

# HELENA



Higher Education Global  
Efficiency Analysis

## *Relativity determination for efficiency in DEA*

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## Agenda

- 1. Research Question**
- 2. Example Dataset**
- 3. DEA Meta-heuristics**
- 4. Discussion**

# 1. Introduction

## Background

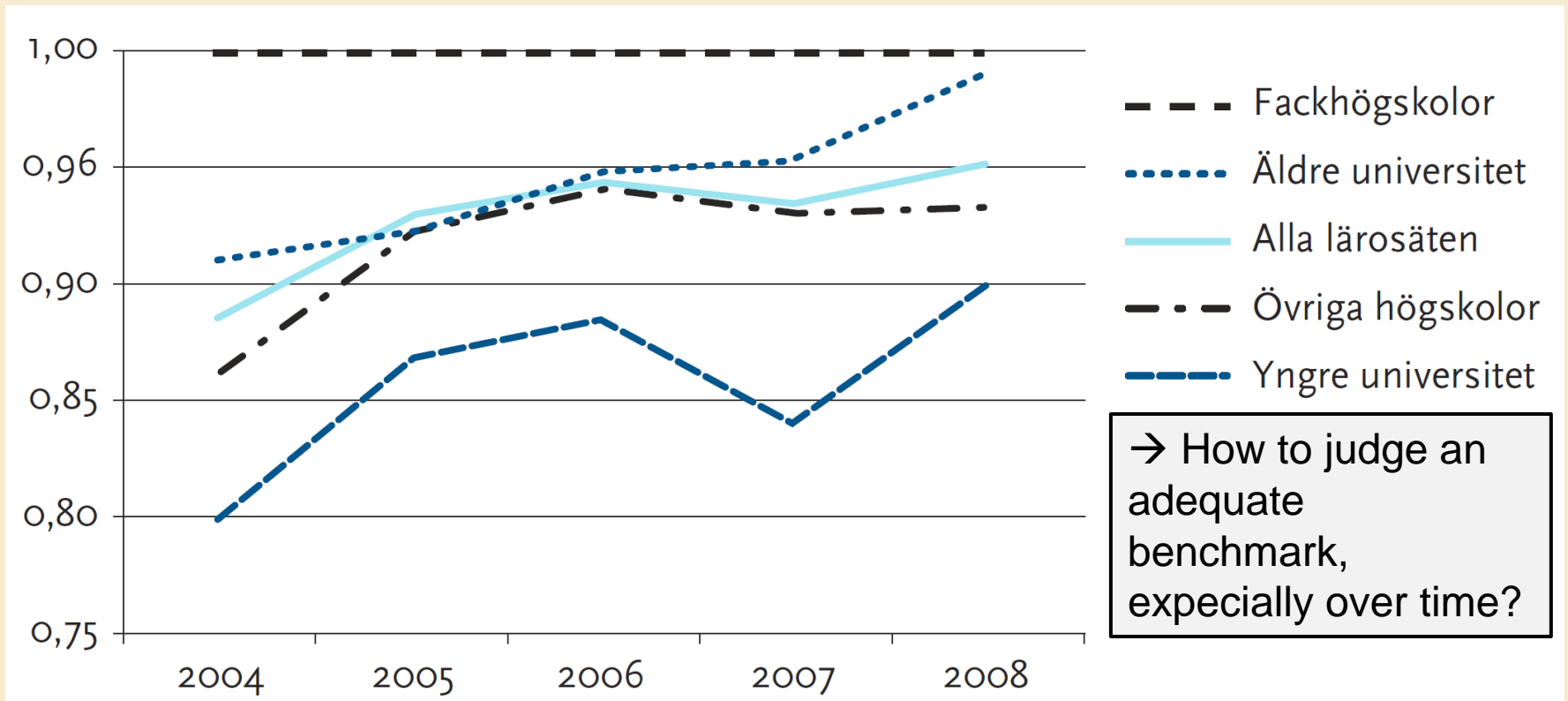
- International research and efforts to increase university performance
- Questions of university evaluation and efficiency measurement: multiple objectives and stakeholders
- Efficiency analysis methods
  - MCDM (Multi Criteria Decision Making), **DEA (Data Envelopment Analysis)**, AHP (Analytic Hierarchy Process), SFA (Stochastic Frontier Analysis)

## Specific Research Question

- How can a meta-heuristics be possibly useful in judging a “confidence level” of the relative university efficiency measurement with DEA?

