disclosing trade secrets; they will also be able to form risk-efficient portfolios and reward talent based on risk-adjusted profit contributions

- LPs get a reliable way of measuring the risk-return payoff of investing in new partnership, recognizing correlations with their existing multi-asset class portfolio

Appendix: Illiquidity

- **Liquidity Premium** for Private Equity varies in the ranges 3 - 12% (Franzoni et al), with the long term value gravitating towards 5%, and also varies across industries, and different types of PE:
  - MBO
  - LBO
  - VC
  - Acquisitions, etc.

- **Mean-variance utility** E(U) = exp(mean – [1/(2*RAP)] * sigma^2} suggests that the marginal market investors (LPs) will be indifferent to buy a public market portfolio vs. a PE investment if the increase in the mean is matched by a commensurate increase in un-diversifiable volatility.

- Consequently, **risk parameters of analogous pubic investments** can be adjusted to reflect private equity liquidity premium

The Price of Constraint

- There are ways to derive the liquidity premium to expected return empirically (Franzoni, Phalippou) as well as analytically (Belev)

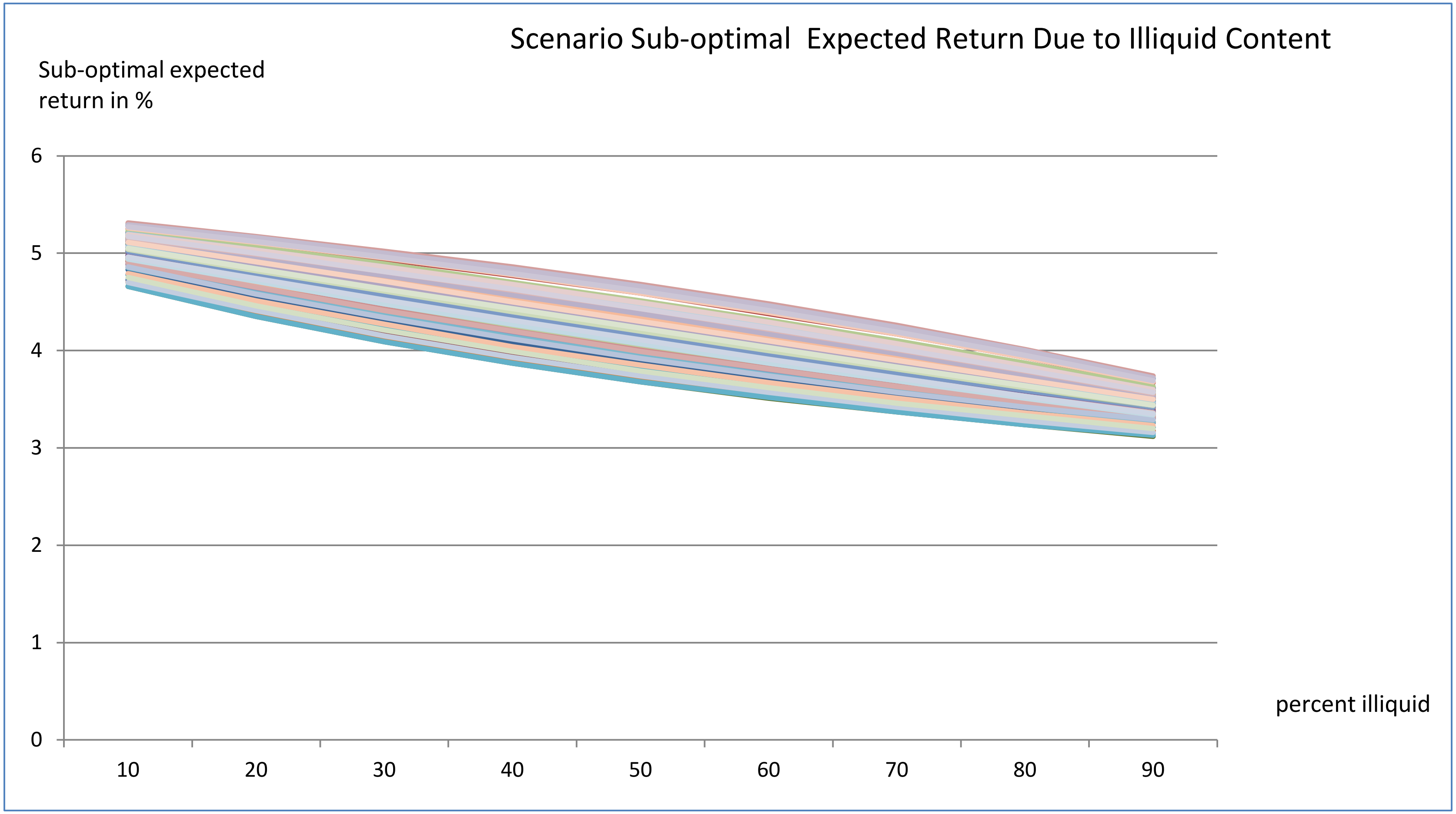
- Then the Cost of Illiquidity (CI) will be expressed in T_1 dollars as:

$$CI = Portfolio\ Value_{T0} * \left(1 + R_\beta\right) * [1 - \frac{(1+R_{suopt})}{(1+R_{req})}]$$

