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Bundesministerium für Bildung und Forschung

PIM

HELENA

Higher Education Global Efficiency Analysis

Higher Education Productivity Modelling with Data Envelopment Analysis Methods

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Workshop on "Efficiency in Higher Education", Thessaloniki, Greece, 24.06.2013

Agenda

1. Introduction
2. Data and DEA Method
3. Case study
4. Discussion

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Background

- International efforts to increase the performance of universities
  - Increasing growth rates of students
  - Increasing societal expectations towards universities
  - Lack of sufficient government financial resources
- Efficiency analysis methods
  - MCDM (Multi Criteria Decision Making), DEA (Data Envelopment Analysis), SFA (Stochastic Frontier Analysis)

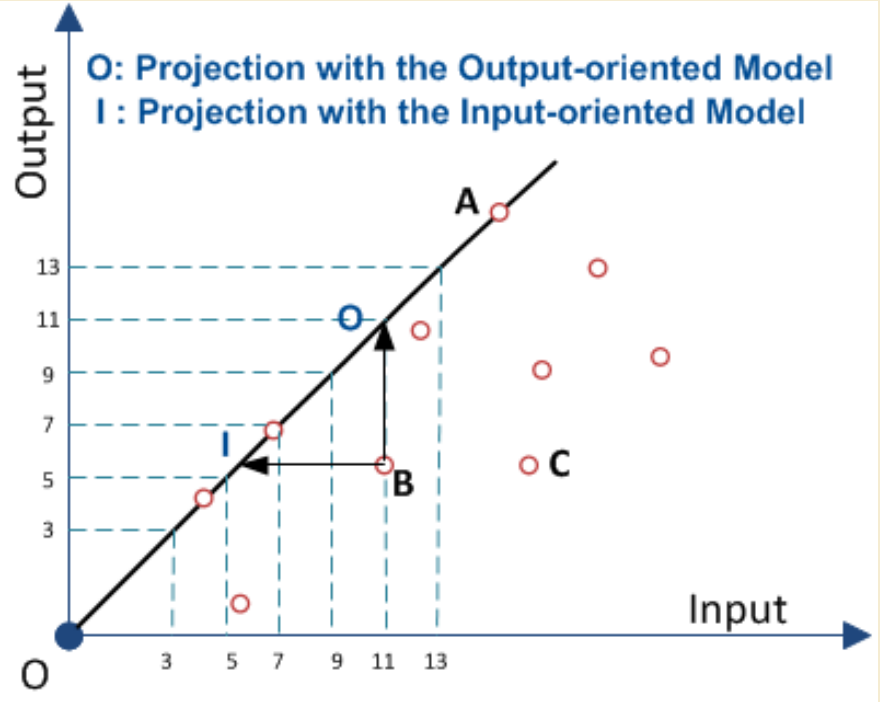
Specific Research Question

- Which DEA Models can be the most adequate to evaluate the performance of universities?

