Aalto University
School of Science

Applications of using additive-linear portfolio value function

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Presentation *4*
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Agenda

- **Additive-linear portfolio value function - recap**
- **Application 1 - Healthcare capital**
- **Application 2 - Army bases**

Application 1
Healthcare capital

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Community Hospital - Investments

- **How to get the most bang for the buck?**
- **Financial returns are not enough to assess the whole situation in many settings**
  - E.g. healthcare, national defence, environment etc.
- **8 step decision process**
  - Helps to prevent bias
  - Creates transparency and explainability

8 step decision process

1. **Establish evaluation criteria**
2. **Classify proposals**
3. **Ensure that proposals are complete and easy to understand**
4. **Determine costs of proposals**
5. **Rate proposals with respect to each criterion**
6. **Set strategic priority weights for each criterion**
7. **Calculate weighted value scores for each proposal**
8. **Rank proposals by benefit-cost ratios**

8 step decision process

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Direct assessment of attribute values

EXHIBIT 1: **PROPOSAL EVALUATIONS**

Proposal	Cost*	Operating Net Present Value*	Average Ratings: Market Share	Physician Relations	Operating Efficiency	Network Development	Patient Outcome	Patient Satisfaction
CT Scanner	$1,000	$1,467	45	60	50	6	50	45
Desktop Hardware	$357	$0	0	0	30	60	5	0
Executive Information System	$300	−$150	5	0	35	70	0	0
Mammography System	$200	$251	75	45	50	0	70	65
Physician Answering System	$250	$0	5	40	15	5	0	0
Osteoporosis Center	$275	$567	75	35	40	5	75	55

* Dollars in thousands

Source: Strategic Approach to Allocating Capital in Healthcare Organizations, Kleinmuntz and Kleinmuntz (1999)

- 12 evaluators assessed each proposal w.r.t. each criterion and assigned a value between 0 and 100 to them
- These assessments were averaged into the values shown in the table

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Direct assessment of priority weights

EXHIBIT 2: **PRIORITY WEIGHTING JUDGMENTS**

Evaluation Criteria	Judged Priority	Priority Weights (%)
Operating Net Present Value	100	16.67
Market Share	100	16.67
Patient Outcomes	100	16.67
Patient Satisfaction	80	13.33
Physician Relations	80	13.33
Operating Efficiency	70	11.67
Network Development	70	11.67
Total	600	100.00

Source: Strategic Approach to Allocating Capital in Healthcare Organizations, Kleinmuntz and Kleinmuntz

- The CEO of the hospital assigned priority values between 0 and 100 for each criterion based on his/her strategic views
- The priority values were then scaled to sum up to 100% as priority weights

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Calculating the value scores for proposals

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Attributes onto a scale of [0,1]
Linear interpolation

EXHIBIT 3: **WEIGHTED VALUE SCORES FOR PROPOSALS**

Proposal	Relative Values: Operating Net Present Value	Market Share	Physician Relations	Operating Efficiency	Network Development	Patient Outcome	Patient Satisfaction	Weighted Value Scores
CT Scanner	1.00	0.60	1.00	1.00	0.08	0.67	0.69	73.0
Mammography System	0.25	1.00	0.75	1.00	—	0.93	1.00	71.3
Osteoporosis Center	0.44	1.00	0.58	0.71	0.07	1.00	0.85	68.8
Executive Information System	—	0.07	—	0.57	1.00	—	—	19.5
Desktop Hardware	0.09	—	—	0.43	0.86	0.07	—	17.7
Physician Answering System	0.09	0.07	0.67	—	0.07	—	—	12.4

Source: Strategic Approach to Allocating Capital in Healthcare Organizations, Kleinmuntz and Kleinmuntz