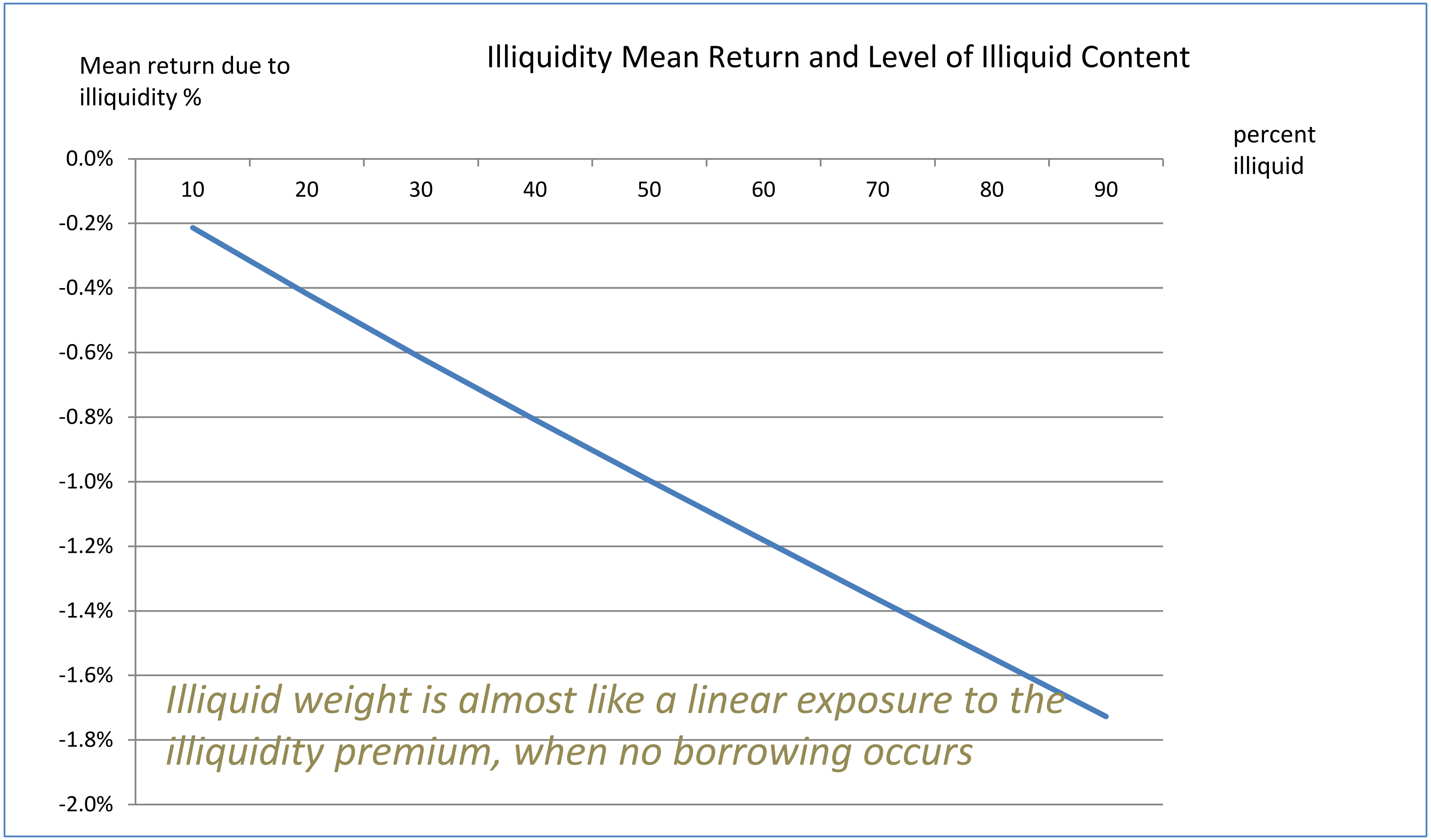
- If we simulate the distribution of R_β, then we can capture the distribution return component up to time T_1 :

$$E\left[R_{illiquiidity}\right] = E[\frac{CI}{Portfolio\ Value_{T0}}]\text{-}1$$