# 1. Introduction

## Example: Sweden – Riksrevisionen, Stockholm 2011, 44



## 2. University Example Dataset

- **DEA for universities, often applied in research**
- **Basic problem of any comparative & quantitative view: Different definitions in **data** gathering and accumulation**
- **Additional problem of changing measurement concepts as well as withheld data with ranking publications (performance measurement)**
- **Indicators in an example dataset (case study) for 67 European Universities:**
  - ARWU ranking scores: Only top 100, 101-150 = 20, 151-200 = 10
  - THE ranking scores: Only top 200
  - Leiden ranking: Publication numbers (alternative: impact, very “level”)
  - EUMIDA data: PhD graduates and BA student numbers
  - Input: Budget data according to official university homepages

## 2. University Example Dataset

### Dataset for 67 European Universities, Top 10 Cutout

	O1: THE Score	O2: ARWU Score	O3: Leiden Score (P)	O4: PhD Graduates	O5: BA Students	I: Budget 2011 in €
<a href="#"><u>U Oxford, UK</u></a>	93,7	55,9	12208	850	19583	1093538183
<a href="#"><u>U Cambridge, UK</u></a>	92,6	69,6	11742	950	17837	942019645
<a href="#"><u>Imperial C. London, UK</u></a>	90,6	41,6	10098	725	11027	837396247
<a href="#"><u>ETH Zürich, CH</u></a>	87,8	43,5	7257	581	10364	1189794717
<a href="#"><u>University C. London, UK</u></a>	85,5	43,0	11208	610	17181	953219017
<a href="#"><u>U Edinburgh, UK</u></a>	76,1	30,5	6320	520	20823	773930364
<a href="#"><u>ETH Lausanne, CH</u></a>	73,0	20,0	4139	266	4749	646111066
<a href="#"><u>Karolinska Inst., SE</u></a>	72,4	32,7	6920	352	6416	604377426
<a href="#"><u>LMU München, DE</u></a>	70,4	29,5	6896	1270	39297	488600000
<a href="#"><u>U Manchester, UK</u></a>	70,1	0,0	8531	830	33640	962018693

### 3. DEA Meta-heuristics

- **Examples:**

**“Rule of thumb” – twice as many DMUs as inputs and outputs combined.**

**(e.g. Sale, Sale 2003)**

Further: The number of required DMU data sets (for  $n_{in}$  inputs und  $n_{out}$  outputs) has to be checked against the general fuzzy requirement as  $n_{Ob}$  with:

$$n_{Ob} \geq \max \{ n_{in} \cdot n_{out}, 3 \cdot (n_{in} + n_{out}) \}.$$

(Cooper, Seiford, Tone 2006)

### 3. DEA Meta-heuristics

- Multi-round iteration of DEA runs with increasing DMU numbers (D), starting value  $D = 10$  (Banxia Frontier Analyst, Min.-Orientation, CRTS/CCR)

D = 10

 $\Sigma d = 0$ 

D = 11

 $\Sigma d = 0$ 

D = 12

Unit name	Score	Efficient	Unit name	Score	Efficient	Unit name	Score	Eff.
ETH Lausanne, CH	78,40%	False	ETH Lausanne, CH	78,40%	False	ETH Lausanne, CH	78,40%	False
ETH Zürich, CH	56,70%	False	ETH Zürich, CH	56,70%	False	ETH Zürich, CH	56,70%	False
Imperial C. London, UK	85,40%	False	Imperial C. London, UK	85,40%	False	Imperial C. London, UK	85,40%	False
Karolinska Inst., SE	86,90%	False	Karolinska Inst., SE	86,90%	False	<b>KU Leuven, BE</b>	<b>87,60%</b>	<b>False</b>
<b>LMU München, DE</b>	<b>100,00%</b>	<b>True</b>	<b>King's C. London, UK</b>	<b>75,40%</b>	<b>False</b>	Karolinska Inst., SE	86,90%	False
U Cambridge, UK	100,00%	True	<b>LMU München, DE</b>	<b>100,00%</b>	<b>True</b>	King's C. London, UK	75,40%	False
U Edinburgh, UK	68,20%	False	U Cambridge, UK	100,00%	True	<b>LMU München, DE</b>	<b>100,00%</b>	<b>True</b>
U Manchester, UK	62,80%	False	U Edinburgh, UK	68,20%	False	U Cambridge, UK	100,00%	True
U Oxford, UK	81,00%	False	U Manchester, UK	62,80%	False	U Edinburgh, UK	68,20%	False
University C. London, UK	83,30%	False	U Oxford, UK	81,00%	False	U Manchester, UK	62,80%	False
			University C. London, UK	83,30%	False	U Oxford, UK	81,00%	False
						University C. London, UK	83,30%	False