2. Data and DEA Method

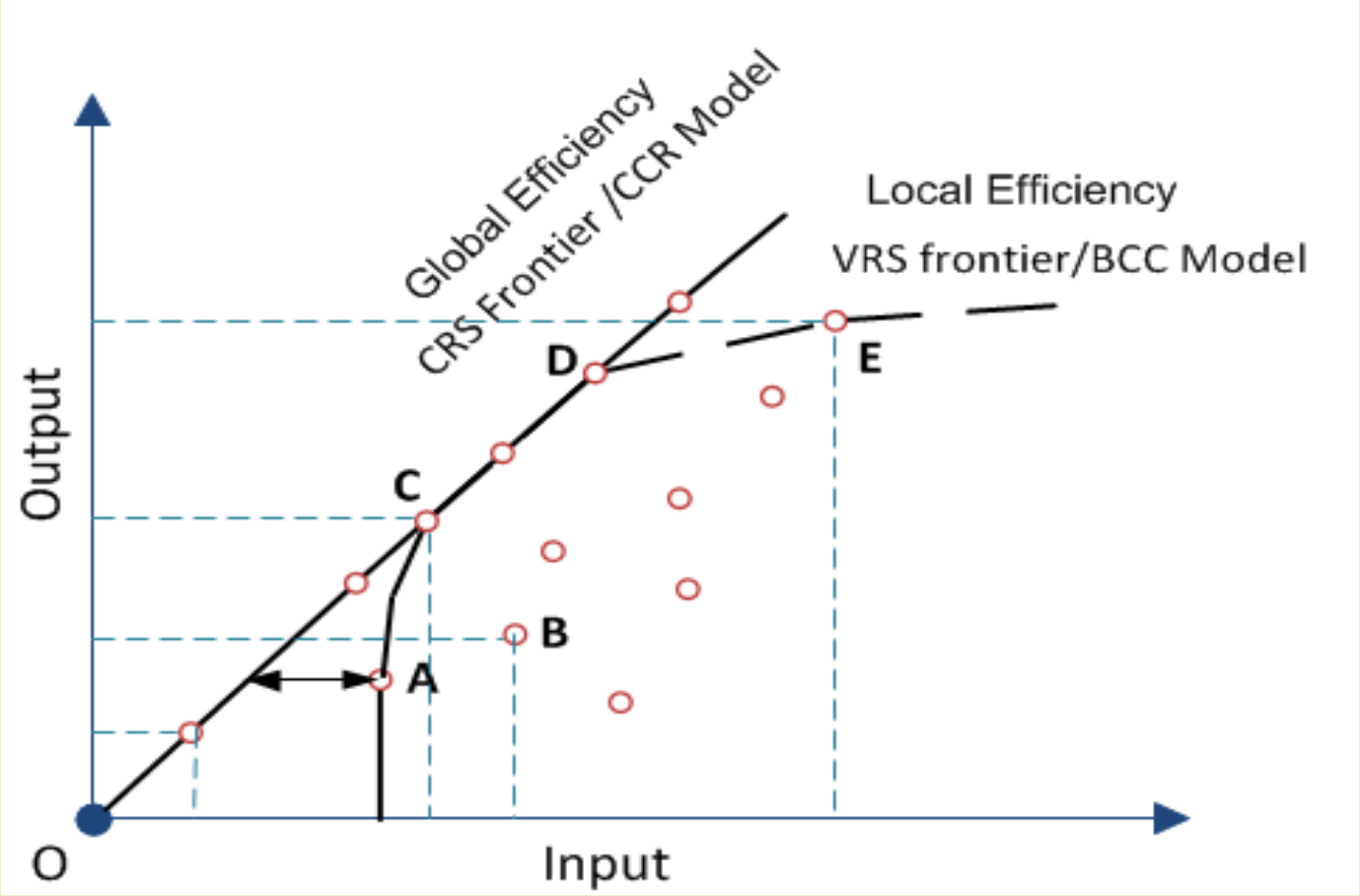
- **DEA is a mathematical programming technique that produces a single aggregate measure for each DMU in terms of its utilization of inputs to produce desired outputs (Kao and Hung, 2008).**

- **DEA offers two main possible orientations in efficiency analysis *(Charnes et al 1994)*:**
  - **Input-oriented models**
  - **Output-oriented models**