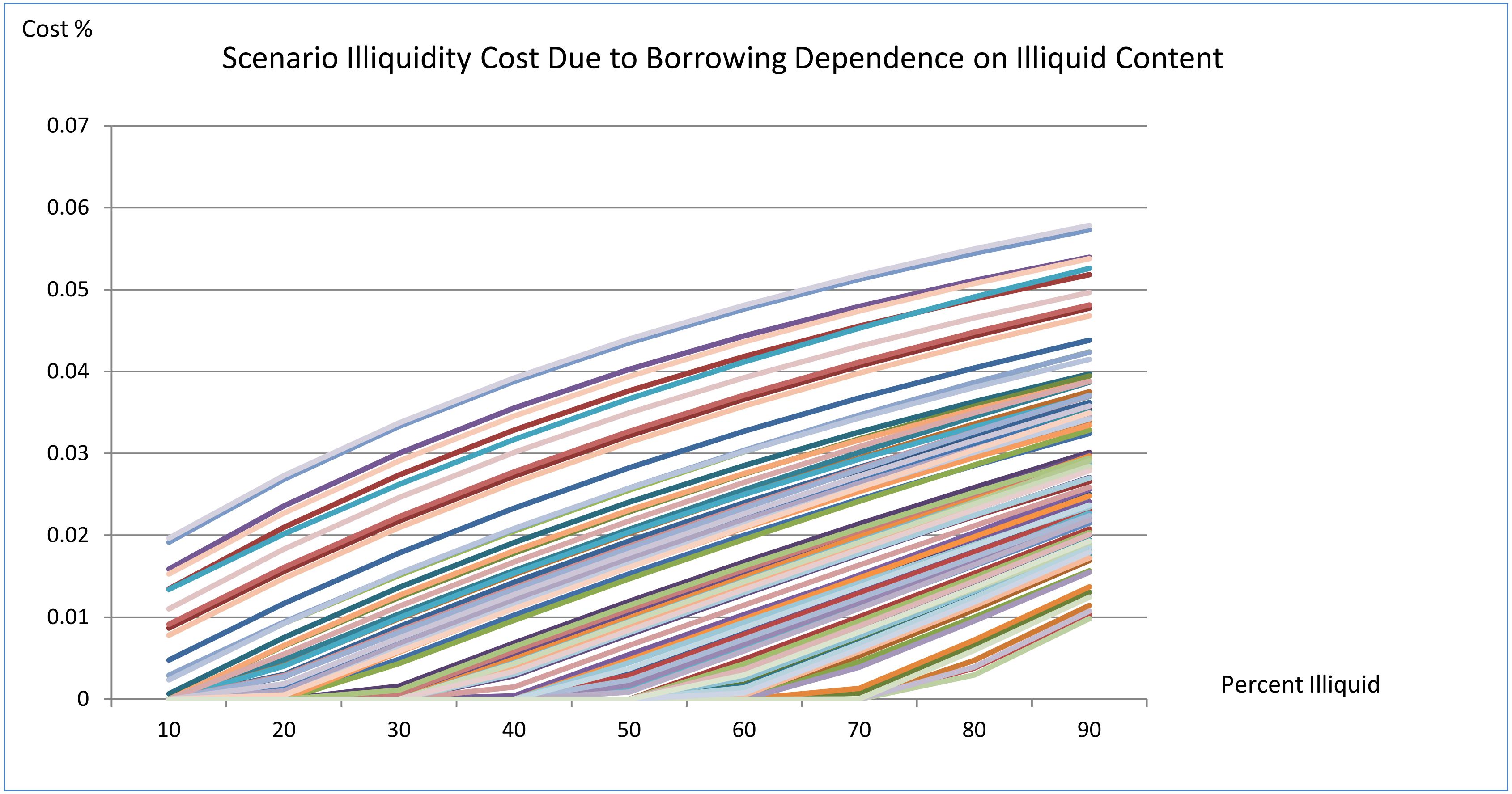
Sub-Optimal Returns and Illiquidity Weight



