The similarities in efficiency of universities and universities of applied sciences in Lower Saxony

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Abstract

Due to the advancing economisation and the associated discussion on the distribution of public budgets and tax revenues, the efficiency of higher education institutions is increasingly coming into focus. Since the 2000s, more and more studies on the efficiency of German universities have been published. While the research focus and the applied methods differ between these studies, the majority have in common that they exclude universities of applied sciences from the data set. The aim of this paper was to show differences and commonalities in efficiency between universities of applied sciences and universities in Lower Saxony. Based on an exclusive data set, the efficiency values were estimated using Data Envelopment Analysis and Stochastic Frontier Analysis including the analysis of efficiency changes, influencing factors and ranking differences between both methods. The central findings are that (1) there existed no significant differences in efficiency between universities and universities of applied sciences, (2) that an alignment process took place between 2010 and 2017 leading to a higher similarity in efficiency and (3) that the ranking and the level of efficiency depends very much on the choice of method stressing the necessity to settle on one method when using it for monitoring purposes.

JEL-Classification: C14, C23, C61, D61, I22, I23
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1 Introduction

Against the background of advancing economisation and the associated discussion on the distribution of public budgets and tax revenues, the public increasingly expects universities (of applied sciences) to pursue not only idealistic values by conducting research and teaching, but also to generate visible and measurable benefits and added value for the society. Thus, the higher education institutions are supposed to spend their budgets efficiently. Politics in Lower Saxony reacts to the idea of performance with instruments of higher education management. One of the instruments is the performance-related allocation of funds, which accounts for 10 % of the total budget for public funding, an other one target agreements with respect to desired development goals.[1]

The efficiency of higher education institutions is thus increasingly coming into focus. Since the 2000s, more and more studies on the efficiency of universities (of applied sciences) in Germany have been published. Two methodologies, the Data Envelopment Analysis (DEA) and the Stochastic Frontier Analysis (SFA), have established themselves as popular measurement methods. Fandel (2007), Agasisti and Pohl (2011), Singh (2013), Gawellek and Sunder (2016) and Wohlrabe et al. (2019) used the DEA for the estimation and assessment of German universities. In Kempkes and Pohl (2008), Johnes and Schwarzenberger (2011), Olivares and Wetzel (2014) and Gralka (2018a) the SFA is applied. Both methods are used by Kempkes and Pohl (2010) and Eck et al. (2015).

While the research focus and the applied methods differ between the cited studies, the majority have in common that they exclude universities of applied sciences from the data set (Fandel, 2007, Kempkes and Pohl, 2008, 2010, Agasisti and Pohl, 2011, Johnes and Schwarzenberger, 2011, Singh, 2013, Gralka, 2018a, Wohlrabe et al., 2019). Consequently, universities and universities of applied sciences are usually not evaluated together or their efficiency is usually not compared. The reasons usually given for excluding universities of applied sciences are that their structure, characteristics and objectives are too different from those of universities: [2] Universities of applied sciences are more application-oriented with a clear focus on teaching. Research takes place only rarely and the doctoral training of graduates can only be carried out in cooperation with universities, as universities of applied sciences are not allowed to award doctorates. Nevertheless, due to the reform processes in the German higher education sector in recent years, the differences between universities and universities of applied sciences have increasingly narrowed, leading them to compete for students, staff and research funds in a common higher education market (Olivares and Wetzel, 2014, p. 655). Finally, despite their different orientation and characteristics, both forms of higher education institutions compete for the same public funds. Additionally, within universities, between the areas of education and research, exist a high variety in the level of research activities as well. In the study at hand, the efficiency of all higher education institutions was evaluated regardless of being a university or university of applied sciences.

The aim of this paper was to show differences and commonalities in efficiency between universities of applied sciences and universities in Lower Saxony. The questions addressed are whether there is a significant difference in efficiency between universities and universities of applied sciences or whether the differences refers more to characteristics within

[1] Education policies are due to the federal structure of Germany in the responsibility of each Federal State. In Lower Saxony the funding is organised and distributed by the Ministry of Education and Culture (Niedersächsisches Ministerium für Wissenschaft und Kultur, MWK). The procedures for allocating funds may differ between the single Federal States, but the idea of performance is common to all.

[2] Singh (2013), Gawellek and Sunder (2016) and Wohlrabe et al. (2019) focus on efficiency under the funding scheme excellence initiative (*Exzellenzinitiative*). As this is only available for universities, universities of applied sciences are simply not part of their analysis.

the universities and universities of applied sciences.

For this purpose, an exclusive data set (*Hochschulkennzahlensystem*, HKS) compiled by the Ministry of Education and Culture of Lower Saxony (MWK) in cooperation with the universities under consideration has been used. As a result, the study is limited to universities in Lower Saxony. The advantage of the HKS in comparison to the higher education statistics provided by the Federal Statistical Office is, that it provides the true accounting values of the universities (of applied sciences). Additionally, all higher education institutions in Lower Saxony are equally subject to the distribution requirements for the allocation of funds and the booking and accounting specifications. Thus, the efficiency results can be easily compared with each other, as the administrative and organisational terms are the same for all universities (of applied sciences) in Lower Saxony.[3]

The efficiency values are determined on the basis of DEA and SFA. The Malmquist Index shows the development of efficiency for the DEA between 2010 and 2017. In addition, a Tobit model is used to investigate factors that influence the level of efficiency and are not directly within the university's sphere of influence. The differences between DEA and SFA are also highlighted.

The results show that regardless of the applied method, universities and universities of applied sciences as a whole acted similarly efficient. When differentiating by the focus of the higher education institutions, only the universities of applied sciences for social sciences exhibited significant differences in efficiency. Between 2010 and 2017 an alignment process took place, in which particularly universities and universities of applied sciences with high inefficiencies were able to improve. As with regard to influencing factors, the efficiency was determined positively by market share, i. e. the larger a subject group, the more likely it was to operate efficiently. A comparison of the DEA and SFA efficiency values shows that the ranking and the level of efficiency depended very much on the choice of method.