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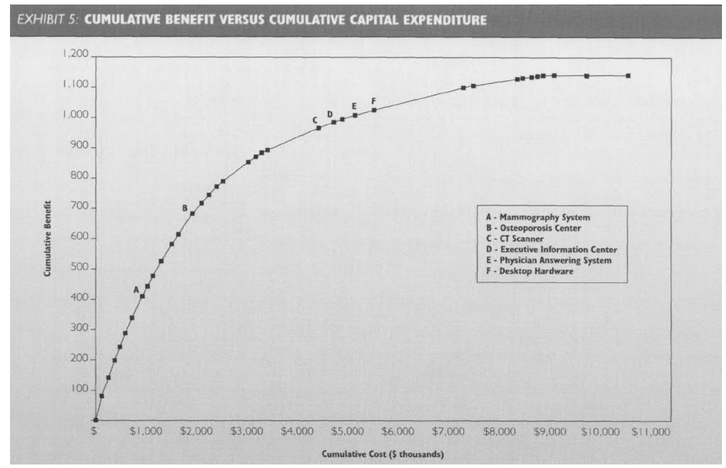
Benefit-cost ratios and optimal portfolio

EXHIBIT 4: **BENEFIT-COST RATIOS**

	Weighted Value Scores	Cost*	Benefit-Cost Ratios	Funding Recommendations: Budget $1,800*	Budget $1,600*	Budget $1,400*
Mammography System	71.3	$200	35.7	✓	✓	✓
Osteoporosis Center	68.8	$275	25.0	✓	✓	✓
CT Scanner	73.0	$1,000	7.3	✓	✓	
Executive Information System	19.5	$300	6.5	✓		✓
Physician Answering System	12.4	$250	4.9			✓
Desktop Hardware	17.7	$375	4.7			✓

* Dollars in thousands

Source: Strategic Approach to Allocating Capital in Healthcare Organizations, Kleinmuntz and Kleinmuntz



- Benefit-cost ratios =

  ”Bang for the buck”

- Final decisions easily obtained by solving a simple optimization problem

8 step decision process

1. **Establish evaluation criteria**
2. (Classify proposals)
3. **Ensure that proposals are complete and easy to understand**
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CRUCIAL!

Application 2
Army bases

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Army base realignment and closure

- Too much capacity - must get rid of some

- Dealing with interacting attributes
- Elicitations of weights using the ”Swing Weight Matrix”
- Sensitivity analysis

Multiple dimension attribute assessment

- What to do when the criteria ”interact” with each other?
  - That is, when the additiveness does not hold inside the projects

- One way is to combine the interacting criteria into one multidimensional attribute in some way

Constructing a multidimensional attribute

Figure 4 **Multidimensional Constructed Scale for Heavy Maneuver Area**

Largest contiguous area (1,000s acres)	Total heavy maneuver area (1,000s acres)			
	≤10	>10 and ≤50	>50 and ≤100	>100
≤10	Label 1	Label 2	Label 3	Label 4
>10 and ≤50		Label 5	Label 6	Label 7
>50 and ≤100			Label 8	Label 9
>100				Label 10

Figure 5 **Assessed Multidimensional Constructed Scale**

Largest contiguous area (1,000s acres)	Total heavy maneuver area (1,000s acres)			
	≤10	>10 and ≤50	>50 and ≤100	>100
≤10	0.1	0.2	1.4	2.0
>10 and ≤50		3.2	4.3	5.2
>50 and ≤100			6.1	7.6
>100				10.0

Source: Use of Decision Analysis in the Army Base Realignment and Closure 2005, Ewing et al.

