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ESM

FOM Hochschule | ild Institut für Logistik- & Dienstleistungsmanagement der FOM University of Applied Sciences

PIM

Bundesministerium für Bildung und Forschung

HELENA

Higher Education Global Efficiency Analysis

University System Production Function Simulation

Matthias Klumpp, HELENA Project, PIM, University of Duisburg-Essen

26th ESM Forum 2012, FOM, Essen, Germany, 22.10.2012

Agenda

1. Introduction
2. EUMIDA Data & DEA
3. GAMS Optimization for Switzerland
4. Outlook

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Research Interest

- International efforts to increase the performance of university systems
  - Economic & HE ranking competition
  - World Class University concepts & policies
  - HE system performance as direct input for national growth / wealth
- Astoundingly low research and knowledge level on HE system performance

Research Question

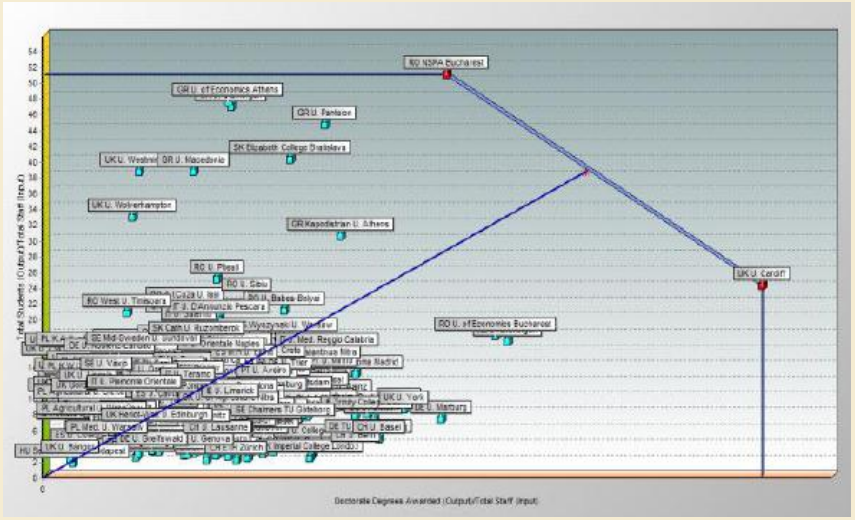
- How could modelling on a HE system level work (*proof of concept*)?

1. Introduction

Research Method

- ***Combination*** **of efficiency analyses (Data Envelopment Analysis) and productivity prognosis in the form of an optimization model for an example national HE system**