The rest of the text is structured as follows. In section 2 the data basis and a descriptive analyses of the higher education institutions in Lower Saxony are presented. The methodology, results and analysis of the DEA as well as the related procedures of the Malmquist Index for efficiency development and the Tobit model for determining influencing factors are given in section 3. In section 4 the methodology and efficiency results of the SFA are presented and the differences to the results of the DEA discussed. In section 5 the findings are summarised and discussed.

2 Data set and descriptive analysis

The data set *Hochschulkennzahlensystem* (HKS) is compiled by the Ministry of Science and Culture of Lower Saxony (*Niedersächsischen Ministerium für Wissenschaft und Kultur, MWK*) in close cooperation with the universities and universities of applied sciences of Lower Saxony. The universities and universities of applied sciences provide detailed information on income, expenditure, stock figures (e.g. usable area), personnel and students, which is validated, coordinated and processed in the context of important key figures. The data includes, for example, the public funding received, third-party funding income and number of graduates. The data set is used to regularly generate key performance indicators for monitoring purposes.[4] For this paper, the data set has been made available exclusively to examine the efficiency of Lower Saxony's universities and universities of applied sciences.

[3]Due to the differences in education policies, the granting of funds and the accounting system, the comparison of efficiency results between different Federal States is somewhat limited.

[4]The key figures are used to reallocate public funding and to monitor the development of the performance. Unfavourable changes can be detected and tackled at an early stage.

At the time of writing, the data set includes 32 variables for the years 2010–2017 and 17 higher education institutions broken down by 56 different teaching and research units. The considered higher education institutions and their abbreviation as well as the different teaching and research units are given in Table 8 and Table 9 in the Appendix. In addition, the detailed university specific information is summarised by different types into 5 focus groups. The single focus groups are: University of applied sciences for social sciences (UAS 1), university of applied sciences for technical sciences including design (UAS 2), university for social sciences (including law) and arts (Uni 1), university for natural sciences including computer sciences (Uni 2) and university for engineering (Uni 3). University hospitals and medical universities are not part of the HKS data set and are thus excluded from this study.

Various adjustments were made to the data set. All teaching and research units of the universities and universities of applied sciences that were not assigned to a focus group were excluded from the data set. This applies in particular to veterinary medicine and human medicine, but also to some higher education units in the transition period after mergers or reorganisations. Different, individually listed locations of a university or university of applied sciences were combined into one unit. Observations with values smaller or equal to zero for the selected variables government funding, third party funds, students and graduates were excluded from the data base.[5] Therefore, the panel data set was unbalanced with 249 different university units, 8 years and a total of 1840 observations.

For the Tobit regression presented in subsection 3.4 the data set was complemented by the local gross domestic product (GDP) per capita. The information is derived from the Regional Accounts provided by the statistical offices of the federal states (Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder (VGRdL), 2019).

In 2017 the sum of public funding accounted for 1137.6 million Euro.[6] With a total amount of 869 million Euro, the major part of public funding (76 %) is alloted to universities. 268.6 million Euros (24 %) is allocated to universities of applied sciences.[7]

Additional financial means for research can be raised from third party funds: in 2017 these funds summed up to 411.7 million Euros in Lower Saxony. Universities were most successful by obtaining 92 % of the third party funds corresponding to 869 million Euros. Universities of applied sciences received 34.6 million Euros from third party funds which is 8 % of the total amount.

185.9 thousand students were overall enrolled in Lower Saxony in 2017, 131.4 thousand (71 %) in universities and 54.5 thousand (29 %) in universities of applied sciences. In the same year, 11.6 thousand persons graduated from universities and 7.4 thousand persons from universities of applied sciences totalling up to 19 thousand graduates. In percentage shares the distribution of the graduates between universities and universities of applied sciences is 61 % and 39 %.

Comparing the above described characteristics, the sum of universities of applied sciences receive 31 % of the public funding of universities. Simultaneously, the amount of students educated there represents 42 % of the university students. As with regard of graduates, universities of applied sciences generate 64 % of the amount of university graduates. In case of third party funds, universities of applied sciences are able to raise 9 % of the sum of third party funds obtained by universities. Summarising, universities of applied sciences use the relatively lower public funds to generate a comparably higher output of students and graduates while the research output (measured in third party funds) is of

[5]The choice of the variables is explained in more detail in subsection 3.1

[6]The values are given in real terms, i. e. in prices of the year 2010. The amount does not include the funding of medical sciences und university hospitals.

[7]The remaining budget is provided to art academies, conservatoires and the University of Veterinary Medicine in Hannover.

lower importance compared to universities.

Table 1 provides a summary statistic of the relevant HKS variables. The difference is not only between the aggregate of universities of applied sciences and universities, but also between the different types of the higher education institutions. There is a high variation in number of students and graduates as well as in the level of public funding and third party funds. On average, universities for engineering (Uni 3) and universities of applied sciences for social sciences (UAS 1) are biggest with the highest number of enrolled students. The average number of graduates is highest with the universities of applied sciences for social sciences (UAS 1) followed by the universities of applied sciences for technical sciences (UAS 2). By far the highest average financial resources (public funding as well as third party funds) go to universities for engineering (Uni 3). The figures also show the typical characteristics of university data: The standard deviation of all focus groups is close to the mean value, which indicates a high diversity even within a group (Gralka, 2018a, p. 6).

