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## Company decision-making for geothermal projects

(GEOCAP course 1.07)

### Topic: Modern Portfolio Theory (MPT)

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Public document (GEOCAP-2016-REP-TNO-1.07-xx)

## Consolidating assets to the portfolio level

- Performance of portfolio  $\neq$  performance of the sum of the assets
  - Simply adding the assets to establish portfolio performance should not be done
- Reasons
  - Shared constraints (mutual dependencies)
  - Correlated uncertainties (pdf's, but also discrete scenario probabilities)
  - Statistical rules such Central Limit Theorem
- Risk on the project level is in fact meaningless if there is a portfolio of projects.
  - Reason: the risks of the individual projects influence each other, even when projects are stochastically uncorrelated.
- Beware of oversimplifying the calculation of performance and risk!

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# Hierarchical optimization

## Decisions and Levels of Aggregation

		Techniques	Authorization	Time	Monetary value	Aggregated Information
Business or Commercial Decisions	Strategic	- portfolio management - efficient frontier	Corporate Management	year	$10^{10}$	
	Operational	- decision analysis - decision trees - Monte Carlo - utility theory - real options valuation - value of: information flexibility stepwise	ASSET Management	month	$10^8$	
Technical Decisions	Business process (Workflow)	- Critical Path Analysis - Project Evaluation (PERT)	Multidisciplinary Team Management	week	$10^6$	
	Single activity	- methodologies - tools	Technical Expertise	day	$10^4$	

↑ Information  
↓ Authorization

↑ Aggregation Process  
↓ Detailed Instructions

Box 02/01-01

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## Portfolio analysis

- Projects often are dependent on each other
- Project risks (e.g. standard deviation of NPV) therefore also have dependencies
  - Negative and positive dependencies
- Total portfolio risk can be  $\ll$  sum of individual project risks
  - But even if projects are *uncorrelated*, total portfolio risk will be  $<$  sum of individual project risks!
- Portfolio management is programming projects such that the total portfolio risk is minimised
  - And that various constraints are obeyed
    - e.g. total cashflow, total production growth, RRR, ROACE, etc

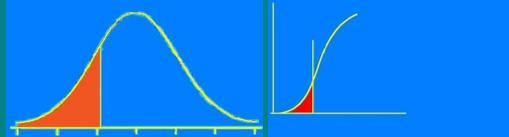
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## Definitions: Risk & Portfolio Analysis Technology for Capital Efficiency

- **Project risk analysis:** evaluation of uncertainties affecting individual assets or projects to estimate expected value and risk (magnitude and probability of loss).



- **Portfolio analysis:** selection of (shares of) assets or projects with:
  - No higher value without increased risk
  - No lower risk without loss of value
  - Under given constraints



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## “Modern Portfolio Theory” (Harry Markowitz, 1952)

- Rational investor will prefer more value to less value, but also less risk to more risk
- Each investment must be considered in the context of what it contributes to the portfolio. Portfolio can be more or less than the sum of its parts, depending on how investments interact
- There is more than one optimal portfolio, because it is possible to gain more value by accepting more risk, or to accept less value at a lower risk

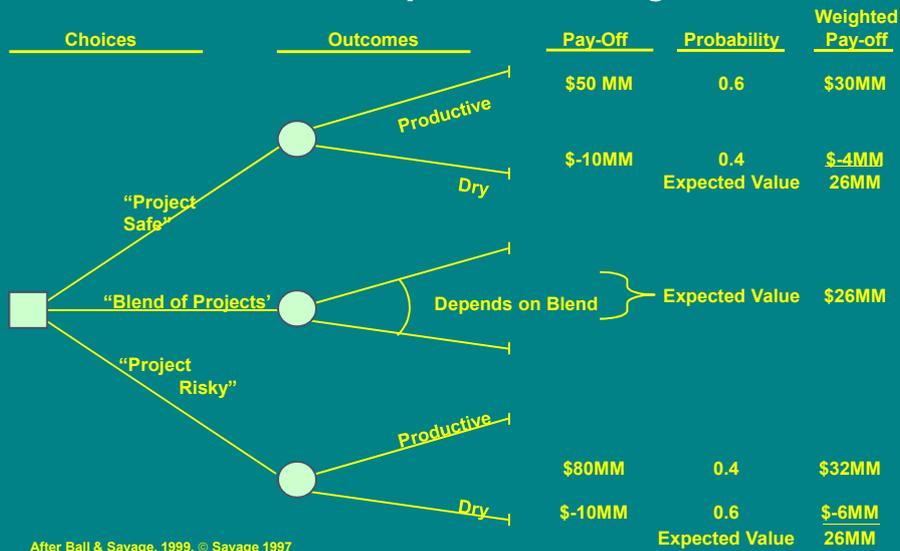
Value should include “opportunity”, i.e. option value

