Innovation Management and New Product Development

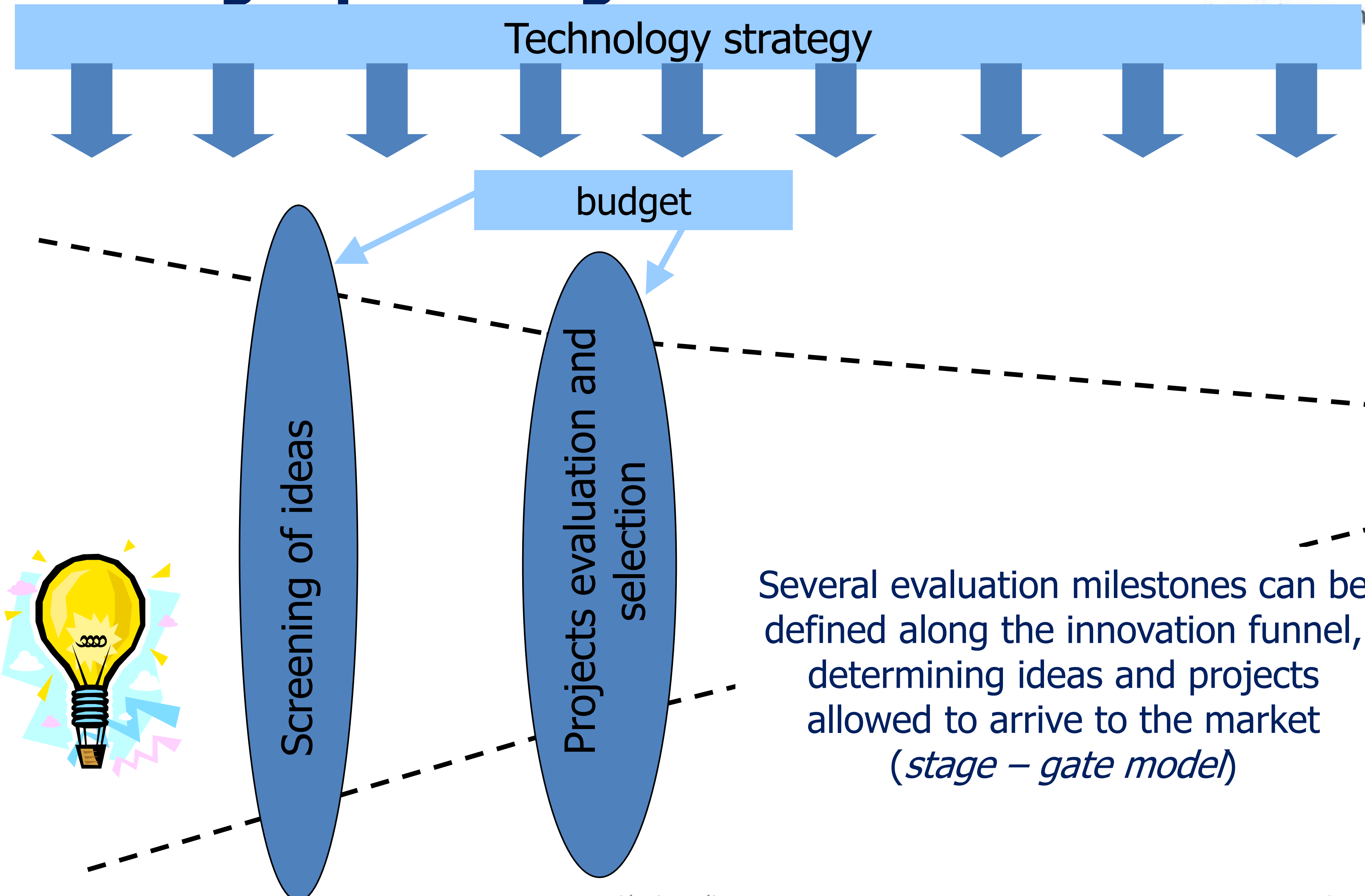
R&D Portfolio Definition

Strategic planning

- Strategic planning aims at implementing the technology strategy decisions. It comprises the definition of:
  - The R&D (or innovation) budget
  - The criteria for innovation projects evaluation and selection

- Innovation projects are selected in coherence with the technology strategy decisions and the budget available

Strategic planning



Several evaluation milestones can be defined along the innovation funnel, determining ideas and projects allowed to arrive to the market (*stage – gate model*)