Table 1: Descriptive statistics (2010-2017)

Variables	Type/Focus	Mean	SD	Min	Max
Public funding (in 1000 Euro)	UAS	4518.2	3713.3	142.5	21737.0
	Uni	4433.2	5205.2	156.3	31124.2
	UAS 1	3866.1	3179.3	142.5	17413.6
	UAS 2	4904.7	3951.8	202.4	21737.0
	Uni 1	2515.4	2417.1	156.3	15614.4
	Uni 2	6683.0	5801.0	297.4	25192.8
	Uni 3	10911.2	8644.4	451.8	31124.2
Third party funds (in 1000 Euro)	UAS	637.5	841.7	3.7	5423.7
	Uni	1874.7	4120.8	0.0	37871.3
	UAS 1	488.5	740.7	10.7	4165.3
	UAS 2	726.2	886.0	3.7	5423.7
	Uni 1	575.5	775.9	0.3	5580.1
	Uni 2	2832.6	3585.6	0.2	22619.1
	Uni 3	7777.7	9674.9	0.0	37871.3
Students	UAS	996	912	36	5078
	Uni	598	649	5	4642
	UAS 1	1162	1089	36	5078
	UAS 2	898	774	76	4180
	Uni 1	528	601	8	4263
	Uni 2	595	474	5	2651
	Uni 3	1107	1097	48	4642
Graduates (weighted)	UAS	133	134	4	876
	Uni	61	65	0	523
	UAS 1	170	167	4	876
	UAS 2	112	104	6	598
	Uni 1	59	66	0	523
	Uni 2	55	43	2	249
	Uni 3	96	97	4	475

Note: UAS: University of applied sciences. UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering. Graduates (weighted): The number of graduates are weighted by the degree, i. e. a Bachelor graduate is weighted by 0.6 (university) and 0.8 (university of applied sciences) respectively whereas a master graduate is weighted by 0.4 (university) and 0.2 (university of applied sciences). The variables public funding and third party funds are given in 1000 Euro at 2010 prices. All other values are in number of persons.

Source: MWK (2019), own calculations, table was produced with xtable (R Core Team, 2019, Dahl et al., 2019).

3 Data Envelopment Analysis (DEA)

A popular approach for measuring efficiency is the data envelopment analysis (DEA) developed by Charnes et al. (1978) based on work of Dantzig (1951) and Farrell (1957). It is a mathematical programming technique that estimates the best practice production frontiers and does not require any detailed knowledge (or assumptions) of the production process. Therefore, the construction of a production, distance or cost function is not necessary. It is an explicit measure that evaluates the relative efficiency using real peer units (Bogetoft and Otto, 2011, p. 94) with the best performing unit representing the benchmark. The method is relatively easy to apply and to interpret.

Nevertheless, the method comes with some drawbacks: it require the data to be without noise as otherwise the results would not be valid (Bogetoft and Otto, 2011, p. 84). Other critical components are the assumption regarding the technology used by the decision making units and the choice of the number of relevant input and output components. The choice of the technology directly influences the outcome by determining the number of efficiently operating units (Bogetoft and Otto, 2011, p. 89).[8] The included input and output variables affect the results in the way that a higher number of inputs and outputs included in the analysis leads to a higher number of decision making units being in the reference set with an efficiency of 1. Consequently, the choice of inputs and outputs has to be carefully set and only definitely relevant inputs and outputs should be included in the analysis (Bogetoft and Otto, 2011, p. 94).

3.1 Methodology

The output efficiency E of an university u under a given optimal reference technology T^* is estimated using the Farrell efficiency measure $E_u = E((x_u, y_u); T^*) = max\{E \in \mathbb{R}_+ | (x_u, Fy_u) \in T^*\}$ in combination with the linear programming problem[9]:

$$\begin{aligned} & \max_{F,\lambda_1,\ldots,\lambda_k} F \\ \text{s.t. } & x_u \geq \sum_{i=1}^{K} \lambda_k x_k \\ & Fy_u \leq \sum_{i=1}^{K} \lambda_k y_k \\ & \lambda \in \Lambda_k(\gamma) \end{aligned}$$

With output maximisation each decision making unit aims at increasing productivity without using more resources, i. e. increasing output without increasing input.[10] The

[8]For the DEA technology models it can be chosen between constant returns to scale (CRS), variable returns to scale (VRS), decreasing returns to scale (DRS), increasing returns to scale (IRS), free disposability hull (FDH) and free replicability hull (FRH) (Bogetoft and Otto, 2011, p. 86). The improving potential of the firm increase with the chosen technology according to the ranking FDH, VRS, FRH/DRS/IRS, CRS implying that the decision making units appear less efficient the higher the improving potential (Bogetoft and Otto, 2011, p. 89).

[9]The reference technology T^* is the best technology that empirically can be observed in the given data set. A derivation and description of T^* is given in Bogetoft and Otto (2011, p. 83).

[10]The counterpart is input orientation/efficiency where the input is minimised holding the output constant.

output orientation or output maximisation can be assumed the right choice for universities and universities of applied sciences as the input (public funding) is not in the direct control of the universities' and universities' of applied sciences management. The financial means are regulated by the government and are results of long negotiations. They are used to produce the maximum possible amount of research and education. Thus, efficiency is gained in maximising output and the evaluation is hence carried out in terms of output. The choice of output orientation is in line with many other studies analysing the efficiencies of higher education institutions using DEA (Rhaiem, 2017, p. 591).

Another assumption that has to be set is the choice of the reference technology, i. e. whether the universities and universities of applied sciences operate under constant returns to scale (CRS) or any other technology such as variable returns to scale (VRS), decreasing returns to scale (DRS), increasing returns to scale (IRS), free disposability hull (FDH) and free replicability hull (FRH). Constant returns to scale, the basic and classical assumption, would imply that small universities and universities of applied sciences can act as efficient in turning input into output as big ones, i. e. that there exists no scale economies. Starting from CRS, other technology models can be tested. In the problem at hand, the basic assumption of CRS was tested against the technology VRS. This was done by estimating both models under each technology and by comparing the efficiency scores g_1 under $T_1 : CRS$ with g_2 under $T_2 : VRS$.[11] Using the Kruskal-Wallis test H_0 had to be rejected, so that VRS was chosen as reference technology.

The last crucial element for the realisation of the DEA is the choice of the input and output variables. As already mentioned in the introduction of this section, the efficiency results are considerably affected by the number of inputs and outputs and only relevant variables should be included in the analysis. Here, the number of relevant input and output variables for the universities and universities of applied sciences can be narrowed down to only three variables: the public funding representing the input as well as the number of graduates and the third party funds representing the outputs education and research.

