FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION

DEPARTMENT < BUSINESS INFORMATICS AND OPERATIONS MANAGEMENT >
RESEARCH GROUP < OPERATIONS RESEARCH & SCHEDULING >

An analytical model for budget allocation in risk prevention and risk protection

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if you want to refer to this presentation, please refer to :

- Guan, X., Servranckx, T. and Vanhoucke, M. (2021). An analytical model for budget allocation in risk prevention and risk protection. Working paper.

OUTLINE

– Introduction
– Problem formulation
– Analytical optimality
– Risk examples
– Experiments
– Conclusion

INTRODUCTION

Project Risk

- Uncertain events or conditions
- Negative impact

  (project delay, budget overrun, failure …)

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Risk response strategy

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Measure

- Expected loss

  = Risk Probability (P) * Risk Loss (L)

Risk response strategy

- Risk Prevention (reduce P)
- Risk Protection (reduce L)

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INTRODUCTION

Project Risk

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  (project delay, budget overrun, failure …)

Measure

- Expected loss

  = Risk Probability (P) * Risk Loss (L)

Risk response strategy

- Risk Prevention (reduce P)
- Risk Protection (reduce L)

Research question:

How to allocate budget among risk prevention and risk protection?

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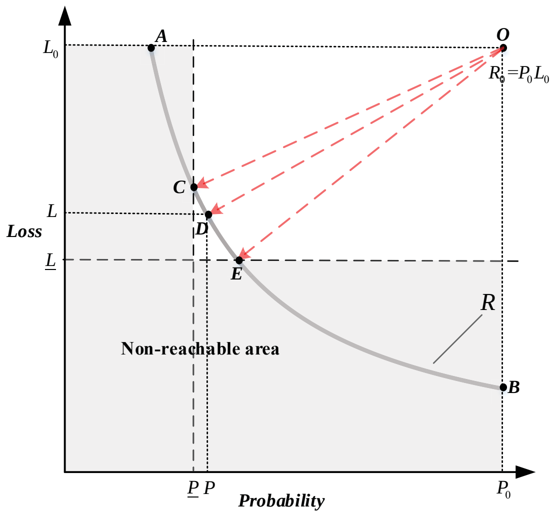
PROBLEM FORMULATION

– Problem statement

- initial risk (P0, L0, R0)
- accepted risk level (R)
  → risk response requirement
- minimal risk ($\underline{P}$, $\underline{L}$)
  → risk controllability

- **Aim:**
  find the cheapest path from point O to curve CE?

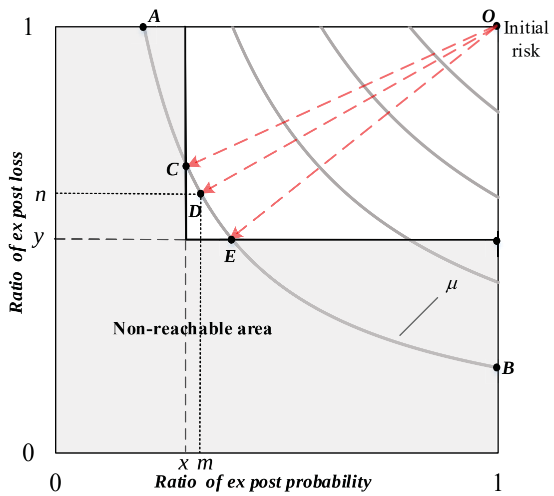


PROBLEM FORMULATION

– Problem statement

- initial risk (P0, L0, R0)
- accepted risk level (R)
  → risk response requirement (**μ** = R/R0)
- minimal risk ($\underline{P}$, $\underline{L}$)
  → risk controllability (**x** = $\underline{P}$/P0, **y** = $\underline{L}$/L0)

- **Aim:**
  find the cheapest path from point O to curve CE?