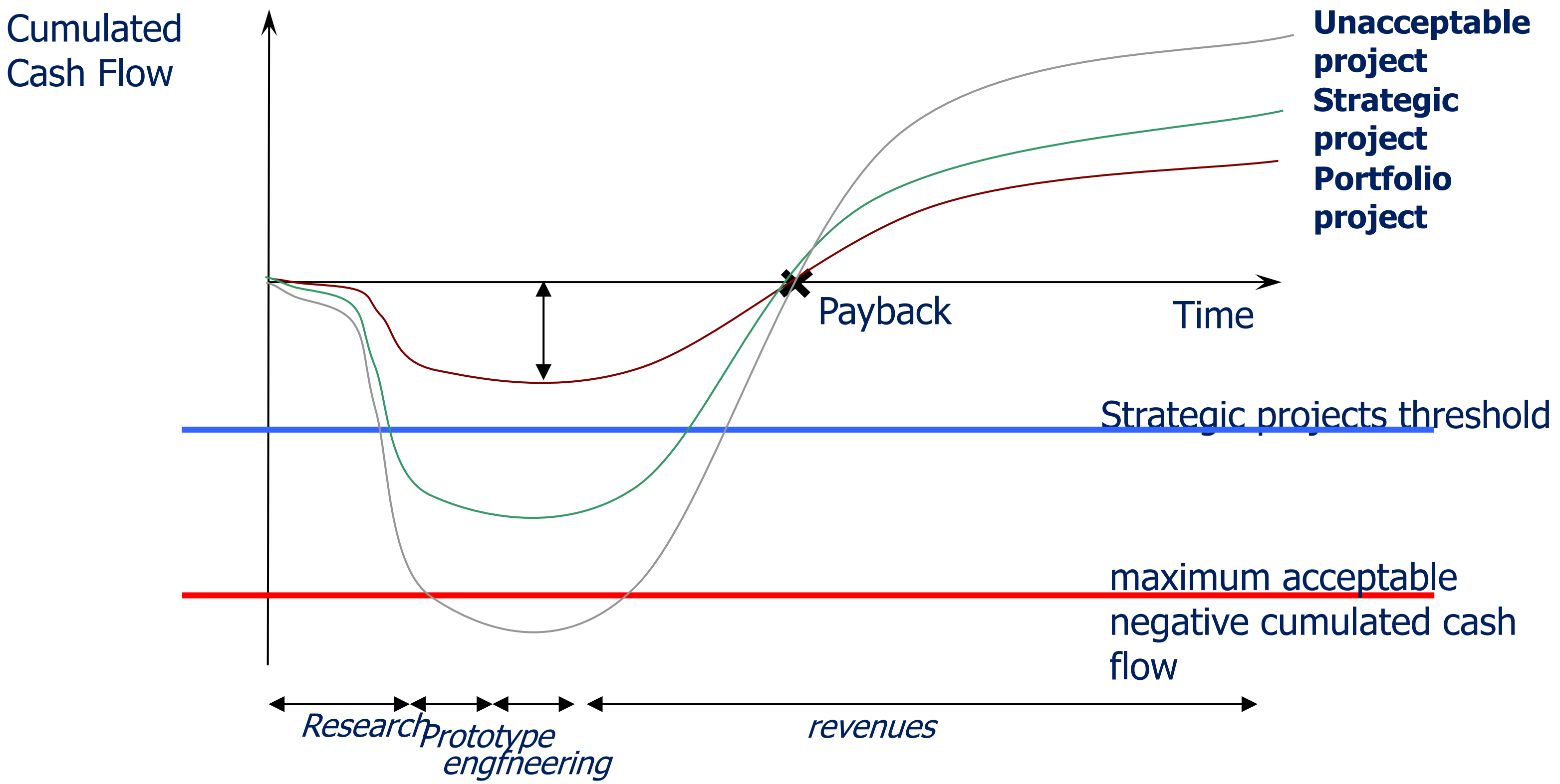
Steps

- Fixing the R&D budget
- R&D project definition
- R&D project evaluation
- R&D project selection
- R&D project portfolio analysis

R&D budget

- The R&D (or innovation) budget should take into account:
  - ***Strategic projects***, characterised by big amount of resources required, high risk, very long term orientation
  - ***Portfolio projects*** ,characterised by lower amount of resources required and lower risk
  - **Projects in pipeline**, already approved in the past, to be completed

Strategic and portfolio projects



R&D budget

Criteria:

- Comparison with competitors
- Fixed % of profits
- Fixed % of revenues
- Reference to previous budget
- Reference to the specific projects to be launched

It is fundamental to consider:

- Coherence with technology strategy decisions
- Distortions due to strategic projects
- Need for stability and coherence of investments in the long run

Evaluation and selection of ideas and projects

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- The **screening of ideas** is mainly based upon qualitative, informal evaluations, as ideas are defined in a fuzzy manner

- The **evaluation of projects** is based upon quantitative techniques, as the object of the evaluation is more precisely defined

Screening

The screening of ideas involves:

