Der Einsatz der Optionstheorie zur Optimierung des Projektportfolios

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Task - Challenge

• Optimisation between
  risks of failure of R&D projects and
  best exploitation of project results

• Multi-dimensional project valuation

• Real options

• Portfolio selection considering:
  limited resources
  limited risk
  project interrelations
Evaluation of R&D Projects

- High uncertainty about project’s value
- Gain of knowledge during the project
- Flexibility to react to new information
- Multi-dimensional aspects
- Interrelations between projects
Real Options – Definition

• A right to buy or sell specific securities or commodities at a stated price (exercise or strike price) within a specified time.

• A call option on an asset gives the right, but no obligation, to acquire the underlying asset by paying a prespecified price—the exercise price—on or before a given maturity.

• A call option on an R&D project gives the right, but no obligation, to implement the results by investing in production and marketing when the research phase is completed.
Real Options – Options Thinking

• Flexibility creates value

• “It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change” [Darwin, 1835]

• Every successful R&D project represents an option on future market introduction
Real Options

Characteristics

Characteristics of real investment projects regarded as option rights:

- Uncertainty
- Flexibility
- Irreversibility

[Hommel, Baecker, 2004]
Kinds of Real Options

- Learning options (option to wait, option to stage investment, option to switch)
- Insurance options (option to abandon, option to shut down, option to switch)
- Growth options (option to expand, option to innovate)
- Improvement options (option to shelve, option to accelerate, option for corrective action)

[Hommel, Baecker, 2004]
Real Options – Shortcomings

- Lack of underlying market for R&D projects
- Various kinds of uncertainty (technical, operational)
- Competition reduces the value of waiting
- Additional complexity by interaction between options
Mapping of Option Pricing Theory to Project Analysis

Underlying $S$ – Present value of project benefits

Volatility $\sigma$ – Uncertainty

Exercise price $K$ – Present value of investment cost

Expiration date of option $t$ – Project duration

Dividend payments $y$ – Payments lost through waiting

Payoff call option – $(S-K)^+ \equiv \max \{S-K, 0\}$
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[Luehrman, 1998]
0/1 Knapsack Algorithm

- Given a Knapsack of capacity $c$ and $n$ objects with sizes $s_1, \ldots, s_n$ and "profits" $p_1, \ldots, p_n$, find the largest total profit of any subset of the objects that fits into the Knapsack (and find a subset that achieves the maximum profit)

- Selects projects with the highest utility values for a portfolio not exceeding a given maximum cost value
0/1 Knapsack with Dependencies

- Project is only considered if the indices of all of its preconditional projects are already members of the current subset.

- In order to allow the indices of all preconditional projects to be members of the subset the projects have to be traversed in topological order.

IT´s T.I.M.E.
IT, Technology, Information, Mind & Exploration
0/1 Knapsack with Risk Limit

• Set risk limit in selected dimensions additional to investment limit.

• Check risk of the selection with respect to each dimension, against the risk limit. If for any dimension the risk limit is exceeded the selection is not considered as a candidate for optimisation.
Hierarchy of Project Interrelations

- non-interrelated
  - independent: synergistic, redundant, preconditional
  - dependent: contingent, mutually exclusive
Copula

- $C(p_1,\ldots,p_n)$ maps multivariate distribution functions to the interval $[0,1]$

$$C : [0,1]^n \rightarrow [0,1]$$

- Copulae represent the interrelations between the values $p_i$ of the distribution functions

- e.g. product copula:

$$C(p_1,\ldots,p_n) = \prod_{i=1}^{n} p_i$$

[McNeil, Frey and Embrechts, 2004]
References