PROBLEM FORMULATION

– Model formulation

- Relation between the cost (q, r) and effect (m, n) of risk response strategy:
- Linear:
- A higher risk reduction requires more budget

$$q = aP^0(1-m) \qquad r = bL^0(1-n)$$

- Nonlinear:
- After a certain risk reduction, further risk reduction requires a larger investment

$$q = aP^0 ln\frac{1-x}{m-x} \qquad r = bL^0 ln\frac{1-y}{n-y}$$

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- Model:

$$\textbf{LBAP} \quad \min \ aP^0(1-m) + bL^0(1-n) \quad s.t. \quad mn = \mu$$

$$\textbf{NBAP} \quad \min \ aP^0(1-m) + bL^0(1-n) \quad s.t. \quad mn = \mu$$

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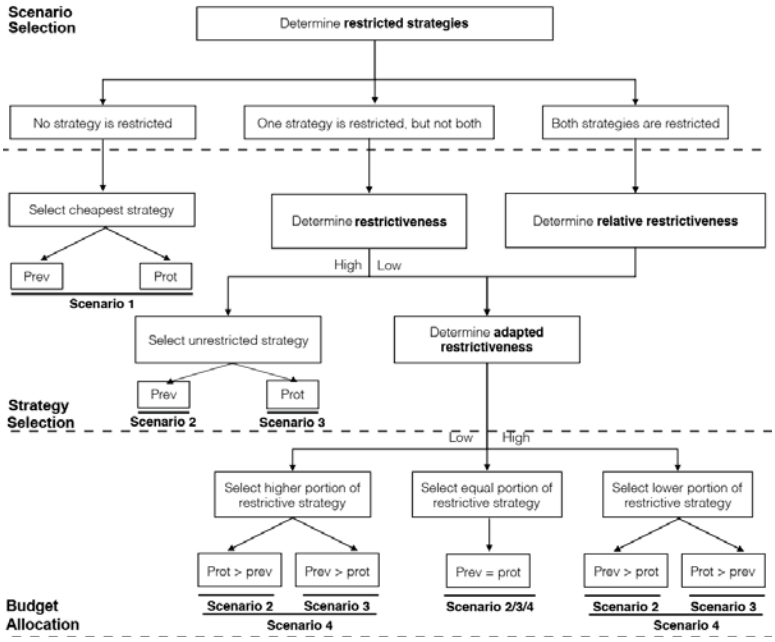
ANALYTICAL OPTIMALITY

- **3-step decision procedure**
  - Step 1: Scenario selection
  - Step 2: Strategy selection
  - Step 3: Budget allocation



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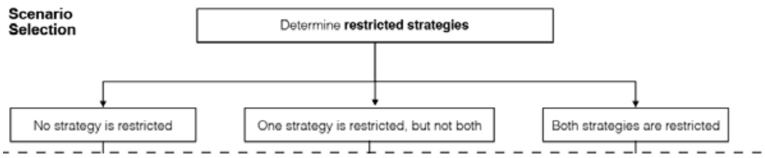
ANALYTICAL OPTIMALITY

- **3-step decision procedure**
  - Step 1: Scenario selection

    risk response requirement vs *risk controllability*



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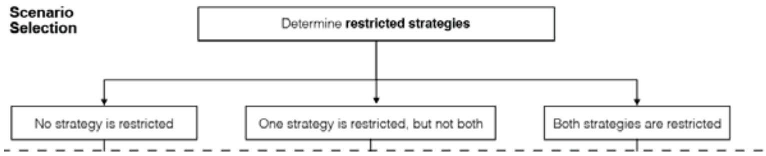
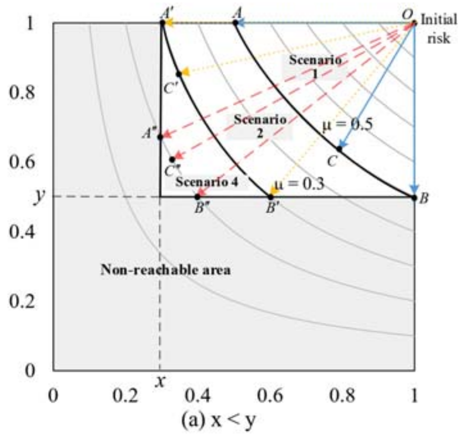
ANALYTICAL OPTIMALITY

– **3-step decision procedure**
– Step 1: Scenario selection
risk response requirement vs *risk controllability*

Example:
scenario 2: x<μ<y
risk protection is restricted.