The majority of studies investigating the efficiency of higher education institutions uses the variable budget as one of the main inputs (Gralka, 2018b, pp. 24–25). In the study at hand, the budget is represented by the actual amount of money that the government makes available to each university (of applied sciences) for free use. It is an exclusive information available due to the data set HKS (MWK, 2019) and represents the true budget that can be used for all kinds of expenses such as university personnel, investments or material expenditures in libraries, computers or similar. It is hence assumed the only relevant input of universities and universities of applied sciences. The original values of public spending were transformed into real terms at 2010 prices using the deflator of public consumption expenditures[12].

The output position education is represented by the number of graduates as it measures the successful education of students. The value provided by the HKS (MWK, 2019) is weighted, i. e. the number of graduates are weighted by the degree: a Bachelor graduate is weighted by 0.6 (university) and 0.8 (university of applied sciences) respectively whereas a master graduate is weighted by 0.4 (university) and 0.2 (university of applied sciences). The number of graduates as proxy for education output was also used by many other studies (Witte and López-Torres, 2017, p. 15, Gralka, 2018b, pp. 28–29). However, this measure focus on the quantity of output neglecting the quality that would be better represented by test scores (Witte and López-Torres, 2017, p. 14). This information is not

[11] $H_0 : g_1 = g_2$ is tested against $H_1 : g_1 \neq g_2$. If H_0 cannot be rejected T_1 is chosen, otherwise T_2. The testing direction is always from the bigger (here CRS) to the smaller technology set (VRS). For more information regarding the testing of the technologies see Bogetoft and Otto (2011, pp. 160-162).

[12] The deflator is provided by the Federal Statistical Office in the National Accounts (Fachserie 18, Reihe 1.4, Table 2.3.3)

available in the consistent data set HKS provided by the MWK (MWK, 2019) nor is it elsewhere freely and easily accessible in Lower Saxony.

As with regard to research, research grants are assumed to be a good approximation for research output and are the most frequently used indicator (Gralka, 2018b, p. 30). The grant income gives an up-to-date picture of the current research activities and represents the research output of the current academic year Johnes (2014, p. 473). It can be interpreted as a quality adjusted measure for the market value of research (Johnes and Schwarzenberger, 2011, p. 489). For the paper at hand, the value third party funds is part of the HKS (MWK, 2019). Third party funds encompasses all kinds of grants that are raised for research projects from public as well as private sources in addition to the public funding. The values were converted into real terms at 2010 prices using the above mentioned deflator of government consumption expenditures. Alternative indicators to research grant used in analysing higher education efficiency are the number of publications or research rankings. There are several reasons to focus on third party funds only: Both pieces of information are not directly available, the data is not necessarily trustworthy[13] and especially publications come with a time lag between publishing and the original research activity. Plus, applied research in German language is often not included in bibliometric indices yielding the risk of biases (Johnes and Schwarzenberger, 2011, p. 489).

All variables were scaled/normalised in the sense that they were divided by the number of students. This was done in order to avoid any magnitude effects.

3.2 DEA efficiency Results for 2017

The level of efficiency and the distribution among the universities and universities of applied sciences differentiated by size (measured in number of students) are depicted in Figure 1. All exact values of the DEA efficiency for the year 2017 are given in Table 10 in the Appendix.[14] Values of 1 represent the most efficient members in the group and form the benchmark. All values above 1 indicate inefficiency.[15] The inefficiency becomes larger the higher the value, i. e. the larger the distance to 1.

In each group of universities types (U 1 to U 3) as well as in the group of universities of applied sciences for social sciences (UAS 1) were at least one university or university of applied sciences with an efficiency of 1. The only exception formed the group of universities of applied sciences for technical sciences (incl. design) (UAS 2) that had no single efficient member. Overall, 13 universities and universities of applied sciences formed with an efficiency of 1 the benchmark. This benchmark group varied considerably in size and area of education and research: The number of students ranged from 87 to 5078 and the are of education and research encompassed everything from philosophy (40), mathematics and natural sciences (340, 350, 360), engineering (690) to arts and music (790, 830).

The other, less efficient universities and universities of applied sciences seemed to be randomly distributed regarding size and focus as well. Nevertheless, two distinct features could be identified: The universities of applied sciences for social sciences (UAS 1) seemed to be more clustered near the efficiency border. Universities of social sciences and arts (Uni 1) were characterised by a high number of outliers with very low efficiency. The least

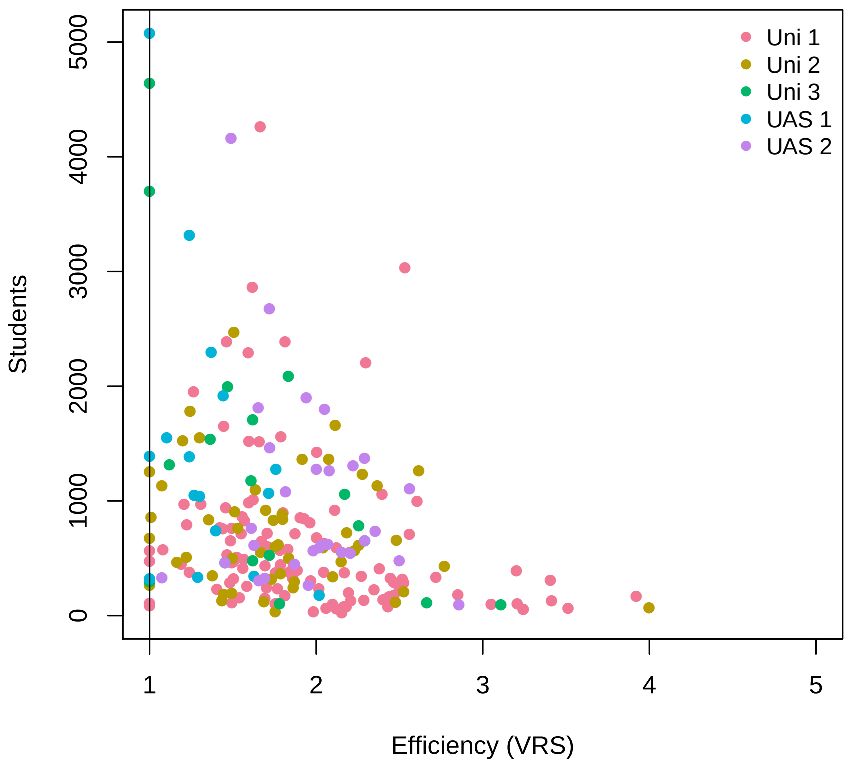
[13]The construction of the rankings is not within the area of influence of the user and not necessarily comprehensible. The number of publications might not represent the value of the research outcome.