DEA



GAMS

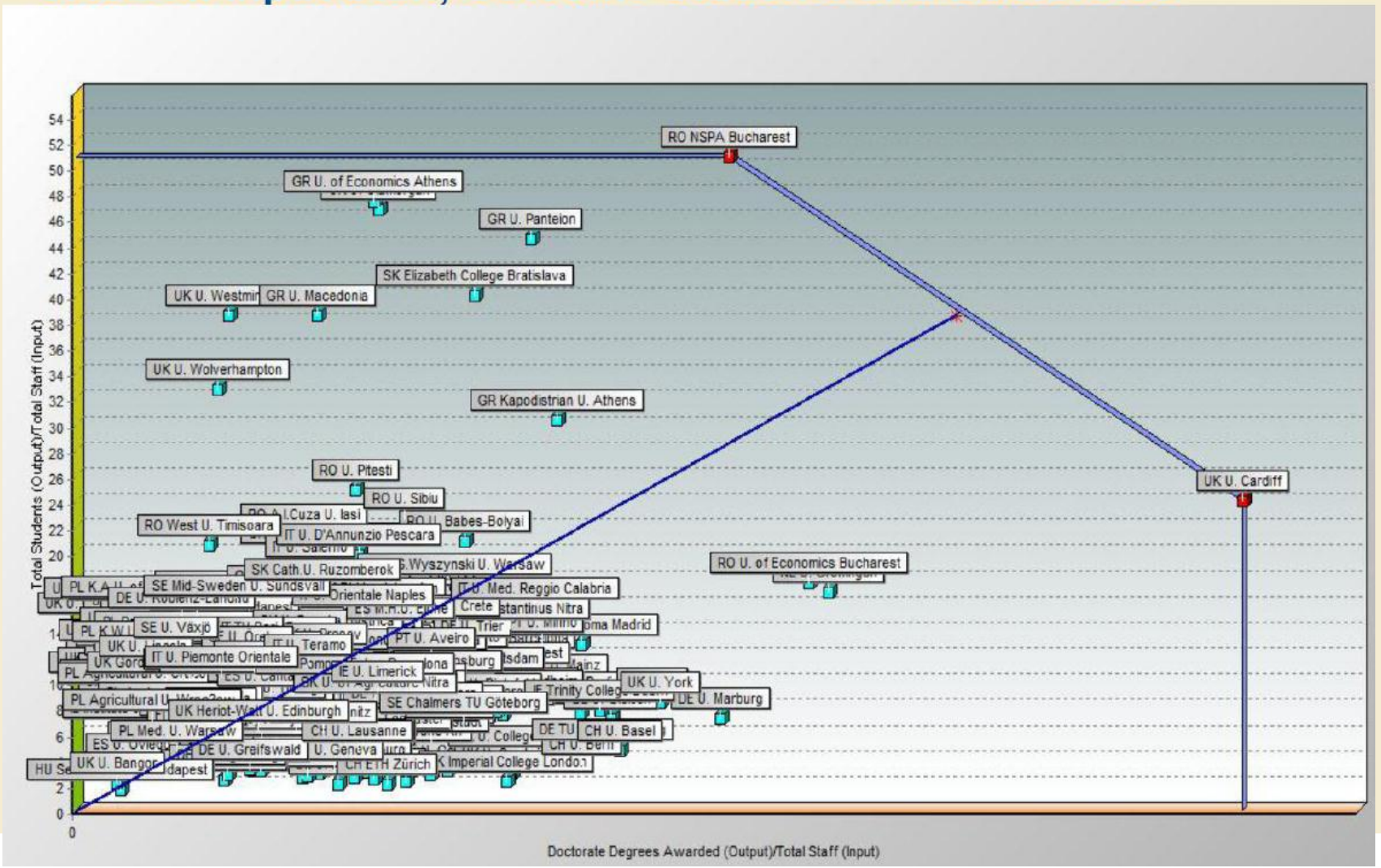
```
sets
i Universities / UBasel, UBern, UGeneva, ULausanne, UZurich, ETHZurich /
j Objectives / Research, Teaching, 3Mission, Medicine / ;

parameters
a(i) capacity in staff hours
/ UBasel 2473, UBern 3616, UGeneva 3872, ULausanne 2436, UZurich 5730, ETHZurich 6875
b(j) HE objectives demand
/ Research 10000, Teaching 10000, 3Mission 2500, Medicine 2500 / ;

table d(i,j) staff productivity
                Research        Teaching        3Mission        Medicine
UBasel          1               1.1             2               1
UBern           1               1               2.1             1.1
UGeneva         2.2             2.1             4.3             1.2
ULausanne       2               2.3             4.2             1.3
UZurich         1.5             1.8             3.0             1.4
ETHZurich       2.1             2.2             4.1             999 ;

variables
x(i,j) staff per objective
z total costs ;
positive variable x ;

equations
coststot        costs in total
supply(i)       staff supply
demand(j)       demand for HE objectives ;

supply(i).. sum(j, x(i,j)) =l= a(i) ;
demand(j).. sum(i, x(i,j)) =g= b(j) ;
coststot .. z =e= sum((i,j), 50000*d(i,j)*x(i,j)) ;

model HE /all/ ;
solve HE using lp minimizing z ;
display x.l, x.m ;
```

2. EUMIDA Data & DEA

- Data Source **EUMIDA project (European University Micro Data)** for European Universities (>2.300) from 27 countries (EU-27 minus France and Denmark plus Norway and Switzerland).
- Data from national statistics offices but not officially „approved/authorized“.
- **University selection** by doctorates awarded annually (>10), staff (> 100) and students (>10,000); exclusioin of distance learning universities
  → All selected universities „research active“ and leading in their countries.
- For altogether **370 universities** a complete dataset with these minimum quality requirements are available and were used.
- Specific universities/countries as e.g. Czeck Republic had to be excluded due to missing data (International Students „0“).