- First, the 2-dim space is binned with regards to both dimensions
- Second, the bins are assigned corresponding values
  - First pass compares increments between adjacent cells
  - Second pass assesses relative pairwise increments

Eliciting the weights with ”Swing Weight Matrix”

Figure 6 **Swing Weight Matrix**

← Ability to change →

Variation of scale (↕)

Mission immutable (very difficult to change)		Mission support (difficult to change without external support)		Mission enablers (change with army dollars)	
Heavy mnvr area **Direct fire** **Brigade capacity** 100	**Light mnvr area** **Indirect fire** 90	**Int./partnering** **Area cost factor** 75	*Housing avail.* *Crime index* *Maint./manuf.* *50*	*RDTE diversity* *20*	Supply & storage Ops/admin Ammo storage 10
Force deploy **Materiel deploy** **Airspace** 90	**Critical infrastr.** **Proximity** **Test ranges** **Mob. history** 75	*Munitions prod.* *Accessibility* *Urban sprawl* *50*	*Connectivity* *Work force* *Availability* *20*	MOUT 10	Applied instructional General instructional 5
Buildable acres 75	*Soil resiliency* *Joint facilities* *50*	*Employment op.* *Water quantity* *Inst unit cost* *ENV. elasticity* *20*	Medical avail. Noise contours Air quality In-state tuition 10	C2 TGT facility 5	1

Level of importance

HIGH	*MEDIUM*	LOW

Source: Use of Decision Analysis in the Army Base Realignment and Closure 2005, Ewing et al.

- Explicitly defines
  - Importance
  - Variance
- Steps
  - Determine dims
  - Place the criteria
  - Assess the weights
  - Normalize the weights

Model formulation

$$\max \sum_j v_j x_j$$
$$\text{s.t.} \sum_j g_{jc} x_j \geq K_c$$
$$\sum_j x_j \leq N_{\min}$$
$$x_j \in \{0, 1\} \quad \forall j.$$

Indices:

j = *installation*

c = *army requirement*

Parameters:

v_j = *value for installation j*

g_{jc} = *installation j´s capacity for army requirement c*

K_c = *army capability for requirement c*

N_{min} = *minimum number of installations that satisfy army capacity requirement c*

Decision variables:

$$x_j = \begin{cases} 1, \mathit{if\ installtion\ j\ is\ contained\ in\ the\ portfolio} \\ 0, \mathit{otherwise} \end{cases}$$

Sensitivity analysis

One single optimal solution is not necessarily enough for the senior DMs. Prepare for questions!

In this case study:

1. How the number of installations affects the selection?
2. How changing the binding constraints affects the selection?
3. How the number of installations affects the final value?

Number of installations on selection

Which installations stay and which move in and out?

Table 2 Selection of the First Five Feasible Portfolios

Portfolio	P1	P2	P3	P4
# of installations in portfolio	63	64	65	66
Total military value	207.05	209.25	211.39	213.35
Installation name				
I1	1	1	1	1
I2	0	0	1	1
I3	1	1	1	1
I4	1	1	1	1
I5	0	1	0	1