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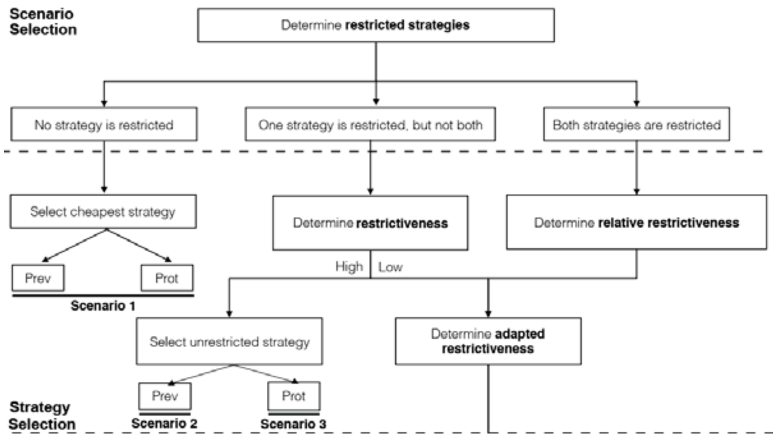
ANALYTICAL OPTIMALITY

– **3-step decision procedure**
– Step 1: Scenario selection
– Step 2: Strategy selection
restrictiveness
(a low value means a strong restrictiveness)
risk prevention: μ/x
risk protection: μ/y



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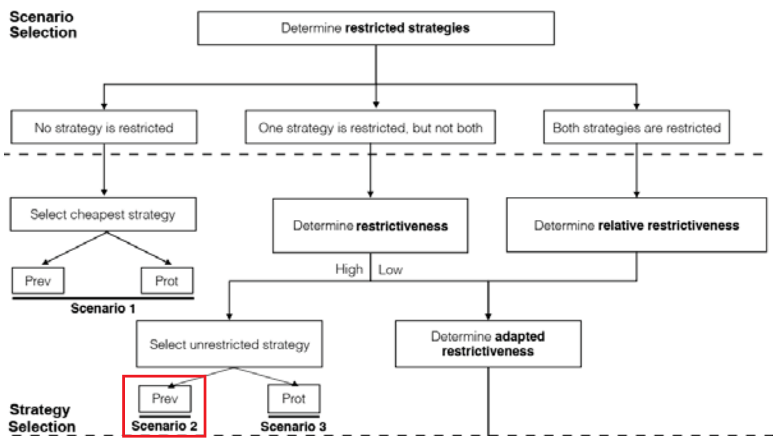

Example:

scenario 2: x<μ<y

risk protection is restricted,

if restrictiveness is high → risk prevention

if restrictiveness is low → both → step 3

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ANALYTICAL OPTIMALITY

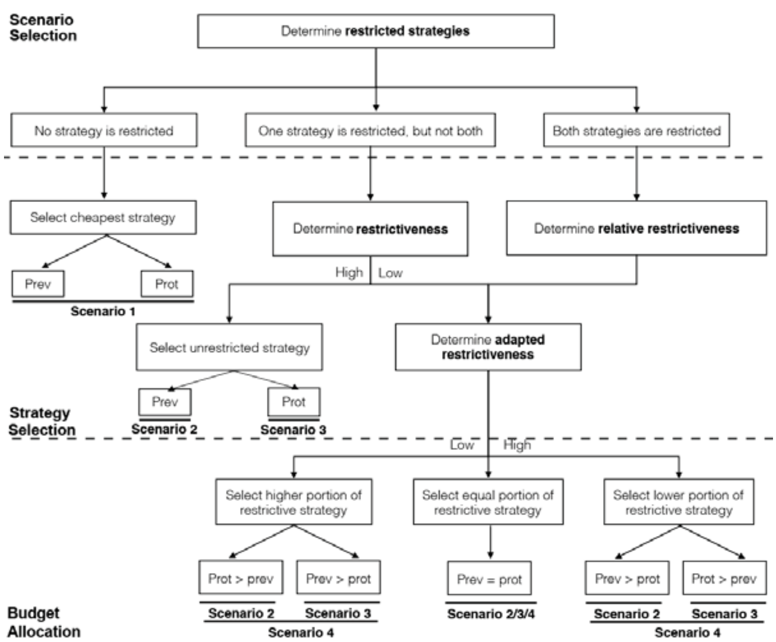
- **3-step decision procedure**
  - Step 1: Scenario selection
  - Step 2: Strategy selection
  - Step 3: Budget allocation

  adapted restrictiveness

  (a low value means a low restrictiveness)

  risk prevention: $\frac{x-\mu}{x(1-x)}$

  risk protection: $\frac{y-\mu}{y(1-y)}$



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ANALYTICAL OPTIMALITY

– 3-step decision procedure

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adapted restrictiveness

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risk prevention: $\frac{x-\mu}{x(1-x)}$

