Aalto University
School of Science

An application: Modeling preference information with assurange regions

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Presentation *17*
19.11.2021

MS-E2191 Graduate Seminar on Operations Research
Fall 2021

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1. Introduction
2. Modelling the data
3. Applying DEA on data and Assurange Region
4. Results of the Study
5. Conclusions

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Finding a location for a SSC

- **How to find a suitable location for a high energy accelator?**
- **SSC= Superconducting super collorider**
  - *Underground, circumference up to 160 km*
  - *Costs around 5 billion dollars*

    → A Vast project requiring thorough analysis

GOAL: Evaluate comparative advantages of feasible sites

HOW: DEA + Assurange regions

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Modelling the data

- **Six feasible sites identifyed**
  1) *Near a major airport*
  2) *Geological uniformity to keep costs moderate*
- **Applying DEA with three index attributes**
  1) *Facility costs*
  2) *User cost index*
  3) *Environmental index*
- **Identifying the best sites**

Modelling the data

- **Six feasible sites identifyed**
  1) *Near a major airport*
  2) *Geological uniformity to keep costs moderate*
- **Applying DEA with three index attributes**
  1) *Facility costs*
  2) *User cost index*
  3) *Environmental index*

  } **How to obtain these?**
- **Identifying the best sites**

Facility costs

- **Comprise all the costs of building the SSC**
- **Tunnelling costs determined by experts via geological, hydrological, and engineering techniques to analyze feasible sites**

  → *This procedure was trusted so much that only most likely scenario was accounted for*
- **Costs simulated and validated by experts**

SCALE building and operating for 20 years: 5 billion $

Facility costs

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Grand total costs (in billion 1984 $)	4.759	4.965	4.714	4.976	4.775	4.667

Numbers' Source: Comparative Site Evaluations for Locating a High-Energy Physics Lab in Texas, Thompson, Singleton Thrall and Smith (1986)

User costs index / Time delay index

- **Time delay index = “The increase in time required to compleate research with a fixed budget at a non ideal site”**
- **Derived surveying field experts**
  - *Three categories: Air Transportation, Technical Support, Research University*
  - *Estimates for experiment times and costs, differences*
- **Analysis on answers: ANOVA methods**

Ideal site: Close to an airport and to technical support

User costs index / Time delay index

	Sites					
	1 South Dallas	2 North Houston	3 South Houston	4 East/ Central Texas	5 West/ Central Texas	6 West Texas
Time Delay Index	1.00	1.00	1.091	1.182	1.125	1.599

Table 3: The time delay index for the six sites in terms of a relative increase in user time required for completion of a given physics experimental plan, under a fixed budget.

Source: Comparative Site Evaluations for Locating a High-Energy Physics Lab in Texas, Thompson, Singleton Thrall and Smith (1986)

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Environmental index

- **Based on the SSC's effect on environment AND environments effect on SSC**
- **Weigted averages of expert assigned ranks**
  - *Sites ranked from 1 to 6, 1 being the best*

Environmental index

Environmental factors that could affect facility

Possible effects on environment

		Site					
Factor	Weight	6	5	1	4	3	2
Subsidence	1.0	5	1	1	1	6	3
Sinkholes	1.0	6	5	1	1	1	1
Faulting	1.0	3	4	3	4	6	5
Flood (Runoff)	0.75	3	5	4	1	6	2
Flood (Surge)	0.75	1	1	1	1	6	1
Water Supply	0.75	6	3	3	1	1	1
Water Quality	0.5	5	6	5	1	1	4
Air Quality	0.5	3	1	6	1	1	1
Habitat	0.5	5	2	2	2	6	4
History	0.25	1	5	6	4	1	1
Summary		28	23	19	12	27	17

Source: Comparative Site Evaluations for Locating a High-Energy Physics Lab in Texas, Thompson, Singleton Thrall and Smith (1986)

Data for DEA

	Sites					
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Environmental Index						
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x_{ij}= Input i at site j → x_{11} = 4.759

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Applying DEA

- **Goal was to evaluate comparative advantages of sites to find best sites**
    - *Best site should maximize the ratio between benefits and costs*
- **DEA used to find the efficient and inefficient sites**
    - *Solving this tells us only site 5 is DEA inefficient*
- **How to evaluate the rest?**

Applying DEA

- **Efficiency of a DMU =** $\frac{\boldsymbol{virtual\ output}}{\boldsymbol{virtual\ input}}$, $where\ virtual\ output = 1$