[14]The table in the Appendix also includes efficiency values under the assumption of CRS. The results differ considerably between the two technology assumptions and stress the importance and sensitivity of the technology choice.

[15]This is the case as output efficiency is analysed. When calculating input efficiency, all values below 1 would represent inefficiency. Under constant returns to scale, the input efficiency is the reciprocal of the output efficiency or vice versa: $E^{output} = 1/E^{input}$ (Färe and Lovell, 1978).

efficient group with values above 3 consisted of 11 universities and was mainly composed of small universities with focus 1 (social sciences and arts). Summarising, at first glance a discrimination in different efficiency groups seems not to be possible.

Figure 1: Distribution of DEA efficiency values by size and focus of universities and universities of applied sciences (2017)



Note: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: MWK (2019), own estimation with R-package Benchmarking (R Core Team, 2019, Bogetoft and Otto, 2019) and own figure.

Table 2 therefore shows the mean efficiencies differentiated by the focus of the universities and universities of applied sciences. The mean values were quite close together ranging from 1.4 for UAS 1 to 2 for UAS 2. Reaching the best mean efficiency value, the visual assessment of the UAS 1 being clustered nearer to the efficiency border seemed to prove true. The outliers of the Uni 1 also showed in the results as this type of universities belonged to the group with the lowest mean efficiency of 2.

The next question to be addressed is whether the differences in efficiency between the different university types are significant, i. e. whether there really exists noticeable efficiency differences between the groups of universities and universities of applied sciences. In Table 3 the test results are given.[16] It reveals that on aggregate level no noticeable

[16]The test results are derived from a Kruskal-Wallis Test that tests on non-parametric basis whether the samples originate from the same distribution. Under the null hypothesis H_0 it is assumed that two groups

efficiency differences between universities and universities of applied sciences were present. Only when considering the focus of universities and universities of applied sciences significant differences in efficiency could be observed. More precisely, UAS 1 had significantly different efficiencies compared to UAS 2, Uni 1 and Uni 2 as well as UAS 2 comparesd to Uni 3. All other groups showed a similar distribution of efficiency. The results can also visually be confirmed by Figure 6 in the Appendix.

Table 2: Average group efficiency (by focus) in 2017

Focus	Average DEA efficiency
UAS 1	1.42
UAS 2	1.96
Uni 1	1.95
Uni 2	1.79
Uni 3	1.71
Total	1.86

Note: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: Own estimations based on MWK (2019) and R (R Core Team, 2019), the table was generated with xtable (R Core Team, 2019, Dahl et al., 2019).

Table 3: Group differences in efficiency (2017)

	p-Values	Distribution
UAS - Uni	0.3221	similar
UAS 1 - UAS 2	0.0000	different
Uni 1 - Uni 2	0.1062	similar
Uni 1 - Uni 3	0.1044	similar
Uni 2 - Uni 3	0.4399	similar
UAS 1 - Uni 1	0.0000	different
UAS 1 - Uni 2	0.0046	different
UAS 1 - Uni 3	0.1415	similar
UAS 2 - Uni 1	0.3639	similar
UAS 2 - Uni 2	0.0540	similar
UAS 2 - Uni 3	0.0358	different

Note: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: Own estimations based on MWK (2019) and R (R Core Team, 2019), the table was generated with xtable (R Core Team, 2019, Dahl et al., 2019).

3.3 Changes in efficiency 2010–2017 (Malmquist index)

The results so far only point to the year 2017 and produce a static picture. The efficiency of the universities is likely to change with technical progress and adaptation processes. In order to capture the improvement in efficiency over time the Malmquist index (MI) can be

or samples are similar in their distribution so that there are no significant differences. H_1 states, that the distributions are significantly different and group differences exist.

used. So the MI provides the opportunity to check whether the different university groups behave similarly over time or whether they became similar due to different developments.

The MI is a geometric average of changes in the performance in t compared to s taking the technology in s as well as in t as benchmark:

$$MI(s,t) = \sqrt{\frac{E(t,s)}{E(s,s)}\frac{E(t,t)}{E(s,t)}}$$

The MI can be decomposed in two factors: technological progress and efficiency change. The first component, the technological progress, comes from outside the university and all universities are equally exposed to it. The second one, the efficiency change, derives from inside of the university and results from its effort and initiatives to gain efficiency. The MI then reads as:

$$MI(s,t) = \sqrt{\frac{E(t,s)}{E(t,t)}\frac{E(s,s)}{E(s,t)}}\frac{E(t,t)}{E(s,s)} = TC(s,t)EC(s,t)$$

with $TC(s,t)$ being technological change and $EC(s,t)$ being efficiency change. If not only the change from one period to another is of interest but the development over time, the MI needs to be transformed into a chain index.

The changes in efficiency and in number of students for 2017 compared to 2010 are visualised in Figure 2. All exact values for the changes in efficiency including a chain index for the period 2010 to 2017 are given in Table 11 in the Appendix. Values above 1 indicate a positive development in efficiency, meaning that the university or university of applied sciences managed to gain efficiency compared to the previous period.[17] Values below 1 represent a negative development, so that the university or university of applied sciences loose efficiency compared to the previous period.