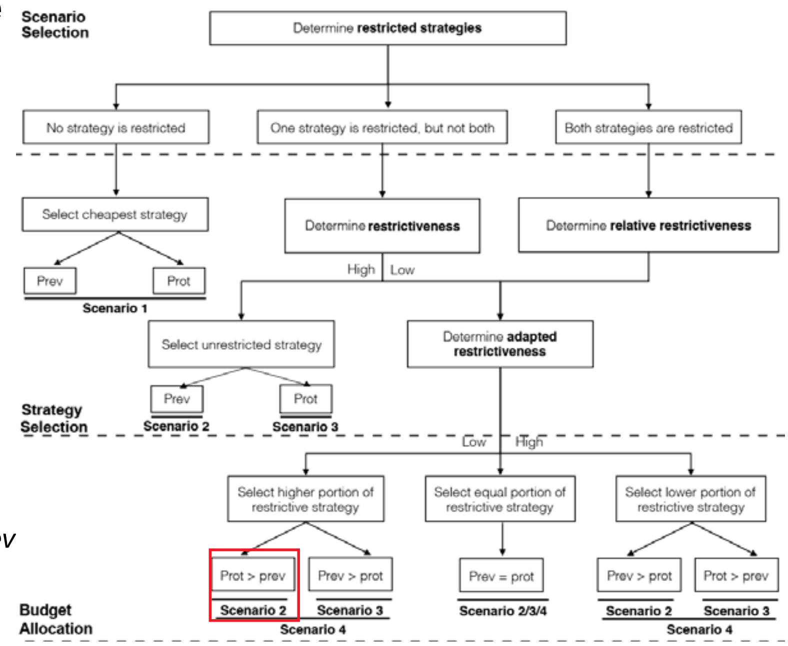
risk protection: $\frac{y-\mu}{y(1-y)}$

Example: scenario 2: x<μ<y

risk protection is restricted,

if restrictiveness is low → both,

if adapted restrictiveness is low → prot>prev



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RISK EXAMPLES

Risk ID		Strategies from literature or practice	Budget allocation decision from model
1	Acts of God. (extreme weather etc.)	• Buy insurance	Protection
2	People safety. (fall, exposure to harmful substances, etc.)	• Additional safety equipment, • Investment in training and protective materials • Insurance	Prevention
3	Potential conflicts between owner and stakeholders.	• Creating communication channels • Contract clauses, penalty clauses • Risk sharing	Protection > prevention
4	Poor schedules or unclear project scope.	• Regular meeting • Including buffer • Activity crashing • Reactive scheduling	Prevention > protection

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- Our model results are consistent with the strategies from literature or practice.

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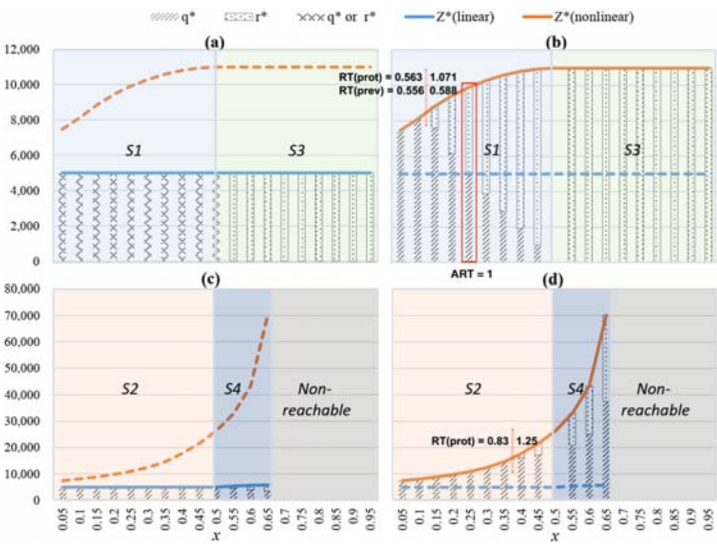
EXPERIMENTS

– Impact of risk controllability in probability (x)

- the controllability has no significant effect on the optimal risk cost in the LBAP.