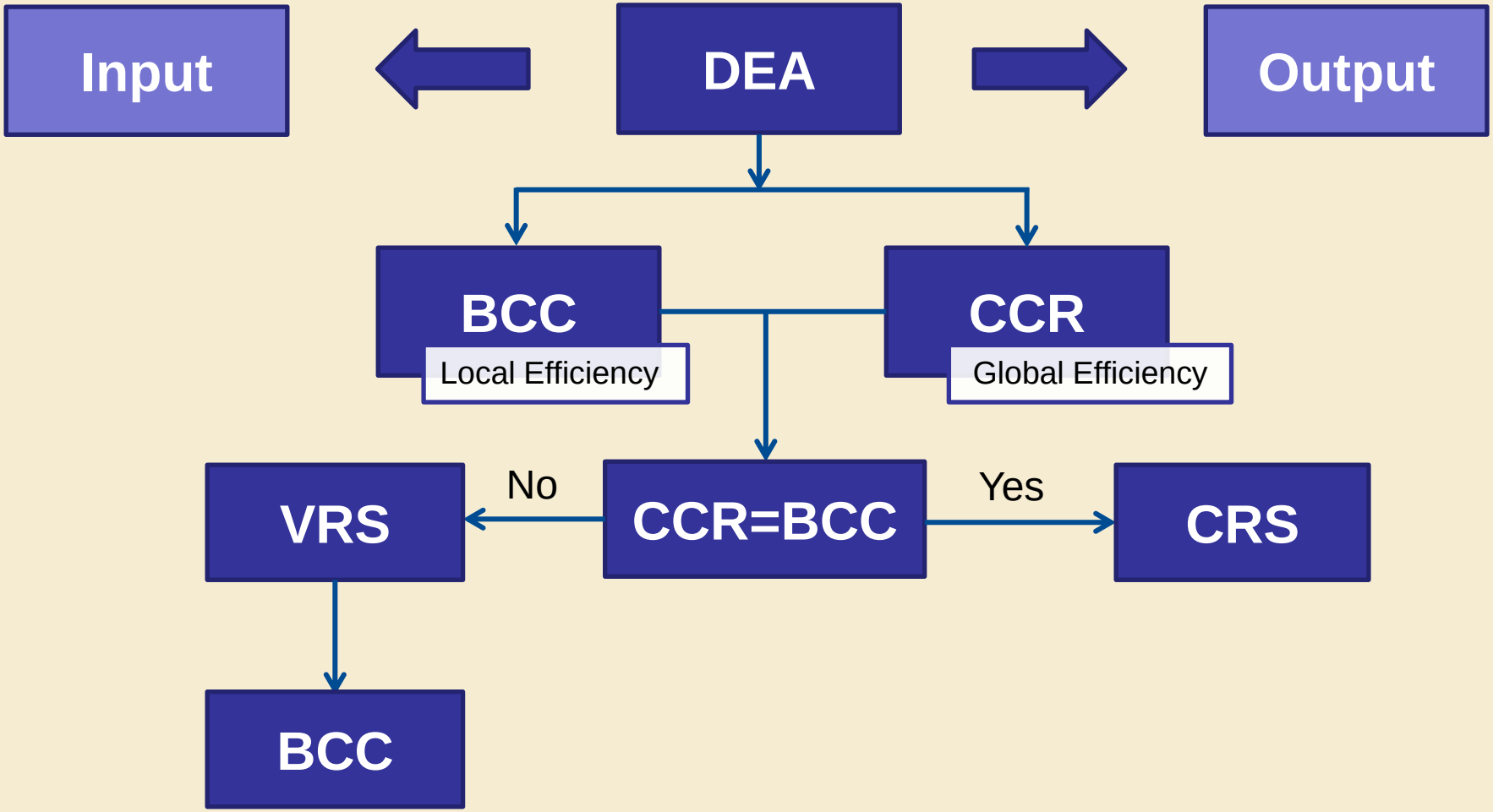


2. Data and DEA Method

CRS and VRS frontiers



2. Data and DEA Method



2. Data and DEA Method

- The participants of this study are 40 German universities.

- For altogether **23 universities** a complete dataset with these minimum quality requirements are available and were used.