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# Risk & Portfolio Analysis: Project Selection



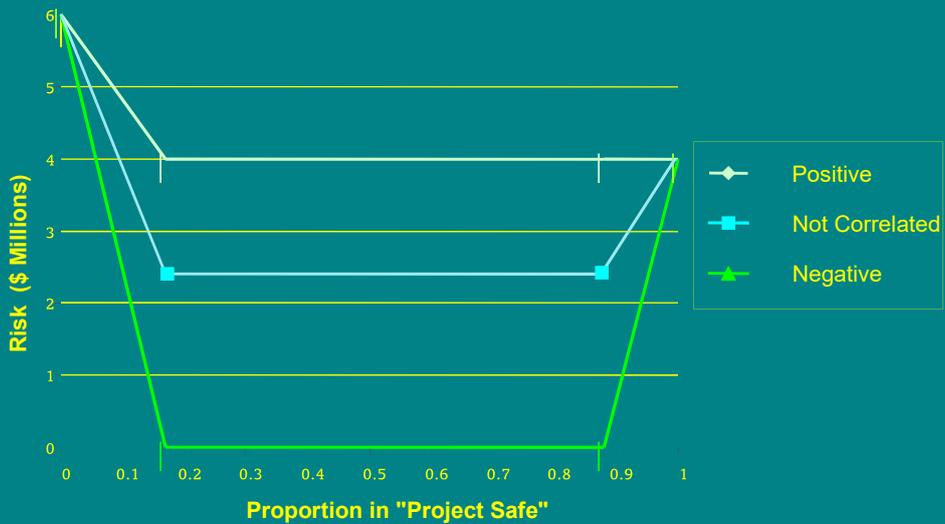
After Ball & Savage, 1999, © Savage 1997

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# Effects of Diversification



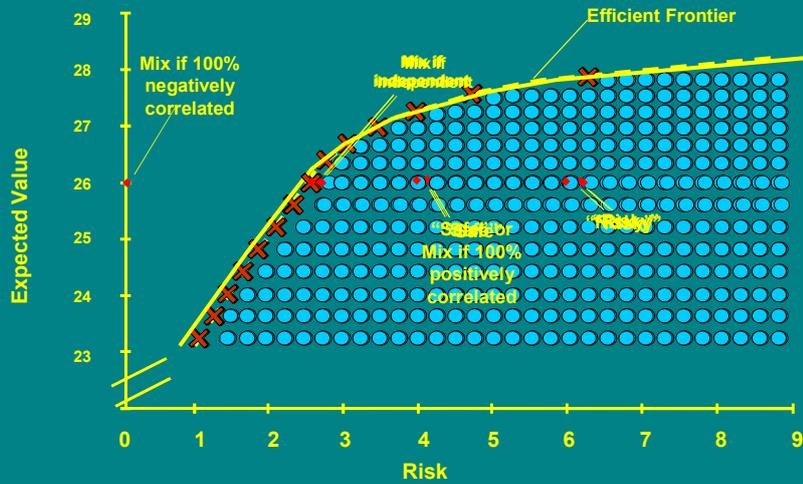
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# Portfolio Analysis Yields "Efficient Frontier"



After Ball & Savage, 1999

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## "Efficient Frontier"

• In Reward vs. Risk graph, the Efficient Frontier is the locus of all possible combinations of projects for which, at the constraints used:

- **No lower risk can be obtained without loss of value**
- **No greater value can be obtained without increased risk**

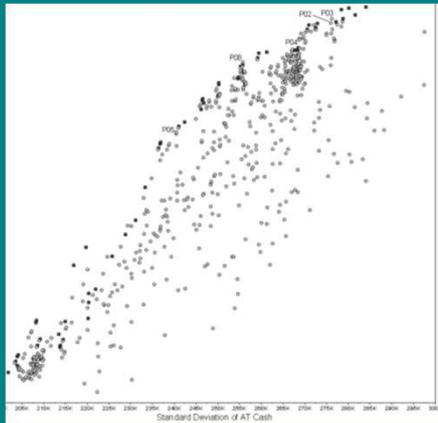


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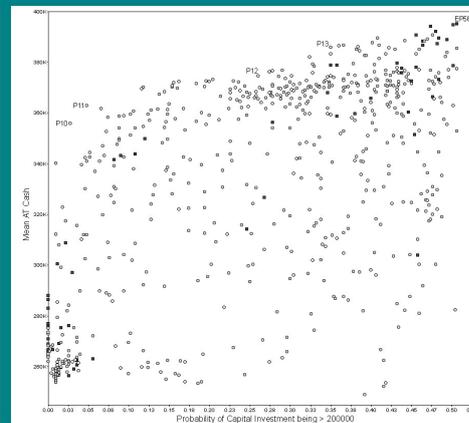


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## Efficient Frontier changes as a function of the definition of risk (vertical axis: mean after-tax NPV)



• Risk = NPV stdev



• Risk = prob of spending >\$200M in 1st yr of portfolio's life.