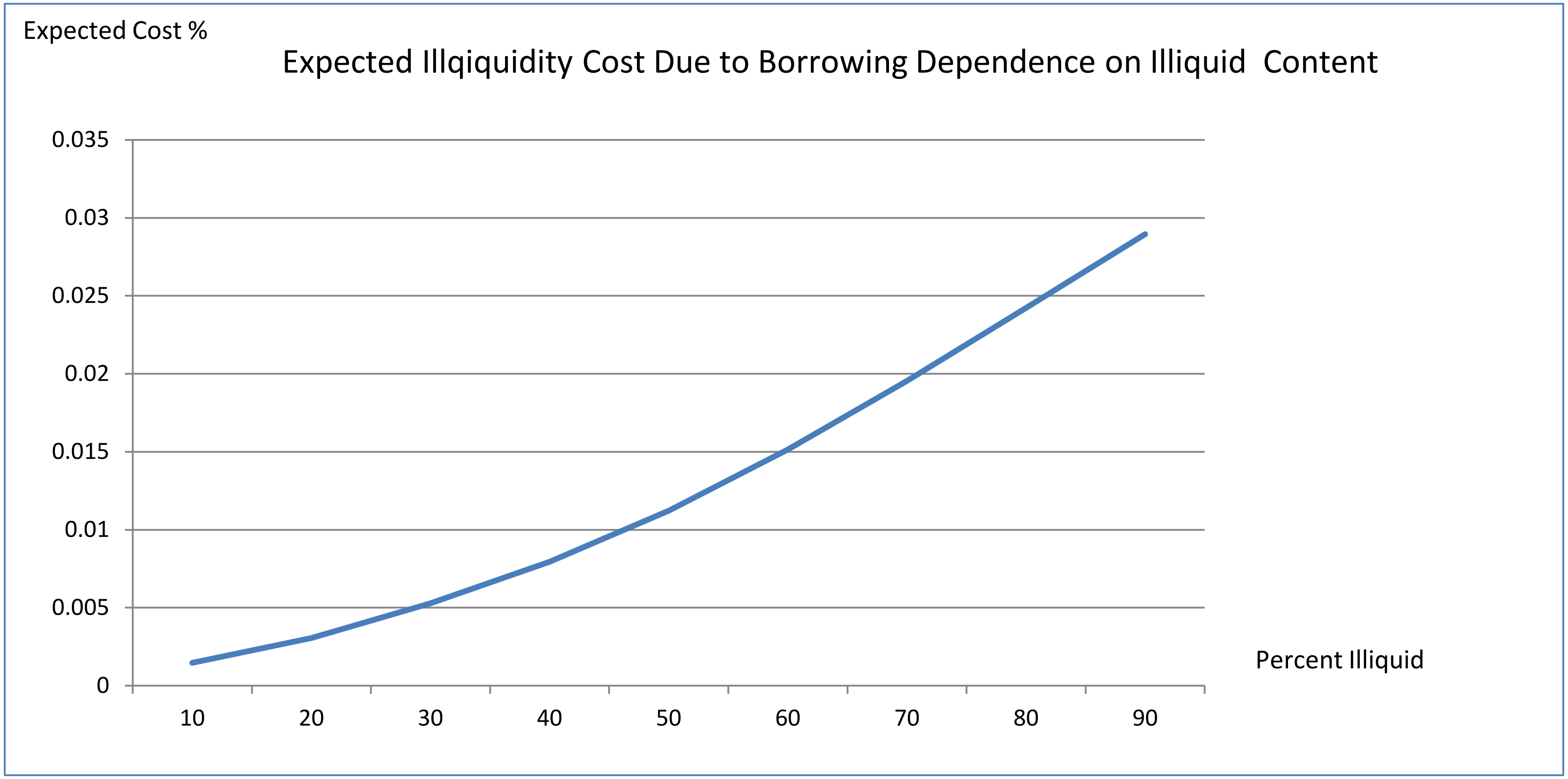
Expected Sub-Optimal Return and Illiquidity Weight



Illiquidity Weight and Scenario Borrowing Cost



Illiquid Weight and Mean Borrowing Impact



Borrowing adds non-linearity to the illiquidity premium required by the investor

Private Equity (cont'd)

- Apart from illiquidity driven by less transparency / thinner market considerations at the deal level, asset owners need to account for two more features at the PE fund level:

  - Lockout provisions in PE fund investments. These pose time limits how soon the funds can be withdrawn. There is a real option application to estimating the cost of distress sale of an inordinate amount of liquid assets to make up for cash needs. That can be translated into "volatility-equivalent" adjustment to underling deal risk parameters.

  - Cash calls from PE fund managers. Those can be either optional or firmly committed, and can be modelled respectively as a call option or a forward position on the underlying fund, with commensurate leverage effect on risk exposure from the PE investment. Dry powder component of commitments should be considered as it mitigates estimated leverage impact.