- R&D
- Manufacturing
- Marketing

→ Allow for the evaluation of technical feasibility and market perspective

- Executive board

→ Allows for verifying the coherence with the technology strategy decisions

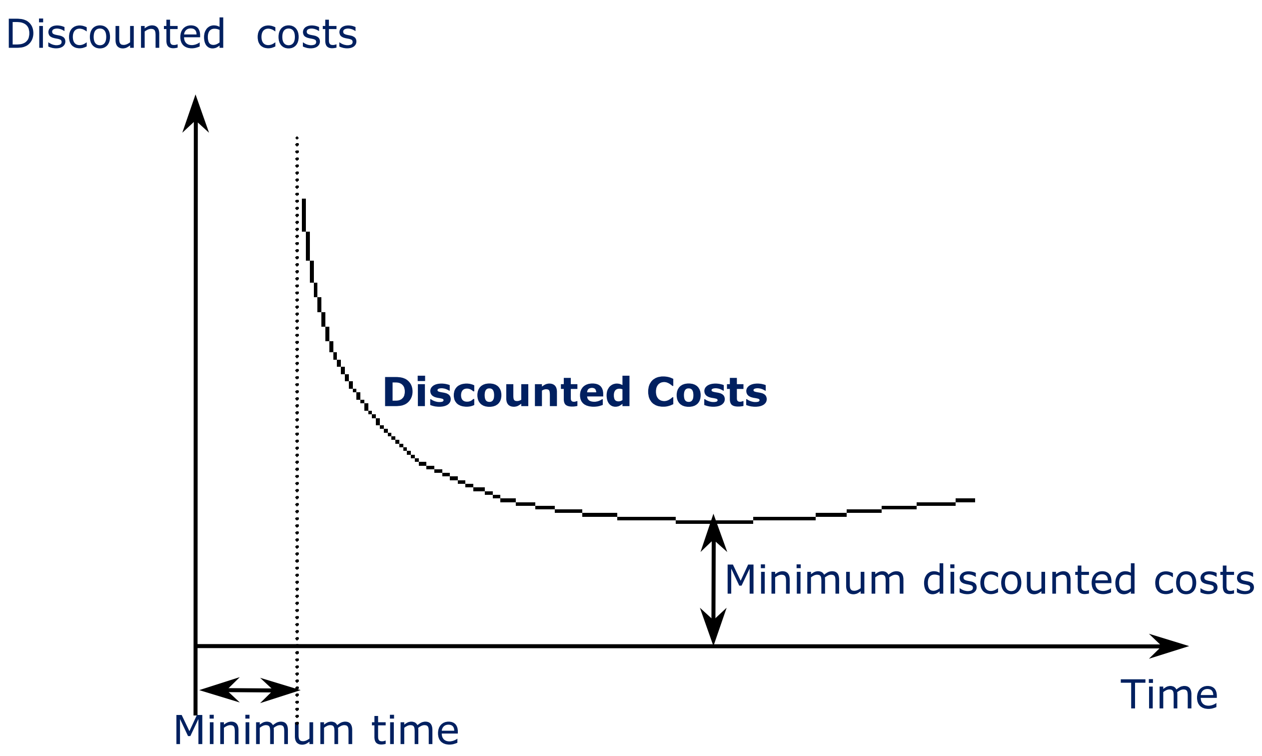
- External experts

→ Enlarge and enrich the company's competences

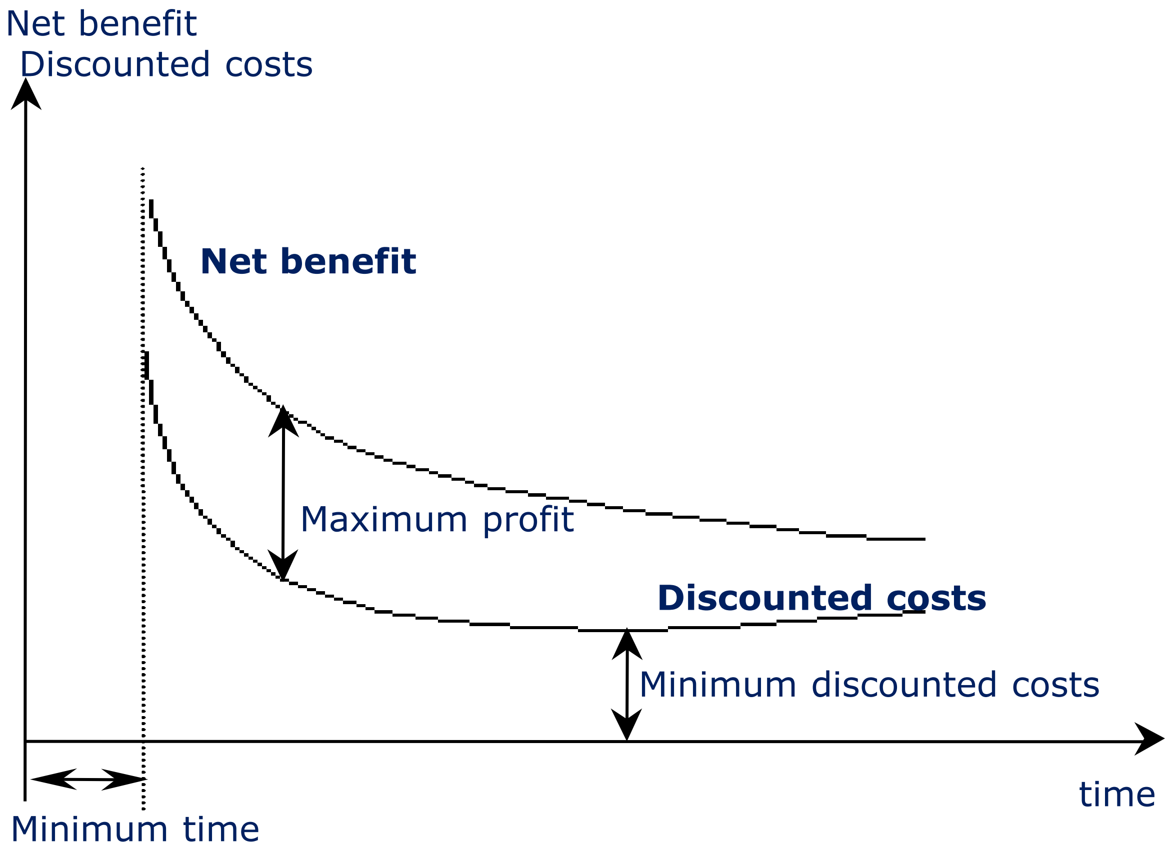
R&D projects

- R&D (or innovation) projects are defined in terms of:
  - Goals and expected benefits
  - Timing (development and launch)
  - Resources required (human, technological, labs…);
  - Resource acquisition (internal development, collaborations, outsourcing)
  - Costs
  - Risk Level and risk typology
- The above variables are correlated each other

Timing and costs



Timing and benefits



R&D project evaluation

- Impact on the overall business and potential return
- Effect on the other projects
- Intrinsically risky projects
- Unit of analysis
- Concept of sunk cost
- Reduce uncertainty

R&D project evaluation

- R&D project evaluation is based upon the analysis of two dimensions:
  - **relevance**
  - **risk**

Relevance

- Relevance is the net benefit generated by the project.
- Relevance is a multi-dimension concept, comprising:
  - Strategic relevance
  - Economic relevance
  - Appropriability
  - Indirect benefits

Risk

- **Technical risk**
  - Measured as the probability that the project does NOT achieve the expected level of performance in the due time
  - It is influenced by:
    - The distance from the state-of-the-art
    - The availability of necessary technical competences
    - The availability of managerial competences

- **Commercial risk**
  - Measured by the probability that the innovation does NOT achieve the expected response by the customer, or the expected returns
  - It is influenced by:
    - The customers' behaviour
    - The competitors' behaviour
    - Imitation among companies

Project evaluation models

- Project evaluation models seek to determine the absolute or relative value of individual projects

- Outputs from these models can be used to make go / no go decisions about projects or to rank projects against each other.

- Mainly two types of models:
  - Economic value models;
  - Relative value models;

Economic value models

- Most popular and diffused:
  - Discounted Cash Flow (DCF) models;
  - Decision tree models;
  - Monte Carlo simulation;
  - Real options;

- Strengths:
  - Evaluation based upon profitability;
  - Help clarify and quantify assumptions;
  - Aid understanding of project dynamics;
  - Facilitate cross-functional communication and planning;
  - Add analytical rigor to the evaluation process;

- Limitations:
  - Outputs are not accurate;
  - Difficult to evaluate several impacts in monetary terms;
  - Rely on estimates of future sales and costs that are likely to be inaccurate;

Relative value models

- Used to make estimates of project value in terms of some conception of “project quality”