- In NBAP,
- Scenarios 1 and 2, the impact of risk controllability is reflected on the restrictiveness and the adapted restrictiveness.
- Scenario 3, the controllability in risk probability has no effect on the optimal risk cost since the complete budget is allocated to risk protection.
- Scenarios 2 and 4, a lower controllability in risk probability (a higher x) leads to a greater investment in risk prevention.



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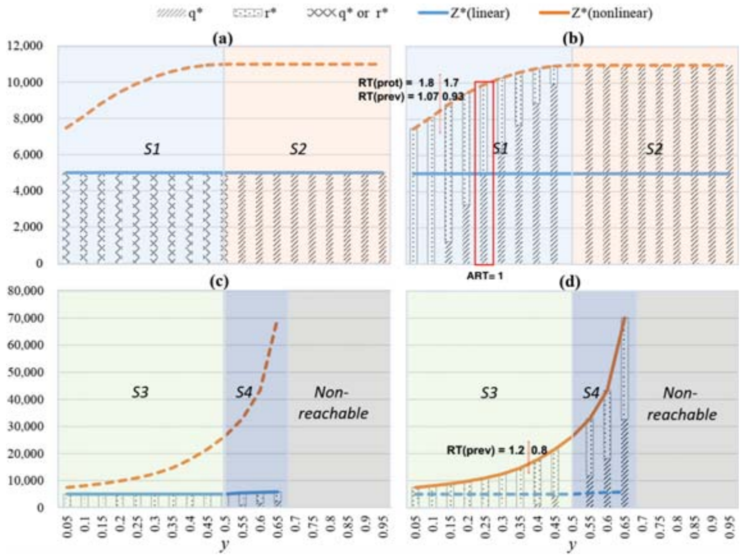
EXPERIMENTS

– Impact of risk controllability in loss (y)

– Similar results are observed.



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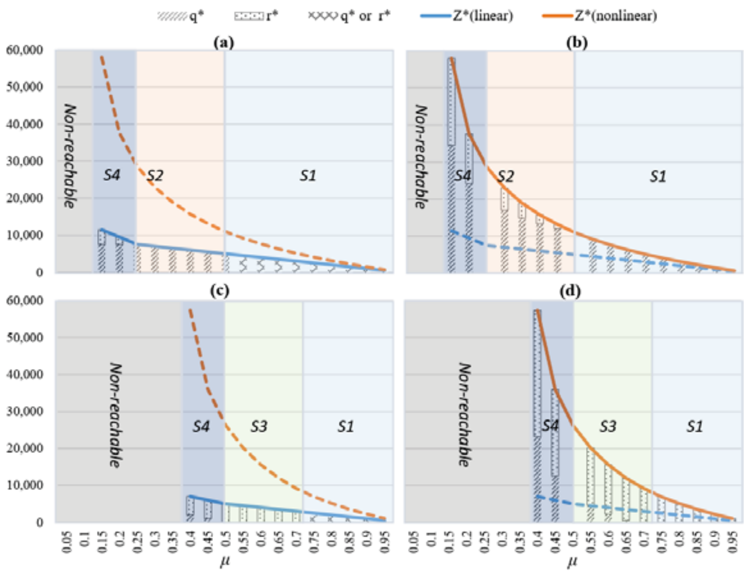
EXPERIMENTS

– Impact of response requirement (μ)

– A strict requirement always leads to a higher response cost.



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CONCLUSIONS

- Conclusions
  - A three-step decision-making process can be followed.
    (the risk response requirement, risk controllability, and the restrictiveness of strategies)
  - A lower controllability in risk loss (probability) leads to a greater investment in risk prevention (protection).

- Future research
  - A more general case: relax the linear and nonlinear relations
  - Multiple risks: extend to multiple risks and construct a risk network with complex relations

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