- **Setting Site 1 as reference DMU**
  - $Virtual\ input_{Site\ 1} = 1$ → Leads to efficiency as $\frac{1}{1} = 1$

v_1= weight on facility costs

v_2= weight on user costs

v_3= weight on environmental costs

Applying DEA

v_1 = weight on facility costs

v_2 = weight on user costs

v_3 = weight on environmental costs

- **Setting Site 1 as reference DMU leads to**

$$x_{11}v_1 + x_{21}v_2 + x_{31}v_3 = 1$$

- **For all other DMUs the value for efficiency ≤ 1, as their virtual input ≥ 1**

Applying DEA

$$x_{11}v_1 + x_{21}v_2 + x_{31}v_3 = 1$$
$$x_{12}v_1 + x_{22}v_2 + x_{32}v_3 \geq 1$$
$$x_{13}v_1 + x_{23}v_2 + x_{33}v_3 \geq 1$$
$$x_{14}v_1 + x_{24}v_2 + x_{34}v_3 \geq 1$$
$$x_{15}v_1 + x_{25}v_2 + x_{35}v_3 \geq 1$$
$$x_{16}v_1 + x_{26}v_2 + x_{36}v_3 \geq 1$$

$\boldsymbol{v_1}$ = weight on facility costs

$\boldsymbol{v_2}$ = weight on user costs

$\boldsymbol{v_3}$ = weight on environmental costs

→Solutions to found in ratios $\frac{\boldsymbol{v_3}}{\boldsymbol{v_1}}$ and $\frac{\boldsymbol{v_2}}{\boldsymbol{v_1}}$

Assurance region, AR

- **Upper and lower bounds imposed on weight ratios**
  - here $\frac{v_3}{v_1}$ and $\frac{v_2}{v_1}$
- **Coefficient bounds can be determined from data and/or expert opinion**
- **Regions included in AR represent reasonable values for the weights**