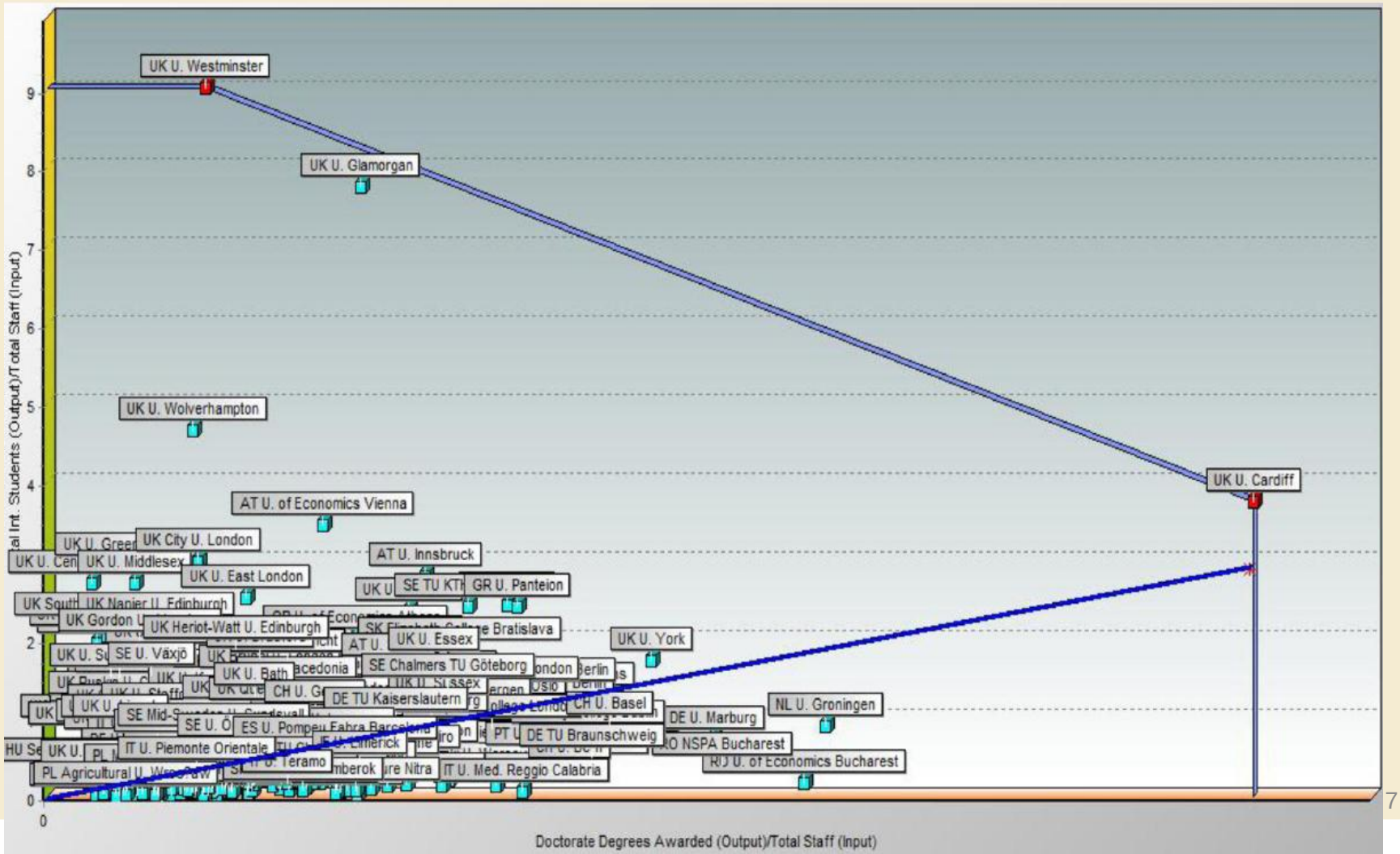
2. EUMIDA Data & DEA

CASE A: Input Staff, Outcome Students and Doctorates



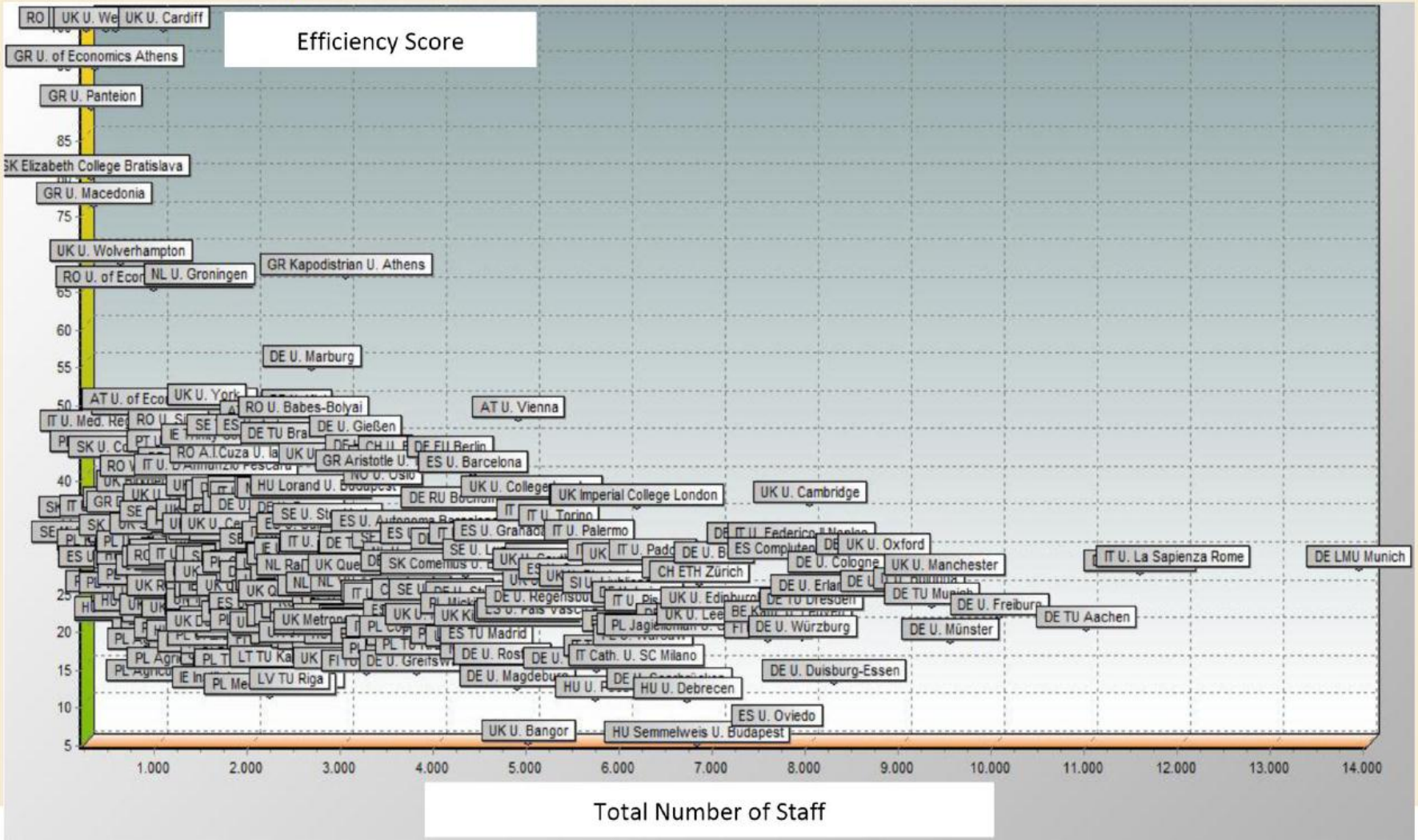
2. EUMIDA Data & DEA

CASE B: Input Staff, Outcome Intern. Students and Doctorates



2. EUMIDA Data & DEA

CASE C: Input Staff, Outcome Int. Students, Students & Doctorates



3. GAMS Optimiziation for Switzerland

- **Within the EUMIDA data set six Swiss universities were analyzed:**

EUMIDA ID	University Name	Found. Year	Univ. Hospital	Staff (Input)	Doctorate Degrees Awarded (Output)	Total Students (Output)	Total Int. Students (Output)	Efficiency (Case A without Int. Students)	Efficiency (Case B without Total Stud.)	Efficiency (Case C - all Output Indic.)	Efficiency (Case D - Restricted Weights 25%)
CH012	CH ETH Zürich	1855	No	6875	581	13572	3624	26.7%	26.7%	26.7%	9.9%
CH001	CH U. Basel	1460	Yes	2473	365	11312	2254	46.6%	46.6%	46.6%	20.2%
CH002	CH U. Bern	1528	Yes	3616	496	13014	1258	43.3%	43.3%	43.3%	11.0%
CH004	CH U. Geneva	1559	Yes	3872	272	12212	4063	22.2%	24.4%	24.4%	16.3%
CH005	CH U. Lausanne	1537	Yes	2436	186	11113	1699	24.1%	24.1%	24.1%	17.0%
CH009	CH U. Zürich	1500	Yes	5730	670	24123	3165	36.9%	36.9%	36.9%	15.1%

3. GAMS Optimiziation for Switzerland

Characteristics:

- **Six universities, four objectives for the HE system: research, teaching, third mission and medicine (SETS)**
- **Capacity restriction in staff hours per year and assumed objective demand (PARAMETERS)**