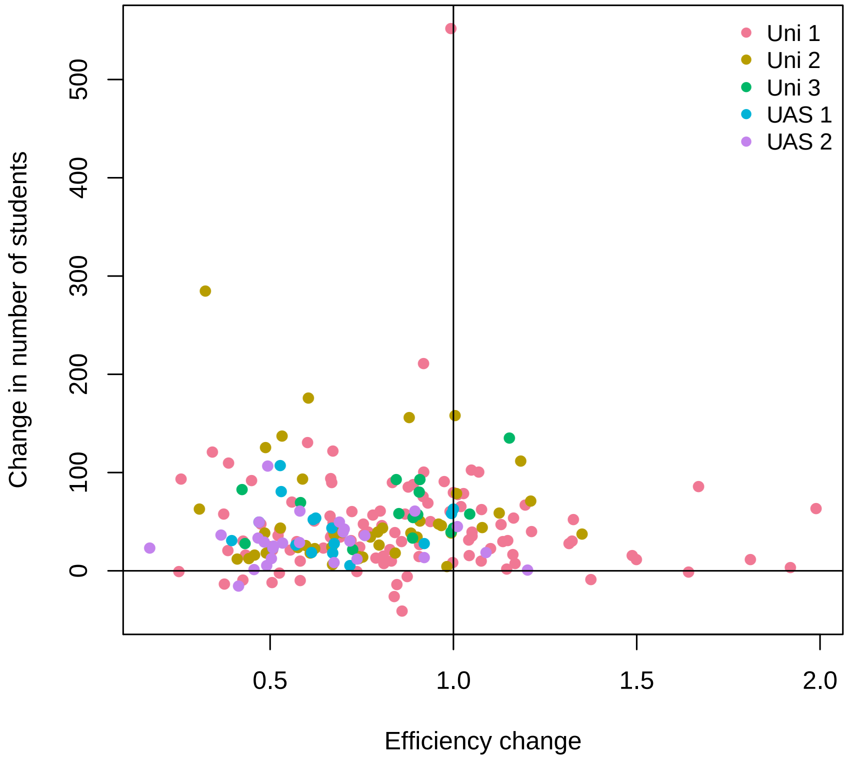
The distribution of efficiency change in Figure 2 shows that the majority of universities and universities of applied sciences are located in the upper left quadrant, which means that most of them faced an increase in the number of students combined with a decrease in efficiency. Less common was a decrease in student numbers combined with a loss of efficiency (lower left quadrant). Taken together, 78 % of all universities and universities of applied sciences showed efficiency losses. The group of universities and universities of applied sciences on the vertical line through 1 were all characterised by stable efficiency in combination with an increase in students. They accounted for 1 % of all universities and universities of applied sciences. On the efficiency gains side, almost all universities and universities of applied sciences (with the exception of 2 cases) also showed a simultaneous increase in student numbers (upper right quadrant). The overall percentage of universities and universities of applied sciences with a positive efficiency development was 21.1 % (see fourth column of Table 4).

Figure 2 also shows that the group with efficiency gains consisted mainly of universities for social sciences and arts (Uni 1) and that universities of applied sciences for social sciences (UAS 1) were not represented there at all. More precisely, the group with efficiency gains consisted of 72.7 % universities for social sciences and arts (Uni 1), followed by universities for natural sciences (Uni 2) with 15.9 % and universities of applied sciences for technical sciences (UAS 2) with 6.8 % (see fifth column of Table 4). However, the group of Uni 1 also represented most of all universities and universities of applied sciences.

[17] The depicted results for the Malmquist (chain) index represent the efficiency change only. Though the values for technical change and the overall values were calculated as well, they were not explicitly shown.

Against their own background (fourth column of Table 4), only 30.2 % of all universities of social sciences and arts (Uni 1) achieved an increase in efficiency. Compared to the other types of higher education institutions, however, this proportion was still the highest. The other types of universities and universities of applied sciences achieved percentages between 11.1 % and 15.6 %.

Figure 2: Distribution of efficiency change by change in total number of students and focus of universities and universities of applied sciences (2017 compared to 2010)



Note: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: MWK (2019), own estimation and figure generated with R (R Core Team, 2019).

On average, all higher education institutions became less efficient in 2017 compared to 2010, as the overall mean value was with 0.8 smaller than 1 (see sixth column of Table 4). This is reflected in the single mean values for the different types of universities and universities of applied sciences: the average efficiency development ranged between 0.6 and 0.9. So most of the universities and universities of applied sciences exhibited a similar development. With an average of 0.7, the universities of applied sciences for social sciences (UAS 1) developed less strongly than the overall average, but at the same time showed the highest average efficiency value in 2017. So here we can see a kind of alignment with the overall group of universities and universities of applied sciences. The opposite is also true for Universities for social sciences and arts (Uni 1): comparatively many universities in this group were able to become more efficient, and in 2017 they thus came closer to the total mean efficiency. In summary, the efficiency development 2010-2017 contributes to the picture with the small differences in efficiency in 2017.

Table 4: Distribution and mean value of efficiency (by focus) 2017 compared to 2010

	# of efficiency losses	gains	Total	Share of gaining UAS/Uni (%) in focus group	in total	Average eff. change
UAS 1	16	0	16	0.0	0.0	0.7
UAS 2	24	3	27	11.1	6.8	0.6
Uni 1	74	32	106	30.2	72.7	0.9
Uni 2	38	7	45	15.6	15.9	0.8
Uni 3	13	2	15	13.3	4.5	0.8
Total	165	44	209	21.1	100.0	0.8

Note: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering. The number of efficiency losses also includes values of 1, i. e. universities and universities of applied sciences with unchanged efficiency.

Source: Own estimations based on MWK (2019) and R (R Core Team, 2019), the table was generated with xtable (R Core Team, 2019, Dahl et al., 2019).

However, looking at the pure mean values does not confirm whether the observation of the alignment process is caused by a significant difference in efficiency development or whether it is just the misinterpretation of a random process. Testing for group differences in efficiency change reveals in Table 5 that for 6 out of 11 comparison pairs of higher education institutions a similar efficiency development could not be rejected. Thus, in the majority of cases the development in efficiency seemed to be similar. But the similarity existed mainly between pairs of universities or pairs of universities of applied sciences. The only reaching across similarity was between the universities of applied sciences (UAS 1 and UAS 2) and the universities for natural sciences (Uni 2). Between universities and universities of applied sciences as a whole there was a significant difference in the efficiency change. Thus, one could state, that the loss in efficiency was significantly higher for the total of all universities of applied sciences than for all universities.