- Project quality is used as a proxy for criteria that are difficult to measure directly, such as profitability
  - Comparative models, such as Analytic Hierarchy Process (AHP);
  - Scoring models;

- Strengths:
  - Able to consider “intangible” impacts, that cannot be easily measured in monetary terms;

- Limitations:
  - High subjectivity;
  - Low rigor;

Economic value models: traditional DCF techniques

DCF techniques, such as the Net Present Value (NPV) are based on the valuation of *differential* net cash flow (NCF) resulting from the investment, in the long run.

$$\mathrm{NPV} = \sum_{t=1}^{T} \frac{\mathrm{NCF}(t)}{(1+k)^{t}} + \frac{V(T)}{(1+k)^{T}} - I(0)$$

In a generic year (t) NCF is defined as:

- (Revenues – cash costs) – investments; or
- [(Revenues – Cash costs) · (1-t*) + (Depreciation/amortisation) · t*] – Investments (when considering taxation effects)

where

- Revenues are the incremental revenues generated by the innovation generated by the project
- Cash costs are the incremental cash cost sustained for producing and selling the innovation (material, labour, rents,…)
- Depreciation is the depreciation of the investments in tangible assets acquired for the project, while amortisation is the amortisation of the investments into intangible assets sustained for the project
- t* is the tax rate
- Investments are the investments into assets and working capital (capital expenditure)

Economic value models: traditional DCF techniques

The traditional deterministic discounted cash flow methods, based on a basic cost-benefit analysis, are not suitable for R&D project evaluation, because:

- **risk is project-specific**: the discount rate ignores the specific level of uncertainty related to a certain project;
- they do not consider the **asymmetry of pay-offs**, that is the possibility that future management actions can improve profits or limit losses, as a consequence of decisions (other than the initial investment) taken during the project life. Future cash flows are assumed highly predictable and deterministic;
- they do not take in account the **value of flexibility** and assume that each project involves a single go / no go decision. A company may invest in a negative-NPV project in order to establish a foothold in an attractive market. Thus a potentially valuable second-stage opportunity justifies the immediate project. Traditional DCF are deemed inappropriate to evaluate such kind of projects

Modifying traditional DCF techniques

- Different valuation approaches have been introduced to overcome these problems. These approaches can be classified into:

  - **Pseudo-deterministic approaches**, that introduce corrective variables to traditional techniques in order to yield a better measure of the relevance of the project (i.e. its capacity to create value for the company)

  - **Stochastic approaches**, that consider variables (costs and revenues) as stochastic variables with an associated probability distribution.