Input
- ✓ Total budget
- ✓ Staff count

Output
- ✓ The number of graduates
- ✓ Publications

3. Case study

GAMS CCR Model:

```
$onsymxref
$onsymlist
$onuellist
$onuelxref

Sets
   i      Units     /DMU01*DMU23/
   j      inputs and outputs  /Budget, Staff, Publication, Graduates/
   ji(j) inputs              /Budget, Staff                        /
   jo(j)              outputs/                Publication, Graduates/;

Alias (i,k);

Table data(i,j)
            Budget          Staff      Publication       Graduates
DMU01       1173500000       13955      3502.6            6895;

parameter slice(j) slice of data
          eff_k(i) efficiency report;

Positive Variables v(ji) input weights
                   u(jo) output weights;

Variable eff efficiency;

Equations defe    efficiency defiition - weighed output
          denom   weighted input
          lime(i) 'output/input < 1';

defe..    eff =e= sum(jo, u(jo)*slice(jo));

denom..   sum(ji, v(ji)*slice(ji))=e=1;

lime(i).. sum(jo, u(jo)*data(i,jo)) =l= sum(ji, v(ji)*data(i,ji));

model dea /defe, denom, lime /;

set headers report / modelstat, solvestat, objval /;
parameter scenrep(k,headers) solution report summary
          scopt /SkipBaseCase 1/;

set dict / K      .scenario.''
         slice    .param. data
         eff      .level. eff_k
         scopt    .opt.   scenrep /;
slice(j) =0; option lp=cplexd;
solve dea using lp max eff scenario dict;
display scenrep,eff_k;
```

GAMS Results:

- Compilation
- Symbol Listing
- Unique Element L
- Equation Listing
- Equation
- Column Listing
- Column
- Model Statistics
- Solution Report
- Execution
- Display

```
---   Total Time (ms)  15

No solution returned
GAMS Rev 238  WEX-WEI 23.8.2 x86_64/MS Windows          06/06/13 13:01:52 Page 8
A CCR Model Outputoriented(GUSS)
E x e c u t i o n


----     75 PARAMETER scenrep  solution report summary

       modelstat   solvestat      objval

DMU01       1.000       1.000       0.411
DMU02       1.000       1.000       0.508
DMU03       1.000       1.000       1.000
DMU04       1.000       1.000       0.637
DMU05       1.000       1.000       0.619
DMU06       1.000       1.000       0.300
DMU07       1.000       1.000       0.424
DMU08       1.000       1.000       0.658
DMU09       1.000       1.000       0.939
DMU10       1.000       1.000       0.386
DMU11       1.000       1.000       0.469
DMU12       1.000       1.000       1.000
DMU13       1.000       1.000       1.000
DMU14       1.000       1.000       0.440
DMU15       1.000       1.000       0.681
DMU16       1.000       1.000       1.000
DMU17       1.000       1.000       0.512
DMU18       1.000       1.000       0.352
DMU19       1.000       1.000       1.000
DMU20       1.000       1.000       1.000
DMU21       1.000       1.000       0.558
DMU22       1.000       1.000       0.381
DMU23       1.000       1.000       0.206


----     75 PARAMETER eff_k  efficiency report

DMU01 0.411,    DMU02 0.508,    DMU03 1.000,    DMU04 0.637,    DMU05 0.619
DMU06 0.300,    DMU07 0.424,    DMU08 0.658,    DMU09 0.939,    DMU10 0.386
DMU11 0.469,    DMU12 1.000,    DMU13 1.000,    DMU14 0.440,    DMU15 0.681
DMU16 1.000,    DMU17 0.512,    DMU18 0.352,    DMU19 1.000,    DMU20 1.000
DMU21 0.558,    DMU22 0.381,    DMU23 0.206
```

3. Case study

Unit name	Efficiency Score	
	CCR Model	BCC Model
University of Bielefeld	100	100
Johannes Gutenberg University Mainz	100	100
Technical University of Munich	100	100
University of Freiburg	100	100
University of Kassel	100	100
University of Kiel	100	100
Ludwig Maximilian University of Munich	41,05	100
University of Munster	63,67	100
University of Erlangen-Nuernberg	93,90	100
Frankfurt University	61,86	94,87
University of Leipzig	65,82	90,98
University of Hamburg	50,77	85,89
Technical University of Dortmund	68,07	73,82
Heidelberg University	46,91	72,44
University of Regensburg	55,82	69,85
Georg-August-University of Goettingen	43,97	69,60
Leibniz University of Hannover	51,18	67,54
Aachen University	29,98	61,56