Table 5: Group differences in changes in efficiency (2017 compared to 2010)

	p-Values	Distribution
UAS - Uni	0.0001	different
UAS 1 - UAS 2	0.5977	similar
Uni 1 - Uni 2	0.0702	similar
Uni 1 - Uni 3	0.8781	similar
Uni 2 - Uni 3	0.1590	similar
UAS 1 - Uni 1	0.0107	different
UAS 1 - Uni 2	0.1585	similar
UAS 1 - Uni 3	0.0344	different
UAS 2 - Uni 1	0.0007	different
UAS 2 - Uni 2	0.0500	similar
UAS 2 - Uni 3	0.0131	different

Note: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: Own estimations based on MWK (2019) and R (R Core Team, 2019), the table was generated with xtable (R Core Team, 2019, Dahl et al., 2019).

This behaviour in similarities and differences in efficiency between the aggregate types of universities and universities of applied sciences raises the question whether there exist general parameters that have an influence on efficiency but cannot easily changed or addressed by universities. Therefore, the next section analyse determinants influencing efficiency.

3.4 Influencing factors (Tobit regression)

A tobit regression is used to test for determinants influencing the efficiency in the cross-section of universities and universities of applied sciences in 2017.[18] According to Coelli et al. (2005) the determinants are supposed not to be directly in the sphere of universities and universities of applied sciences. Additionally, they should not be part of or connected to the inputs or outputs of the production process.

Thus, as influencing factors in the regression were selected: GDP per capita of the respective university region in 2010 prices, the market share (in percentage of students) and the type of focus of the universities and universities of applied sciences.[19] The two variables GDP per capita and the market share represent regional characteristics the universities and universities of applied sciences are confronted with (Gralka, 2018b, p. 39). More precisely the GDP per capita is supposed to act as proxy for the local economic situation and is used by many authors in this context (e. g. Kempkes and Pohl, 2010, Agasisti et al., 2016, Barra et al., 2018). The market share is a measure for concentration and competition respectively proposed and used by Agasisti et al. (2016). The effect is meant to be u-shaped, i. e. at low levels of concentration (many small universities) efficiency can be gained by mergers due to economies of scale; if the concentration becomes too high (few big universities), however, the efficiency decreases again as the low level of competition does not create incentives to increase efficiency (Agasisti et al., 2016). The different types of universities and universities of applied sciences are included as factors comparing the university of applied sciences for technical sciences (Focus 2, UAS 2), the university for social sciences and arts (Focus 3, Uni 1), the university for natural sciences (Focus 4, Uni 2) and the university for engineering (Focus 5, Uni 3) with the university of applied sciences for social sciences (Focus 1, UAS 1). The aim is to verify the group differences in efficiency and to assess the direction and the magnitude of this effect.

The regression results are shown in Table 6. The market share had a negative impact on inefficiency whereas the quadratic term was insignificant.[20] There was hence a linear relationship between market concentration and efficiency suggesting that the (fields of education and research of the) universities and universities of applied sciences are rather small sized. Gaining market shares, i. e. gain in the number of students relative to the others, supports efficiency. The economic environment however had no significant effect on efficiency. Finally, the focus of the university or university of applied sciences explained efficiency differences. All types of universities and universities of applied sciences were significantly less efficient than the universities of applied sciences for social sciences (UAS 1).[21] The difference was highest for universities of applied sciences for technical sciences

[18]A tobit regression is necessary as the output efficiency are left censored at 1.

[19]The region is defined by the NUTS 3 region the university or university of applied sciences is located in. If the university or university of applied sciences has multiple locations, the GDP per capita is calculated by a weighed average of the respective regions using the number of students as weight. The values were deflated with the GDP deflator for Germany provided by the Federal Statistical Office (Statistisches Bundesamt (Destatis), 2020).

[20]With the DEA output measure efficiency is characterised by a value of 1. Higher values indicate inefficiency. Consequently, coefficients with negative signs imply a reduction in inefficiency or, put differently, reduce the distance to efficiency.

[21]The positive coefficients indicate that the distance to efficiency becomes larger, that is inefficiency is

(Focus 2, UAS 2) and lowest for universities for engineering (Focus 5, Uni 3).

Table 6: Tobit cross-sectional regression results for efficiency-influencing factors (2017)

	Dependent variable:
	Efficiency.VRS
Market.share	−0.627***
	(0.216)
Market.share.squared	0.124
	(0.107)
GDP.per.capita	0.00000
	(0.00000)
factor(Focus)2	0.551***
	(0.162)
factor(Focus)3	0.447***
	(0.145)
factor(Focus)4	0.315**
	(0.155)
factor(Focus)5	0.305
	(0.191)
logSigma	−0.629***
	(0.049)
Constant	1.655***
	(0.165)
Observations	230
Log Likelihood	−186.189
Akaike Inf. Crit.	390.378
Bayesian Inf. Crit.	421.321
Note:	*p<0.1; **p<0.05; ***p<0.01

Note: Focus 1: UAS 1 (university of applied sciences for social sciences), Focus 2: UAS 2 (university of applied sciences for technical sciences, Focus 3: Uni 1 (university for social sciences and arts), Focus 4: Uni 2 (university for natural sciences), Focus 5: Uni 3 (university for engineering).

Source: Own estimation with R-package censReg (R Core Team, 2019, Henningsen, 2019), the table was generated with stargazer (Hlavac, 2018).