### 3. DEA Meta-heuristics

#### Iterations D = 10 , 15 , 20

$$\Sigma d_{(10)} = -5,7 \text{ (2 DMU)}$$

$$\Sigma d_{(10)} = -189,2 \text{ (9 DMU)}$$

**D = 10**

Unit name	Score	Efficient
ETH Lausanne, CH	78,40%	False
ETH Zürich, CH	56,70%	False
Imperial C. London, UK	85,40%	False
Karolinska Inst., SE	86,90%	False
<b>LMU München, DE</b>	<b>100,00%</b>	<b>True</b>
U Cambridge, UK	100,00%	True
U Edinburgh, UK	68,20%	False
U Manchester, UK	62,80%	False
U Oxford, UK	81,00%	False
University C. London, UK	83,30%	False

**D = 15**

Unit name	Score	Efficient
ETH Lausanne, CH	<b>73,70%</b>	False
ETH Zürich, CH	56,70%	False
Imperial C. London, UK	85,40%	False
KU Leuven, BE	87,60%	False
Karolinska Inst., SE	86,90%	False
King's C. London, UK	75,40%	False
<b>LMU München, DE</b>	<b>100,00%</b>	<b>True</b>
U Cambridge, UK	100,00%	True
U Edinburgh, UK	<b>67,50%</b>	False
<b>U Göttingen, DE</b>	<b>100,00%</b>	<b>True</b>
U Leiden, NL	88,80%	False
U Manchester, UK	62,80%	False
U Oxford, UK	81,00%	False
U Utrecht, NL	75,50%	False
University C. London, UK	83,30%	False

**D = 20**

Unit name	Score	Efficient
ETH Lausanne, CH	<b>58,30%</b>	False
ETH Zürich, CH	<b>38,30%</b>	False
EU Rotterdam, NL	59,90%	False
Imperial C. London, UK	<b>60,10%</b>	False
KU Leuven, BE	61,60%	False
Karolinska Inst., SE	<b>61,80%</b>	False
King's C. London, UK	54,80%	False
<b>LMU München, DE</b>	<b>100,00%</b>	<b>True</b>
TU Delft, NL	61,00%	False
U Bristol, UK	66,30%	False
U Cambridge, UK	<b>77,50%</b>	False
U Edinburgh, UK	<b>50,70%</b>	False
U Göttingen, DE	79,10%	False
U Heidelberg, DE	100,00%	True
U Leiden, NL	65,20%	False
U Manchester, UK	<b>47,20%</b>	False
U Oxford, UK	<b>55,60%</b>	False
U Utrecht, NL	53,10%	False
U Wageningen, NL	45,90%	False
University C. London, UK	<b>58,60%</b>	False

### 3. DEA Meta-heuristics

#### Iterations D = 10 , 30 , 50

$$\Sigma d_{(10)} = -195,8 \text{ (9 DMU)}$$

$$\Sigma d_{(10)} = -216,2 \text{ (9 DMU)}$$

D = 10

D = 30

D = 50

Unit name	Score	Efficient	Unit name	Score	Efficient	Unit name	Score	Eff.
ETH Lausanne, CH	78,40%	False	ETH Lausanne, CH	56,90%	False	ETH Lausanne, CH	46,00%	False
ETH Zürich, CH	56,70%	False	ETH Zürich, CH	38,30%	False	ETH Zürich, CH	37,50%	False
Imperial C. London, UK	85,40%	False	EU Rotterdam, NL	59,50%	False	EU Rotterdam, NL	57,80%	False
Karolinska Inst., SE	86,90%	False	HU Berlin, DE	97,20%	False	FU Berlin, DE	90,10%	False
LMU München, DE	100,00%	True	Imperial C. London, UK	60,10%	False	HU Berlin, DE	97,10%	False
U Cambridge, UK	100,00%	True	KU Leuven, BE	61,60%	False	Imperial C. London, UK	60,10%	False
U Edinburgh, UK	68,20%	False	Karolinska Inst., SE	61,50%	False	KTH Royal Inst. of Techn., SE	50,40%	False
U Manchester, UK	62,80%	False	King's C. London, UK	54,40%	False	KU Leuven, BE	61,60%	False
U Oxford, UK	81,00%	False	LMU München, DE	100,00%	True	Karolinska Inst., SE	59,60%	False
University C. London, UK	83,30%	False	TU Delft, NL	58,90%	False	King's C. London, UK	51,50%	False
			TU München, DE	29,30%	False	LMU München, DE	100,00%	True
			U Amsterdam, NL	63,60%	False	RU Nijmegen, NL	57,00%	False
			U Bristol, UK	66,10%	False	TU Delft, NL	50,10%	False
			U Cambridge, UK	77,50%	False	TU Eindhoven, NL	70,30%	False
			U Durham, UK	100,00%	True	TU München, DE	29,10%	False
			U Edinburgh, UK	50,20%	False	Trinity C. Dublin, IR	81,90%	False
			U Ghent, BE	92,70%	False	U Amsterdam, NL	63,60%	False
			U Groningen, NL	58,10%	False	U Basel, CH	70,70%	False
			U Göttingen, DE	77,60%	False	U Bristol, UK	62,30%	False
			U Heidelberg, DE	100,00%	True	U Cambridge, UK	75,90%	False
			U Leiden, NL	64,80%	False	U Durham, UK	80,30%	False
			U Lund, SE	54,40%	False	U Edinburgh, UK	46,00%	False
			U Manchester, UK	47,20%	False	U Freiburg, DE	92,90%	False
			U Oxford, UK	55,60%	False	U Geneva, CH	48,20%	False
			U Uppsala, SE	52,90%	False	U Ghent, BE	92,70%	False