    Stochastic approaches provide separate measures of the relevance of the project and of the associated risk (i.e. the probability the project reaches the success)

Pseudo-deterministic approach
Risk Adjusted Rate (1)

The Risk Adjusted Rate (RAR) corrects the discount rate considering the specific risk of the project:

$$RAR = \sum_{t=0}^{T} \frac{NCF(t)}{(1+k')^t}$$

where

NCF(t) is the expected value of NCF of year t

k’ = i + a + d is the discount rate

i = *risk free rate*
a = enterprise risk (a > 0)
d = specific risk of the project (d < 0 ; d > 0)

Pseudo-deterministic approach
Risk Adjusted Rate (2)

Enterprise risk (a) measures the premium (with respect to the risk free rate) for the risk associated to the core business of the company.

The specific risk of the project (d) takes into account the extent to which the project significantly differs from the usual activities carried out by the company:

- for a traditional pharmaceutical company developing a new biotechnology drug means $d > 0$
- for the same company, developing a "me too" drug (i.e. a product reformulation) means $d < 0$

Pseudo-deterministic approach
Certainty Equivalent (1)

The Certainty Equivalent (CE) corrects directly the expected NCFs with a certainty parameter (α), that measures the degree of risk associated to each net cash flow

$$CE = \sum_{t=0}^{T} \frac{\alpha(t)NCF(t)}{(1+i)^{t}}$$

where

NCF(t) is the expected value of NCF of year t

α (t) is the certainty parameter ($0 < \alpha < 1$)

i is the risk free rate

Pseudo-deterministic approach
Certainty Equivalent (2)

The certainty parameter α corrects the value of each NCF in respect of its related risk (the higher risk, the lower certainty parameter)

An example of the values of α is given below

Investment	**Year**		
	1-3	**4-6**	**7-10**
R&D	0,7	0,6	0,4
New product	0,8	0,7	0,6
Plant replacement	0,9	0,8	0,8

Stochastic approach
Net Present Value (1)

In the Net Present Value under uncertainty conditions NCFs are considered stochastic variables (with an associated probability distribution)

$$\mathrm{NPV} = \sum_{t} \frac{\mathrm{NCF(t)}}{(1+i)^{t}}$$

The discount rate in the stochastic approach is the risk free rate (i) as the risk is implicitly taken into account in NCFs (that are stochastic variables)

Using a different (risk-adjusted) discount rate results in a double counting of associated risk and therefore brings to wrong evaluations

Stochastic approach
Net Present Value (2)

The expected value of NPV measures the relevance of the project:

$$E(NPV) = \sum_t \frac{E(NCF_{(t)})}{(1+i)^t}$$

E (NCF (t)) is the expected values of each NCFs

or

$E(NPV) = NPV_j * p(NPV_j)$

Stochastic approach
Net Present Value (3)

The risk associated to the NPV in uncertainty conditions can be measured in different ways:

- the range of the possible future project results (the dispersion coefficient, the variance, the standard deviation)

- the probability that the company undertaking the project reduces its value (that is the probability that the NPV is negative)

$$p\ (\text{NPV} < 0)$$

- the worst event (we), that is the minimum NPV (complete failure)

$$\text{we} = \min\ (\text{NPV})$$

Stochastic approach
Net Present Value (4)

In order to calculate the *variance of NPV* (σ^2_{NPV}) as a measure of the risk associated, the following formula may be used :

$\sigma^2_{NPV} = E[(NPV - E(NPV))^2]$

or

$$\sigma^2_{NPV} = \sum_t \frac{\sigma^2_t}{(1+i)^{2t}} + 2\sum_j \sum_k \frac{\sigma_j \sigma_k \rho_{jk}}{(1+i)^{j+k}}$$

where

- σ_{NPV} is the standard deviation of the NPV
- σ_t is the standard deviation of the NCF of year t
- ρ_{jk} is the coefficient of linear correlation between the NCFs of year j and k

Stochastic approach
Net Present Value (5)

The linear correlation coefficient (ρ) measures the extent to which NCFs of different years are correlated each other.

Theoretically, its value varies from –1 to +1:

$\rho < 0$ means that if the NCF value is above (below) the average in a year, the probability that it is below (above) the average in the other years increases. This does not seem to be the case of R&D projects

$\rho = 0$ means that NCF value in a given year does not influence the NFC value in other years

$\rho > 0$ means that if the NCF value is above (below) the average in a year, the probability that it is above (below) the average in the other years increases

Usually, in R&D project evaluation, the variance is calculated in the cases of correlation equal to 0 and correlation equal to 1, which lead to define the minimum and the maximum values of the variance of NPV

Stochastic approach
Real Option Analysis

The Real Option Analysis is especially tailored to deal with uncertainty and flexibility related to an investment project.

There is substantial evidence that R&D and innovation management are key areas for the application of such approach.

The basic idea is to transfer the sophisticated option pricing models used in capital market theory to the valuation of risky R&D projects.

Several contributions suggested that an R&D investment is analogous to an investment into a call option in capital market.