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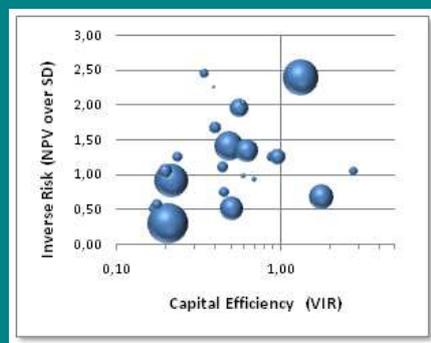


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## Project risk: is it a good KPI for decision-making?

- Only if it has been validated as a good proxy at the portfolio level.
- Portfolio effects will in principle cater for project risk

**Q: Would this be a useful project ranking methodology, i.e. including formal risk measure (size of bubble proportional to NPV)**



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## Overall coherency of KPIs across decision levels

- At each individual decision-level different KPIs are being optimized within different constraints:
  - At the *top level (corporate level)*, for example, KPIs such as Earning Per Share (EPS) or Return On Capital Employed (ROCE) are being optimised within various constraints such as average unit production cost (UTC) or reserves replacement ratio (RRR).
  - At the *portfolio level* (e.g. an operating company), this may be a production growth or exploration discovery target within a finding and development cost (F&D) constraint.
  - At the *field level*, a KPI may be optimised such as production plateau period within a Unit Technical Cost (UTC) constraint.
  - At the *project level*, Net Present Value (NPV) may be optimised within an Internal Rate of Return (IRR) constraint.
  - And at the single activity or operational level, the average daily production rate for the next 3 months may be optimised within a Gas-Oil-Ratio (GOR) constraint.
  - Or a *project manager* may optimise for minimum capex, within a total budget and time constraint, over a limited time-window.

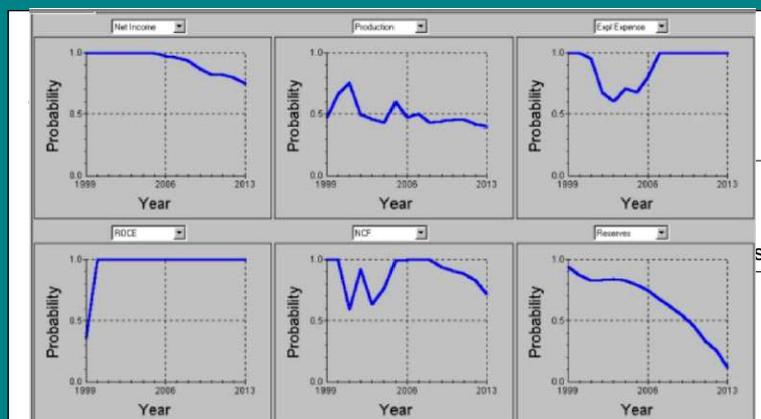
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## Probability of meeting portfolio multi-criteria objectives in time

Ref. SPE68576 (Howell, Tyler): Using Portfolio Analysis to Develop Corporate Strategy

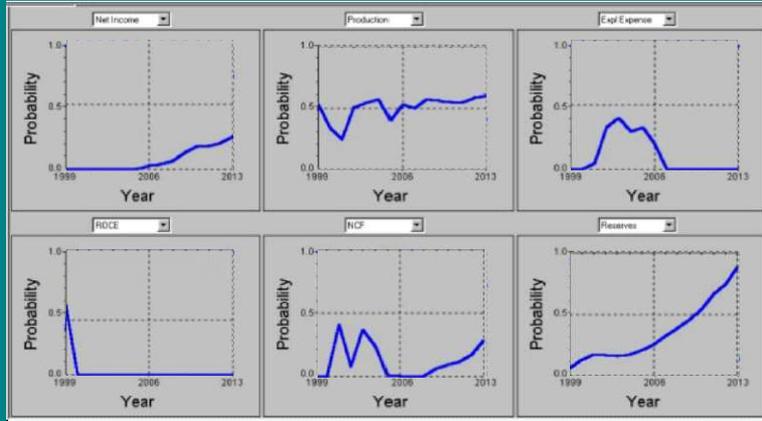


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## Probability of exceeding portfolio multi-criteria constraints in time



Risk tolerance to be specified: acceptable probability of not-meeting hurdle rate

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