International Data Envelopment Analysis in Higher Education: How Do Institutional Factors Influence University Efficiency?

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Abstract: Institutional factors in higher education like for example being a private or a public higher education institution are major differences in the concept of higher education. Therefore many research and practical discussions are evolving around question like, e.g., "Are private universities more efficient than public ones?" or: "Are large universities with all kinds of study programs more efficient than small universities with specialized fields like business and engineering?" In this research paper data for 33 German universities is analyzed and compared in order to find a tentative answer towards these questions. As a research method the data envelopment analysis (DEA) with a strong research application background in higher education research is used. A BCC model assuming variable returns to scale is implemented due to existing research results regarding the RTS situation in universities, nevertheless also CCR model is used. As input and output indicators the following data sources are used: Budget (input), staff (input), graduates (output) and third party funds acquisition (output).

Keywords: higher education; efficiency; institutional factors; DEA; BCC model; CCR model

JEL codes: M11, H83

1. Introduction

As efficiency is an important research question in higher education, especially in the face of a majority of university budgets worldwide raised from the public (state and study fees) (Berbegal-Mirabent J., Lafuente E., Solè F., 2013; Edgara F., Geare A., 2013; Worthington A. C., Higgs H., 2011; Shin J. C., Toutkoushian R. K., 2011; Sarrico C. S., Teixeira P., Rosa M. J., Cardoso M. F., 2009; Taylor B., Harris G., 2004), influencing factors such as the *institutional setup* of higher education institutions are of special interest as they allow the notion of improving efficiency in higher education and therefore "getting more for less". Especially strategic university decisions derived from efficiency demands like, e.g., *merger* or *franchise decisions* are of high relevance for higher education research and management (Drowley W., Lewis D., Brooks S., 2013; Klumpp M., Zelewski S., 2012; Healey N., 2013).

Institutional factors in higher education include the question of private or a public higher education institutions or the size of institutions as well as their type (in two-type systems). Usually it is interesting to know which kinds of higher education institutions (HEI) are the most efficient ones. If there could be an answer to this question, it would affect the future strategy in higher education and change the focus of institutional development.

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In Germany there are various kinds of HEI, but the two most relevant are the "Universität" and the "Fachhochschule". The biggest difference between both was that in the past that basic research and doctoral theses were only reserved for the "Universität". But in recent years, this has been changed step by step, not "de jure" but "de facto" by collaborative PhD programs and projects (Bode C., Becker W., Habbich C. & Klofat R., 1997; Klumpp M. & Teichler U., 2008; Kramer J., Nagy G., Trautwein U., Lüdtke O., Jonkmann K., Maaz K. & Treptow R., 2011; Müller W., Pollak R., 2004).

2. Research Method

In this research German university data is analyzed and compared in order to find a first answer towards the question of the influence of institutional factors on higher education efficiency. As a research method the data envelopment analysis (DEA) with a strong research application background in higher education research is used (Johnes J., 2006; Klumpp M., Maleki G., 2013; Luptacik M., 2002). A BCC model assuming variable returns to scale is implemented due to existing research results regarding the RTS situation in universities (Maleki G., Klumpp M., Cuypers M., 2012). As input and output indicators the following data sources are used: Budget (input), staff (input), graduates (output) and third party funds acquisition (output).[1] These two output areas are assumed to be good representations of the "performance" of HEI in the areas of teaching and research. Though there are multiple further objectives and outcome areas for HEI (third mission etc.), these can be seen as the two "core areas" for HEI performance.

For this research data of 33 German HEIs was collected. Furthermore, 23 of these HEIs are "Universitäten" and the remaining 10 are "Fachhochschulen". Altogether 4 out of these 33 HEI are Universities of Technology. Please check the appendix for the table of all applied data for this research. Due to lack of data of private HEIs as well as for clarity reasons this research has 3 different HEI categories:

- "Universität" (University)
- "Fachhochschule" (University of Applied Sciences)
- "TechnischeUniversität" (University of Technology)

For this data DEA efficiency scores were calculated (CCR vs. BCC) and the mean and median for all these efficiency scores are also determined. Table 1 shows the number of data for every category.

Table 1   HEI Categories

	General	Technology	∑
"Universität"	19	4	23
"Fachhochschule"	10	0	10
∑	29	4	33

3. Results and Discussion

Table 2 shows the efficiency scores for all HEIs taken into account in this research.