Stochastic approach
Real Option Analysis

A call option for a common stock can be seen as a contract where the purchaser of the option obtains the right (but not the obligation) to purchase at a specified price on a specified future date the underlying asset (common stock) whose price is subject to some form of random variation.

When the future date arrives, the holder of the option can decide whether to exercise or not the option:

- the holder will exercise the option if the market price of the stock is higher than the price specified in the option contract. He will obtain a profit proportional to the difference between the market price and the option price
- if the market price of the stock is lower than the option contract price, the option holder will allow the option to expire and the loss will be limited to the amount of money originally invested in the option

Stochastic approach
Real Option Analysis

The rational behind applying option pricing theory to R&D projects (Real Option Analysis) is the following:

- in the case of an option there is always the possibility to refrain from exercising the right to buy the underlying asset
- similarly in an R&D project there is usually a substantial sales and profits potential behind the possible output of the project, but if the results of the project at each phase during the development process do not meet the expectations, the decision maker has the opportunity to react to this new information, for example stopping the project. This allows to avoid losses which would have been realised by continuing to invest in the project

Stochastic approach
Real Option Analysis

Real Options present even some differences from financial option

- in financial option pricing theory, the risk of the underlying is **exogenous**. As far as investment projects are concerned, risk is partly **endogenous** because the management is able to add or remove risk from a project at each phase in the developing process
- in real options **technical uncertainty** other than market uncertainty has to be considered
- in real options there are a **number of possibilities** (other than stopping the project) to react to changing circumstances. The project may be enhanced, halted to wait for new information, or the scope of the project might be changed,…

Scoring method

- Scoring methods are based on the following steps:
  - Fixing the criteria to be used for the evaluation
  - Assigning each criterion a weight
  - Assigning each project a score in relation to each criterion

Total score for a project is calculated as:

$$T_i = \sum_j W_j \times S_{ij}$$

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- T_i is the total score project i
- W_j is the weight of criterion j
- S_{ij} is the score of the project i against criterion j

Scoring method

It is possible to build a *scoring method* able to evaluate separately:

- the project relevance
- the project risk

Scoring method

Project Relevance

Criteria	*Sub-criteria*
Strategic relevance	• Market relevance • Impact on competitive positioning • Range of possible application • Value creation for the customer • Value creation for stakeholders
Economic relevance	• Revenues • Costs • Return on investment • Pay back time
Appropriability	
Robustness	• With respect to norms and regulations • With respect to the technological context • With respect to the economic context
Indirect benefits	

Scoring method

Project risk

Criteria	*Sub-criteria*
Technical risk	• Technical target – Distance from the state of the art – Technical feasibility • Level of Available competencies – Technical competencies – Managerial competencies (leadership, team) – *project management capabilities* • Engineering resources and competencies
Commercial risk	• Market volatility • Marketing capabilities and resources • Competitors behaviour • Imitability

Scoring method

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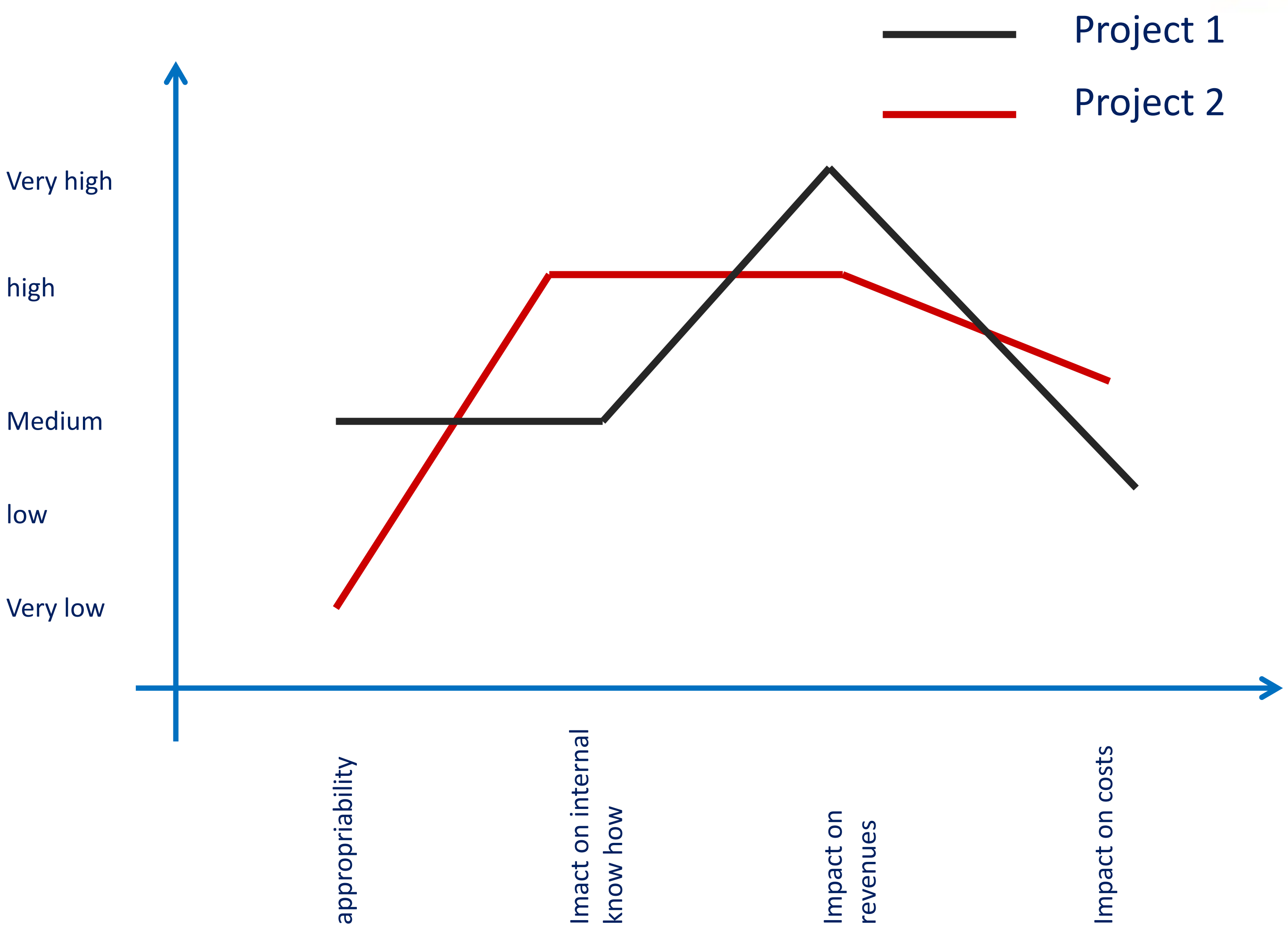
- Weight related to each criterion gives a measure of the importance of that criterion against the others;
- Weight is usually normalized and the sum of weights is = 1;
- The score assigned to each project for each criterion reflects the impact of the project in relation to the specific criterion;
- At the end of the evaluation, each project is assigned a total score concerning relevance and a total score concerning risk.