Globally efficient

Locally efficient

3. Case study

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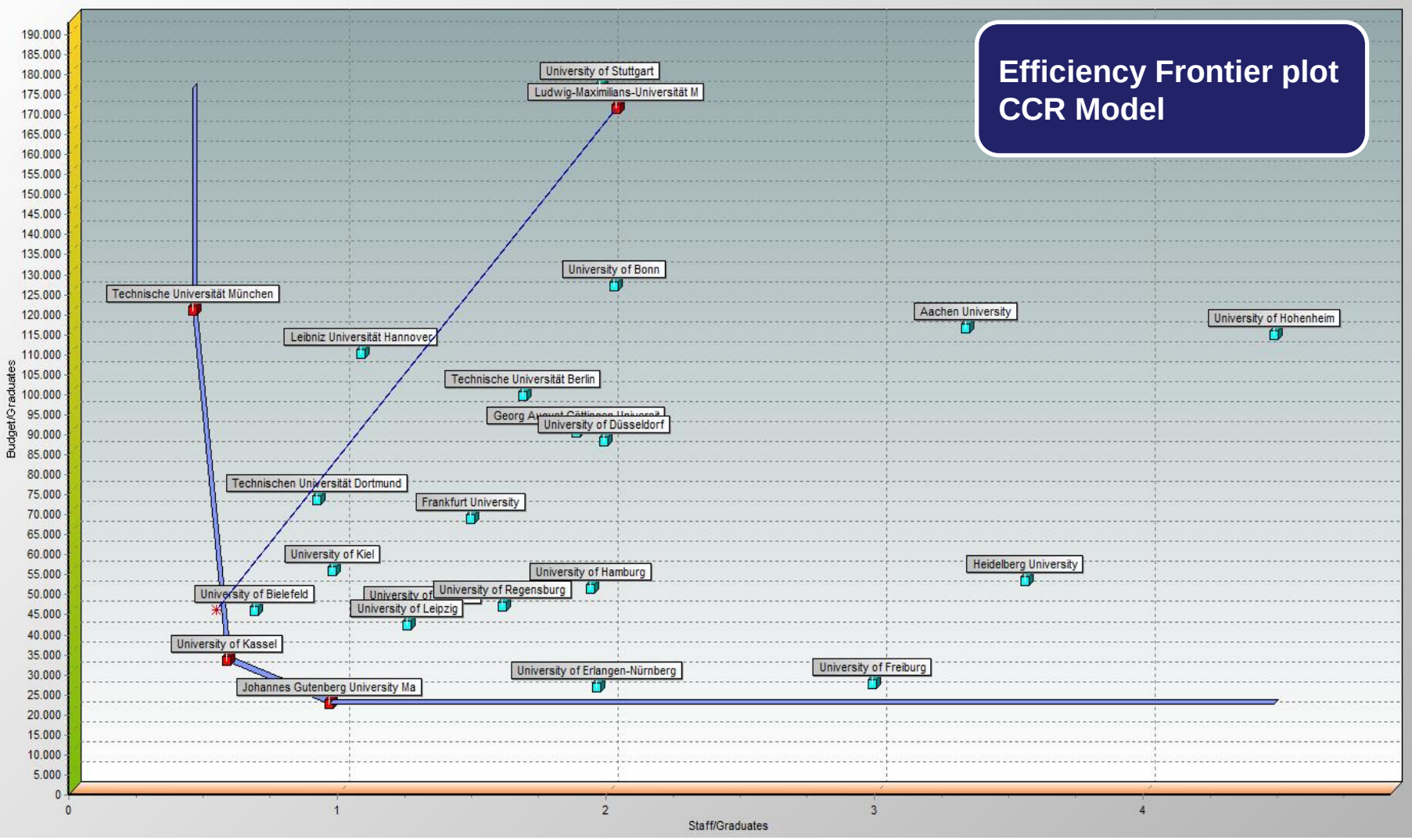