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[1] The authors are aware that there is a correlation (of about 0.62) and interdependency between the inputs *budget* and *staff*. However, the relations between those two inputs are not constant at "Universität" and "Fachhochschule", because salary at the "Fachhochschule" is less as they are at the "Universität" (approximately just two thirds). Beyond that the German professor salary system "C" with fixed wages and only seniority increases has been changed to the "W" system with individual up to additional 30% performance-based payments, so that the salaries will become even more diverse in the future.

Table 2   Efficiency Scores

No.	HUC	CCR	BCC
1	AACH_TU	57.24%	100.00%
2	BERL_TU	62.73%	68.11%
3	BIEL_UN	59.32%	82.52%
4	BONN_UN	16.18%	26.07%
5	DORT_TU	34.20%	48.81%
6	DUSS_UN	35.06%	38.69%
7	FRAM_UN	45.91%	66.38%
8	FREI_UN	100.00%	100.00%
9	GOTT_UN	36.68%	45.53%
10	HAMB_UN	44.05%	59.93%
11	HAMB_GW	38.25%	48.65%
12	HEID_UN	76.33%	100.00%
13	HOHE_UN	16.34%	17.60%
14	KASS_UN	66.14%	100.00%
15	KIEL_UN	67.49%	74.28%
16	LEIP_UN	51.89%	84.91%
17	MAIN_JP	100.00%	100.00%
18	MUNI_LM	42.05%	100.00%
19	MUNI_TU	100.00%	100.00%
20	MUNS_WW	47.49%	100.00%
21	NURE_UN	99.09%	100.00%
22	REGE_UN	46.51%	49.74%
23	STUT_UN	55.17%	59.97%
24	AACH_HS	35.74%	40.19%
25	AUGS_HS	41.06%	60.80%
26	BERL_TW	100.00%	100.00%
27	COLO_FH	52.86%	61.48%
28	DUSS_FH	100.00%	100.00%
29	ERFU_FH	39.55%	68.80%
30	FULD_HS	100.00%	100.00%
31	MITH_TH	33.76%	37.73%
32	SCHM_FH	64.45%	100.00%
33	TRIE_HS	76.83%	90.13%

First of all, as indicated before, the assumption of variable RTS is valid also in this dataset as the BCC model states more efficient universities than the CCR model [cp. 17]. Second, it is obvious that universities as well as universities of applied sciences are both among the most efficient institutions in this dataset.

These efficiency scores have to be analyzed further. The following tables will show the mean and median for the different categories. At first Table 3 will show the mean and the median for the plain distinction between "Universität" and "Fachhochschule".

Table 3   Mean (Median) "Universität" vs. "Fachhochschule"

Category	CCR	BCC
"Universität"	56.44% (51.89%)	72.66% (74.28%)
"Fachhochschule"	64.43% (58.66%)	75.91% (79.47%)

It occurs that "Fachhochschulen" on average are *more efficient* than "Universitäten" for this dataset in Germany, though in the BCC case only by 3.3%. This is surely due to the teaching area with the output indicator graduates. In this context it has to be stressed that the used indicator graduates does not differentiate between bachelor (BA) and master (MA) level graduates.

So how about a general HEI in relation to a technology one? Secondly Table 4 will show the mean and median for the distinction between a general HEI and an HEI of Technology.

Table 4   Mean (Median) General vs. Technology

Category	CCR	BCC
General HEI	58.21% (51.89%)	72.88% (74.28%)
HEI of Technology	63.54% (59.99%)	79.23% (84.06%)

It seems also that Technology HEIs are more efficient than General HEIs. These two previous findings would raise the question which is the most efficient HEI: "Fachhochschule" or HEI of Technology? Table 5 will show mean and median for all three analyzed categories.

Table 5   Mean (Median) all Categories

Category	CCR	BCC
"Universität"	54.94% (47.49%)	71.28 % (74.28%)
"Fachhochschule"	64.43% (58.66%)	75.91 % (79.47%)
HEI of Technology	63.54% (59.99%)	79.23 % (84.06%)

The results above provide the following picture: HEI of Technology are more efficient than "Fachhochschulen", which are more efficient than "Universitäten". This has to be seen critically as only 33 HEI were included into the analysis and in the categories only 4 universities of technology.