Assurance region, AR

- **Defining assurance intervals for weights v_2 and v_3**

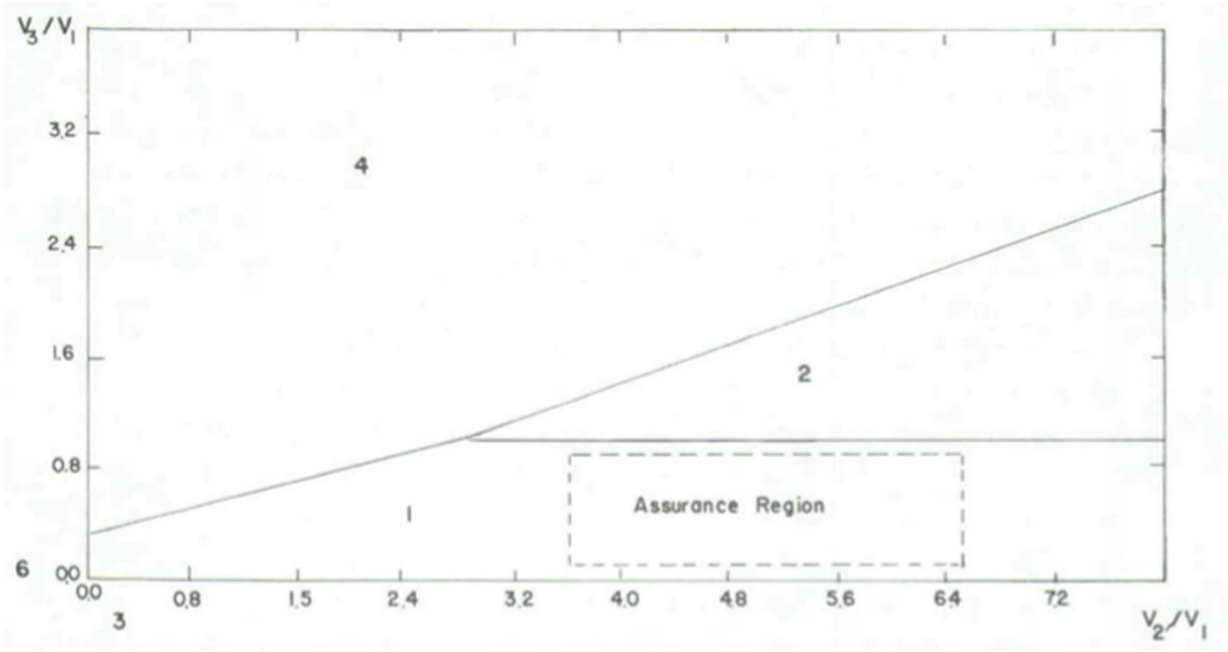
For v_1 , $v_1 = 1$

For v_2 , $3.6 \leq v_2 \leq 6.5$

For v_3 , v_3: $0.104 \leq v_3 \leq 0.939$

Defined via expert views

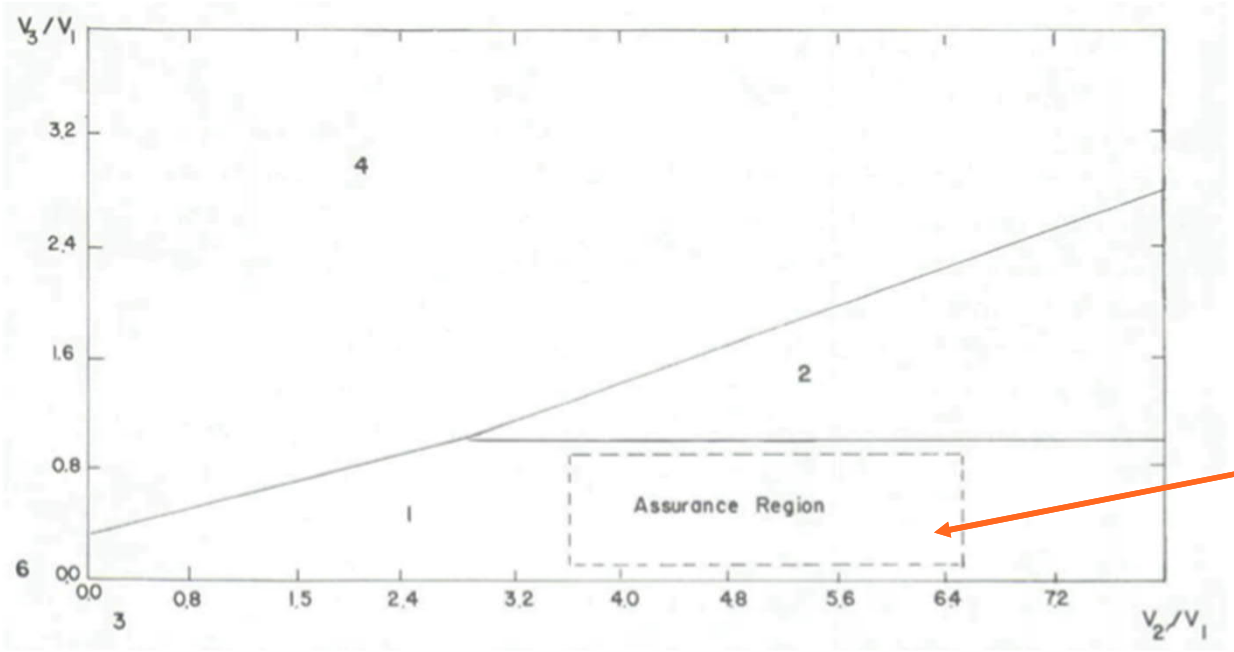
Assurance region



Weight space divided in to regions of site preferences.

Source: Comparative Site Evaluations for Locating a High-Energy Physics Lab in Texas, Thompson, Singleton Thrall and Smith (1986)

Assurance region



Weight space divided in to regions of site preferences.

Assurance region located entiry in site 1's region.

Source: Comparative Site Evaluations for Locating a High-Energy Physics Lab in Texas, Thompson, Singleton Thrall and Smith (1986)

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Results of the Study

- **Site 1 (South Dallas) portrayd as preferred site due to low construction costs and low user costs**
    - Constructions where actually started on this site...
    - Until the project was halted due to budjet issues

"In this project, we described the conditions most likely to be encountered and did not use a worst-case scenario" Source: Comparative Site Evaluations for Locating a High-Energy Physics Lab in Texas, Thompson, Singleton Thrall and Smith (1986)

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Conclusions

- **Preprosessing the data is laborous → Big part of work done already before the actual modelling**
- **Assurance regions can be used to further identify preferred solution**
- **The valuation of different aspects can lead to very different results**

References

-Thompson, R.G., Singleton, F.D.,Thrall, R.M., Smith, B.A., 1986: Comparative site eveluations for locating a high-energy physics lab in Texas.

-Thompson, R.G., Langemeier, L.N., Lee, C., Lee, E., Thrall, R.M., 1990: The role of multiplier bounds in efficiency analysis with application to Kansas farming.

Homework

1) If we would trust solely the assurance region to decide the predered solution out of the efficient solutions, how would you define it if you wanted site 2 to be chosen (Fig Slide 24)?

2) What is the issue if we define assurance region just with expert knowledge?

Send answers by Friday 26.11 9am using subject “HW 17”