### 3. DEA Meta-heuristics – All 67 DMU

Unit name	Score	Unit name	Score	Unit name	Score
<b>U St Andrews, UK</b>	<b>100,00%</b>	VU Amsterdam, NL	63,20%	U Bonn, DE	51,70%
<b>U Sussex, UK</b>	<b>100,00%</b>	U Bristol, UK	62,30%	King's C. London, UK	51,50%
<b>U Heidelberg, DE</b>	<b>100,00%</b>	U Amsterdam, NL	62,20%	U Newcastle, UK	51,30%
<b>U Vienna, AU</b>	<b>100,00%</b>	KIT Karlsruhe, DE	61,70%	U Liverpool, UK	50,90%
<b>LMU München, DE</b>	<b>94,80%</b>	KU Leuven, BE	61,60%	RWTH Aachen, DE	50,80%
U Ghent, BE	92,70%	U Warwick, UK	60,60%	KTH Royal Inst. of Techn., SE	50,40%
U Freiburg, DE	92,10%	Imperial C. London, UK	60,10%	TU Delft, NL	50,10%
HU Berlin, DE	91,30%	U Leiden, NL	59,80%	U Leicester, UK	48,50%
U Lancaster, UK	90,90%	U Leeds, UK	59,70%	U Geneva, CH	48,20%
U East Anglia, UK	88,90%	Karolinska Inst., SE	59,60%	U Manchester, UK	46,30%
FU Berlin, DE	82,40%	University C. London, UK	58,60%	U Edinburgh, UK	46,00%
Trinity C. Dublin, IR	81,90%	EU Rotterdam, NL	57,80%	ETH Lausanne, CH	46,00%
U Durham, UK	79,20%	U Nottingham, UK	57,50%	<b>U Bern, CH</b>	<b>39,10%</b>
U Aberdeen, UK	76,70%	U Helsinki, FI	57,30%	<b>ETH Zürich, CH</b>	<b>37,50%</b>
U Reading, UK	76,10%	U Sheffield, UK	57,20%	<b>U Wageningen, NL</b>	<b>37,50%</b>
U Cambridge, UK	75,90%	RU Nijmegen, NL	57,00%	<b>U Zürich, CH</b>	<b>31,30%</b>
U Göttingen, DE	71,20%	U Groningen, NL	56,90%	<b>TU München, DE</b>	<b>29,10%</b>
U York, UK	71,10%	Queen Mary, U London, UK	55,80%		
U Basel, CH	70,70%	U Oxford, UK	55,60%		
TU Eindhoven, NL	70,30%	U Col. Dublin, IR	55,50%		
U Maastricht, NL	69,30%	U Southampton, UK	54,50%		
U Exeter, UK	68,60%	U Utrecht, NL	53,10%		
U Twente, NL	66,60%	U Lund, SE	51,90%		
U Frankfurt, DE	66,20%	U Glasgow, UK	51,90%		
U Lausanne, CH	64,40%	U Uppsala, SE	51,80%		

## 4. Discussion

**How can a meta-heuristics be possibly useful in judging a “confidence level” of the relative university efficiency measurement with DEA?**

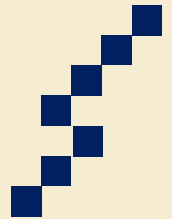
**(A) High variance of efficient DMU as well as efficiency values.**

**(B) Possible analogy to local optima?**

**(C) Proposed metaheuristics measure of sum of efficiency deviations probably not useful.**

**(D) Possible other indicators: variance, square od deviations sums, deviations sum divided by number of (new) DMU, ... ?**

**(E) Adding further DMU can only *reduce* efficiency values of existing DMU.**



**Thank you for  
your attention!**

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