Profile methods

- Based on the following steps:
  - Identification of a set of criteria relevant for the evaluation
  - Qualitative judgement of projects against the above criteria
  - Graphic representation of the analysis

Profile methods



Check list methods

- Based on the following steps:
  - Identification of critical performance criteria to be considered for the evaluation of projects
  - Definition of a target value for each performance criterion
  - Yes/no evaluation of each project with respect to its ability to achieve the target value for each performance criterion

Check list methods

Example

Criteria	Target
Cost reduction	15%
Lead time reduction	30%
Sales increase	10%
Improvement of internal KH	high

Scoring, profile and check list method – advantages and limits

- Advantages
  - Simple
  - Able to take into account soft, intangible elements that cannot be translated in monetary terms

- Limits
  - Subjectivity
  - Not useful in case of the evaluation of a single project

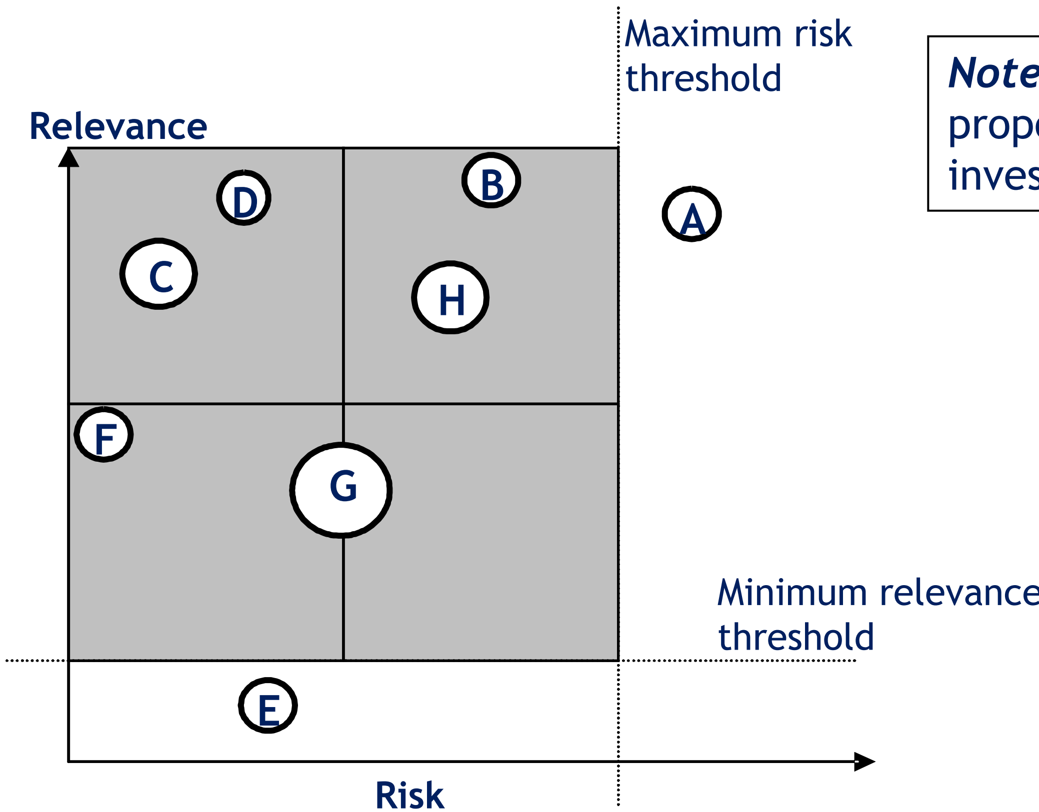
Selection of projects

- On the basis of the results of the evaluation process, the selection of projects is performed