3. Case study

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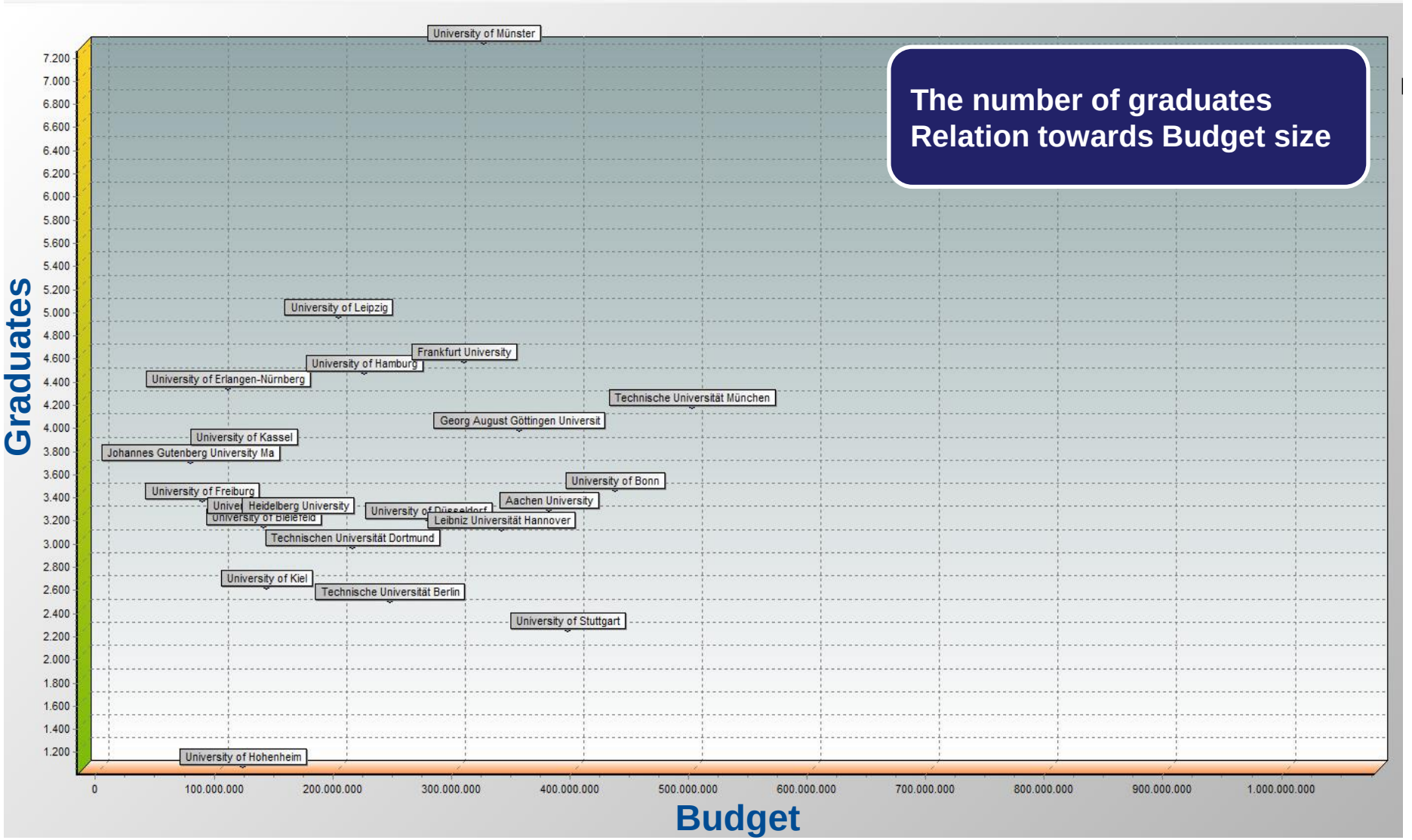