4. Conclusions

As already the efficiency differences among the three reported institutions categories universities, universities of technology and universities of applied sciences in Germany are very interesting, further research is clearly needed in order to establish

● For this research agenda outlook it first would be interesting to take more international data from HEIs worldwide into account. This could be a promising research setting as there are several places where two or three HEI categories are present in one city, for example Munich, Berlin and Hamburg in Germany, Gothenburg in Sweden, Boston in the US, Zurich in Switzerland as well as Vienna in Austria—providing for a similar comparative setting (regional interaction and business activity, higher education framework).

● Also it would be appealing to include the data of private HEIs into the research as a third dimension. With this included dimension there would be at least 6 categories to analyze in detail:

(1) Public University

(2) Private University

(3) Public University of Technology

(4) Private University of Technology

(5) Public University of Applied Sciences

(6) Private University of Applied Sciences

Finally, *further* institutional factors influencing efficiency in higher education shall be identified besides the obvious ones discussed here–for example the gender setup among researchers and individual units within HEI, the subject mix, the institutional age, profile and history (e.g., "Are religious oriented HEI more or less productive than secular/state ones?") or the specific state legislation framework (e.g., "Do objective agreements really enhance efficiency among HEI?").

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Appendix

Table 6   Data of German Higher Education Institutions

No.	HEI Name	HUC	Budget (2011)	Staff (2011)	Third Party Funds (2011)	Graduates (2011)
1	University of Aachen	AACH_TU	382478700	11017	102606100	3314
2	Technical University of Berlin	BERL_TU	248665000	4230	57096700	2525
3	University of Bielefeld	BIEL_UN	142284000	2143	26059700	3170
4	University of Bonn	BONN_UN	438631000	7021	2476300	3483
5	Technical University of Dortmund	DORT_TU	217048000	2711	14442300	2988
6	University of Düsseldorf	DUSS_UN	281444709	6377	40968500	3226
7	University of Frankfurt	FRAM_UN	310885429	6801	58282100	4591
8	University of Freiburg	FREI_UN	90000000	10090	71115300	3389
9	University of Göttingen	GOTT_UN	357500000	7511	52561200	4003
10	University of Hamburg	HAMB_UN	226646000	8671	53314900	4500
11	University of Hannover	HANN_GW	342900000	3378	37609700	3143
12	University of Heidelberg	HEID_UN	171477283	11606	87319600	3271
13	University of Hohenheim	HOHE_UN	124847000	4904	3085900	1096
14	University of Kassel	KASS_UN	125240000	2205	16763800	3857
15	University of Kiel	KIEL_UN	144219300	2544	36162000	2636
16	University of Leipzig	LEIP_UN	205021800	6199	41195900	4976
17	University of Mainz	MAIN_JG	80427400	3548	48409300	3723
18	LMU München	MUNI_LM	1173500000	13955	154655600	6895
19	Technical University of Munich	MUNI_TU	503100000	1868	103862100	4199
20	University of Münster	MUNS_WW	327400000	9566	56639300	7349
21	University of Erlangen-Nürnberg	NURE_UN	112331901	8505	76738300	4362
22	University of Regensburg	REGE_UN	150200000	5226	31869400	3263
23	University of Stuttgart	STUT_UN	398797000	4462	66936800	2273
24	Fachhochschule Aachen	AACH_HS	66049761	3628	9028188	1178
25	Fachhochschule Augsburg	AUGS_HS	24468100	639	2230000	528
26	Hochschule für Technik und Wirtschaft Berlin	BERL_TW	54700000	530	7700000	2147
27	Fachhochschule Köln	COLO_FH	116450920	1401	11990306	2439
28	Fachhochschule Düsseldorf	DUSS_FH	24200000	472	2500000	1319
29	Fachhochschule Erfurt	ERFU_FH	27452633	393	3708137	378
30	Hochschule Fulda	FULD_HS	28323200	389	9560089	978
31	TechnischeHochschuleMittelhessen	MITH_TH	55800000	866	4300000	803
32	Fachhochschule Schmalkalden	SCHM_FH	12811800	218	1010400	414
33	Fachhochschule Trier	TRIE_HS	40132000	403	6181533	1058