- Then, the resulting portfolio is defined, according to the relevance – risk matrix

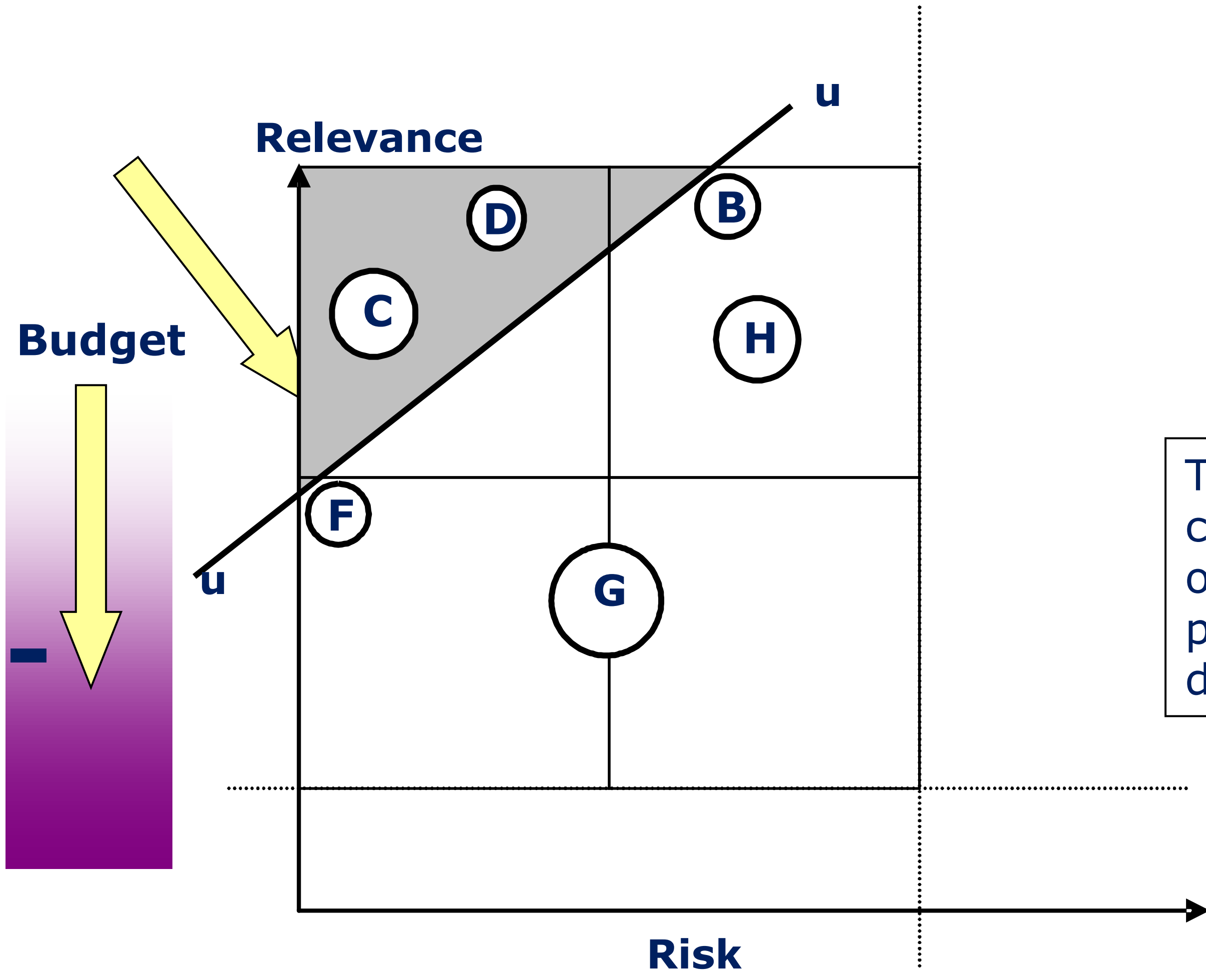
Selection

- R&D projects are mapped into a relevance – risk matrix



Note: "bubbles" size is proportional to required investment

Selection by the utility theory



The slope of the utility curve is representative of the risk aversion / propensity of the decision maker

Portfolio optimization

- The identified portfolio is analysed in terms of:
  - Timing of selected projects
  - Conflicts over resources
  - Timing Interdependencies among projects
  - Risk of selected projects
  - Number of projects selected

- The portfolio should be “balanced” in terms of timing and risk and should avoid interdependencies with non selected projects and conflicts over critical (scarce) resources

Portfolio optimization: possible actions

- If the selected portfolio of R&D projects is not satisfactory, it is necessary to introduce some corrective actions, such as:

  – Increasing the budget

  – Modifying projects in terms of:
    – Timing
    – Productivity
    – Ability to manage risks and uncertainty