$$\max \sum_j v_j x_j$$

$$\text{s.t.} \sum_j g_{jc} x_j \geq K_c$$

$$\sum_j x_j \leq \boxed{N_{\min}}$$

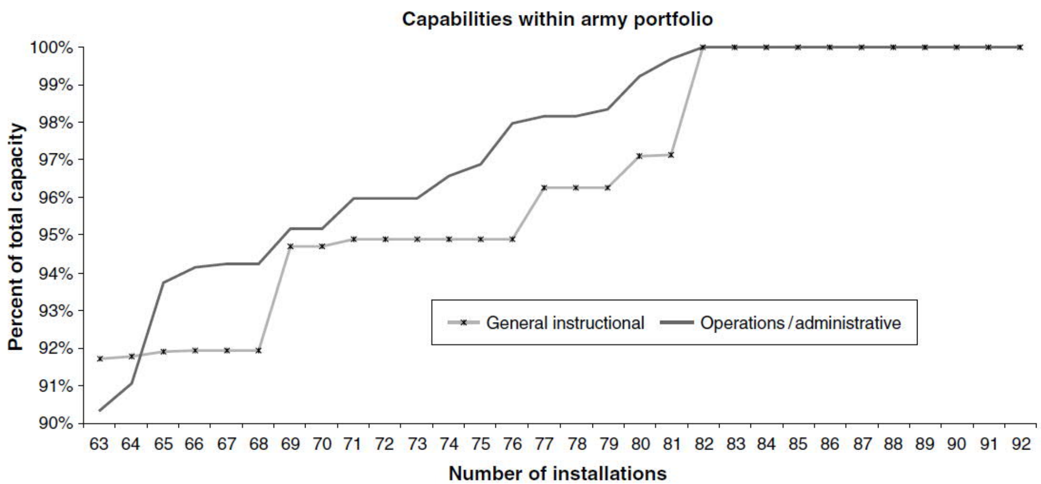
$$x_j \in \{0, 1\} \quad \forall j.$$

Source: Use of Decision Analysis in the Army Base Realignment and Closure 2005, Ewing et al.

Binding constraints on selection

If the binding constraints are changed in some way, which installations leave or enter the portfolio?

Figure 7 Example Capabilities Across Portfolios



$$\max \sum_j v_j x_j$$

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$$\sum_j x_j \leq N_{\min}$$

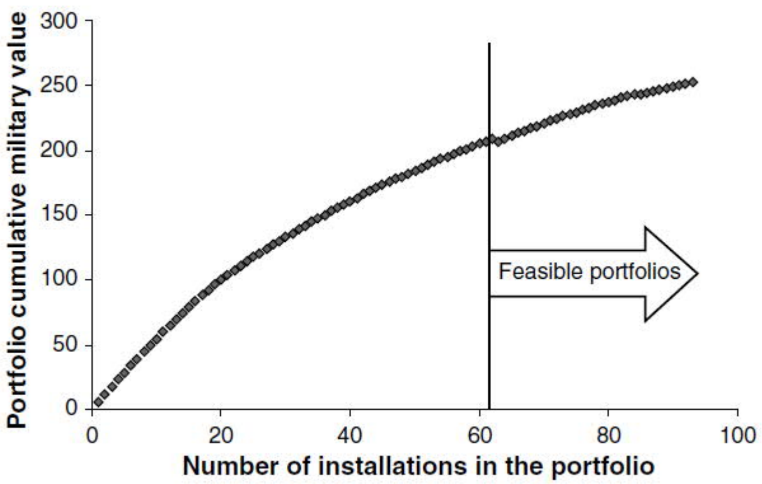
$$x_j \in \{0, 1\} \quad \forall j.$$

Source: Use of Decision Analysis in the Army Base Realignment and Closure 2005, Ewing et al.

Number of installations on final value

How does the final value change if the number of installations was increased?

Figure 8 Maximum Military Value Curve for a Portfolio of Installation



Source: Use of Decision Analysis in the Army Base Realignment and Closure 2005, Ewing et al.

$$
\begin{aligned}
\max \quad & \sum_j v_j x_j \\
\text{s.t.} \quad & \sum_j g_{jc} x_j \geq K_c \\
& \sum_j x_j \leq \boxed{N_{\min}} \\
& x_j \in \{0, 1\} \quad \forall j.
\end{aligned}
$$

Take-home messages

- **The importance of good evaluation criteria**
- **Effective co-operation and communication**
- **Transparency and explainability**

References

- [1] Strategic Approach to Allocating Capital in Healthcare Organizations, Kleinmuntz and Kleinmuntz (1999)
- [2] Use of Decision Analysis in the Army Base Realignment and Closure (BRAC) 2005, Ewing et al. (2006)

Homework

- **Task 1**
  - Come up with a simple decision making problem where you are faced with interacting attributes. Solve the situation by converting them into a single multidimensional attribute. (Slide 22)
- **Task 2**
  - Describe shortly the steps one needs to make while forming a Swing Weight Matrix. Explain concisely why the Swing Weight Matrix is highly explainable? (Slide 23)

- **Submission and possible questions**
  - Email answers to konsta.holopainen(at)aalto.fi, with subject “OR-seminar HW4”
  - If you have any questions regarding the homework, feel free to contact me via email or Telegram @Jarrupoljin