3. Case study

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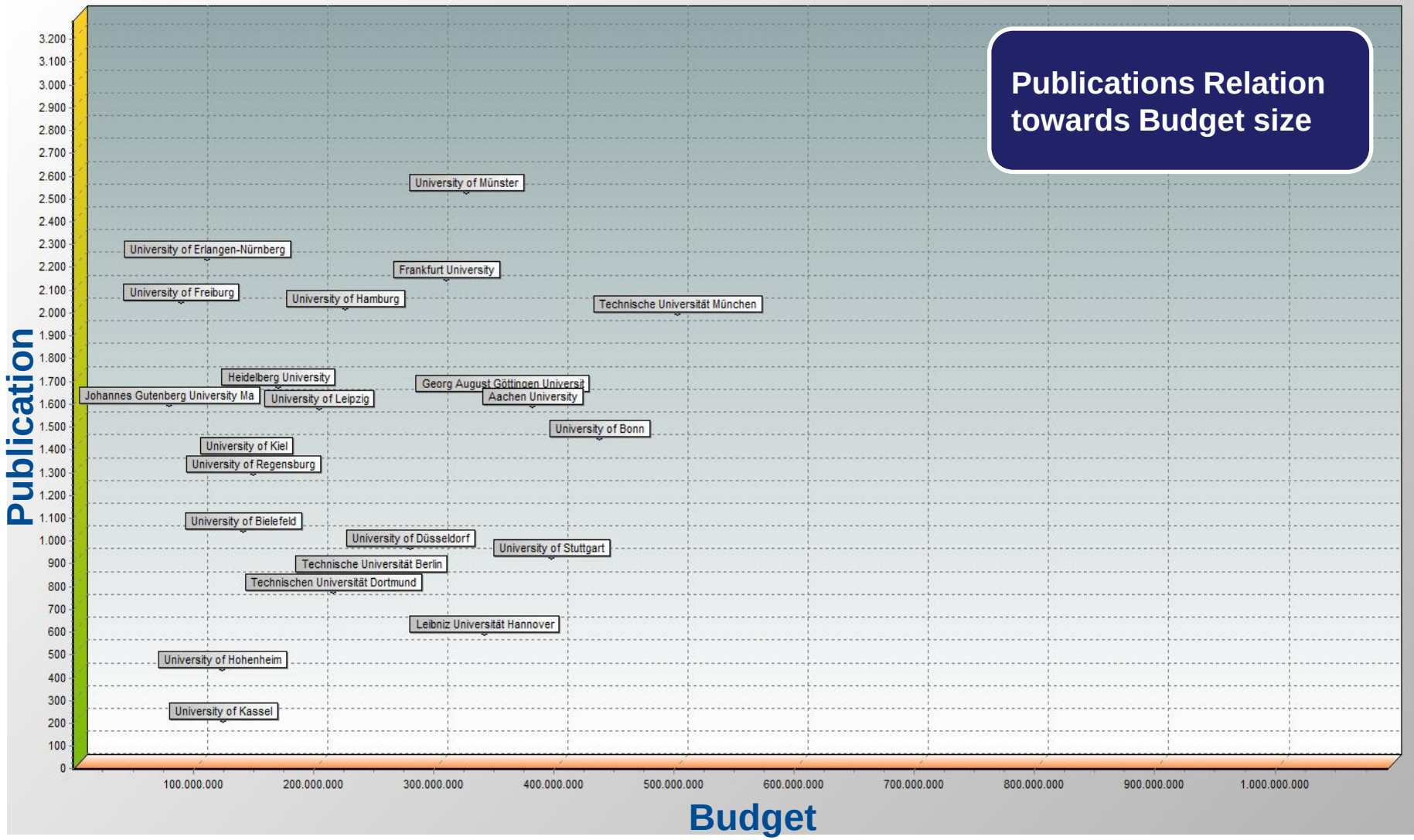

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Which DEA model is more appropriate for the performance analysis of the data in this study?

BCC / Output-oriented

The results of two DEA models have revealed, that the RTS has been a variable factor, therefore BCC model should be considered. (Charnes et al. 2007)

$\theta_{CCR} \neq \theta_{BCC}$ → Variable RTS

→ BCC Model

1. The lack of finances for higher education programs.
2. The lack of universities' control and supervision on some of the inputs.

(Fandel 2007; Gutierrez 2005)

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Thank you for your attention!

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