- **Staff productivity (TABLE) detailed from the *DEA results***
- **Total cost function based on staff cost (50.000 Euro p.a. on average) as objective function to be minimized (EQUATION)**
- **LP minimizing function**

- **{Discussion: LP maximizing objective outcome more appropriate to HE}**

3. GAMS Optimiziation for Switzerland

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                           LOWER      LEVEL      UPPER     MARGINAL

---- VAR z                 -INF   2.1439E+9       +INF         .

  z  total costs


**** REPORT SUMMARY :        0     NONOPT
                             0  INFEASIBLE
                             0  UNBOUNDED
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G e n e r a l   A l g e b r a i c   M o d e l i n g   S y s t e m
E x e c u t i o n


----     36 VARIABLE x.L  staff per objective

              Research    Teaching    3Mission    Medicine

UBasel                                2473.000
UBern                    3589.000      27.000
UGeneva                  1372.000                 2500.000
ULausanne     2436.000
UZurich       5730.000
ETHZurich     1834.000    5039.000


----     36 VARIABLE x.M  staff per objective

              Research    Teaching    3Mission    Medicine

UBasel       10000.000   10000.000                50000.000
UBern         5000.000                            50000.000
UGeneva      10000.000                55000.000
ULausanne                10000.000   50000.000     5000.000
UZurich                  10000.000   15000.000    35000.000
ETHZurich                            40000.000 4.988500E+7
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3. GAMS Optimiziation for Switzerland

Results

- **As third mission and teaching objectives were associated with the highest cost / staff input the most efficient universities Basel, Bern and Geneva should be attributed theses tasks, also medicine.**
- **This is no feasible policy recommendation as distribution on institutional level not feasible – but sometimes still used e.g. in merger discussions.**

	Research	Teaching	3Mission	Medicine
UBasel			2473.000	
UBern		3589.000	27.000	
UGeneva		1372.000		2500.000
ULausanne	2436.000			
UZurich	5730.000			
ETHZurich	1834.000	5039.000		

4. Outlook

Impact

- **Proof of concept showed feasibility of HE system optimization calculation**
- **But historically proven wrong concepts of “planification” (1970s) have to be overcome by detailed data gathering and heuristic approaches for detailed resource allocation for example**

Future Research

- **Further steps to include more productivity indicators**
- **Test other optimization mechanisms beside LP optimization**

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Thank you for your attention!

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http://www.helena.wiwi.uni-due.de

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