4 Stochastic frontier analysis (SFA)

Another approach to measure inefficiency is to use stochastic frontier models. There are several advantages but also some drawbacks compared to the DEA method. The downside of the SFA method is that it is a parametric procedure making the a priory assumption of a functional form necessary. A wrong choice of functional form causes the risk of misspecification with the consequences of biased coefficients and incorrect efficiency measures (Johnes, 2014, p. 468). Multicollinearity and omission of relevant variables pose further challenges in the estimation process (ibid.). However, the main advantage of the SFA approach is that a testable relationship between inputs used and outputs produced is

increasing.

established (Bogetoft and Otto, 2011, p. 197). The approach allows for noise in the data, i. e. deviations from the frontier are not necessarily solely caused by inefficiency (ibid.).

4.1 Methodology

The stochastic frontier is estimated using a functional form for the technology and assuming that the error term (ϵ) is composed of two parts, one that expresses inefficiency (u) and the other representing the stochastic error term (ν):

$$
\begin{aligned}
y_{it} &= \alpha_0 + f\left(x_{it};\beta\right) + \nu_{it} - u_{it} \\
u_{it} &\sim N^+\left(\mu_i, \sigma_i^2\right) \\
\nu_{it} &\sim N\left(0, \sigma_{v,it}^2\right)
\end{aligned}
$$

where y_{it} represents the output of production unit i (here university/university of applied sciences) at time t. The output is generated by the production technology $f\left(x_{it};\beta\right)$ consisting of input x and technology parameters β. The term ν_{it} is a random tow-sided normally distributed noise term. The distribution of the inefficiency measure is truncated, i. e. it is half-normally distributed as $u_{it} \geq 0$.

The data set comprise the years 2010–2017.[22] Thus, a stochastic frontier model was chosen that takes the panel structure into account: A panel models with random effects and a distance function in combination with the COLS approach as proposed by Coelli and Perelman (1999) has been applied.

The distance function was preferred to the production or cost function for various reasons. Universities and universities of applied sciences act output-oriented as the input, i. e. the public funding, is determined by the government and cannot immediately be influenced or changed. The output consists of two main components: education and research. With production functions only one output can be considered. This could be avoided by output aggregation making the rather strict assumption of separability necessary which would lead to suboptimal and unstable results (Coelli and Perelman, 2000, p. 1973). Additionally, a wrong choice of aggregation weights would result in biased estimates (Coelli and Perelman, 1999, p. 332). Adverse to that, cost functions can have multiple outputs, but it requires information on costs, prices and output. Because of the public good character of universities and universities of applied sciences, prices are not directly available. The derivation of prices would involve a lot of additional assumptions. Furthermore, cost-minimisation is not the main focus or goal of universities and universities of applied sciences. Therefore, cost functions should rather be avoided as well. Distance functions are very flexible in the way that they can be output oriented and that they can be applied in situations with multiple inputs, multiple outputs and no price information. Furthermore, distance functions are suitable for regulated markets where cost minimisation or profit maximisation is not present. The output distance function is defined as follows[23]:

$$
D(x,y) = min\left\{D > 0 | \left(x, \frac{y}{D}\right) \in T\right\} = \exp(u)
$$

with D being the Shephard output distance function (Shephard, 1970), x and y representing inputs and outputs, T being the available technology set and u a measure of inefficiency. In order to estimate the parameters and the inefficiency, a functional form

[22] The panel is unbalanced encompassing $N = 249$ universities, $T = 8$ time periods and a total of 1840 observations. Thus, 152 observations are not in the panel.

[23] A more extensive description is given in Bogetoft and Otto (2011, p. 233–239)

has to be assumed for the distance function. The translog distance function is very popular as it combines the properties of being flexible, easy to estimate and allowing homogeneity. For the problem at hand with one input x_1 (public funding) as well as two outputs y_1 (graduates) and y_2 (third party funds) the translog distance function is defined as:

$$\begin{aligned}\ln D_{it}(x,y) = {} & \alpha_0 + \alpha_1 \ln y_{1it} + \alpha_2 \ln y_{2it} + \frac{1}{2}\alpha_{12} \ln y_{1it} \ln y_{2it} \\ & + \beta_1 \ln x_{1it} + \delta_{11} \ln x_{1it} \ln y_{1it} + \delta_{12} \ln x_{1it} \ln y_{2it} + \epsilon_{it}\end{aligned}$$

Taking y_2 as numeraire and applying the homogeneity condition the function can be transformed into:

$$-\ln y_{2it} = \alpha_0 + \alpha_1 \ln \left(\frac{y_{1it}}{y_{2it}}\right) + \beta_1 \ln x_{1it} + \delta_{11} \ln x_{1it} \ln \left(\frac{y_{1it}}{y_{2it}}\right) + \tau_t t_t + \sum_{f=2}^{5} \omega_f focus_i + \epsilon_{it}$$

with $\epsilon_{it} = \nu_{it} - u_{it} = -\ln D_{it}(x,y)$

A time trend (t_t) was added to the estimation that was supposed to measure technical progress. Also included in the estimation function were the focus of the university or university of applied sciences. The categorical variable $focus$ take the values 1 to 5 which corresponds to UAS 1, UAS 2, Uni 1, Uni 2 and Uni 3[24] and was applied as factor in the regression with UAS 1 being the reference. The idea was to capture and illustrate effects that are due to the focus of the university or university of applied sciences and cannot be addressed in the quest to improve efficiency. The model was estimated as feasible generalized least squares (FGLS) panel model using the plm package (Croissant and Millo, 2008).[25]

In a second step, the distance measure, that is the technical inefficiency, can be derived from the estimation results applying the COLS method[26]:

$$TE_{it} = \exp\left(\epsilon_{it} - min\left(\epsilon_{it}\right)\right)$$

4.2 Results

The regression results are given in Table 12 in the Appendix. The coefficients had the right signs and the overall measure of fit was good with a multiple R-Squared of 0.9. There could be noted a competing relationship between the two kinds of outputs education and research: An increase in the number of graduates relative to a unit of third party funds lead to a disproportionate decrease in research indicating that education is more input intense. An increase in input, that is public funding, had a positive effect on research. However, only half of the additional budget would be used for research. The time trend was negative indicating that the research output (represented by third party funds) declined during the observation period. This suggests an orientation towards education. Finally, universities

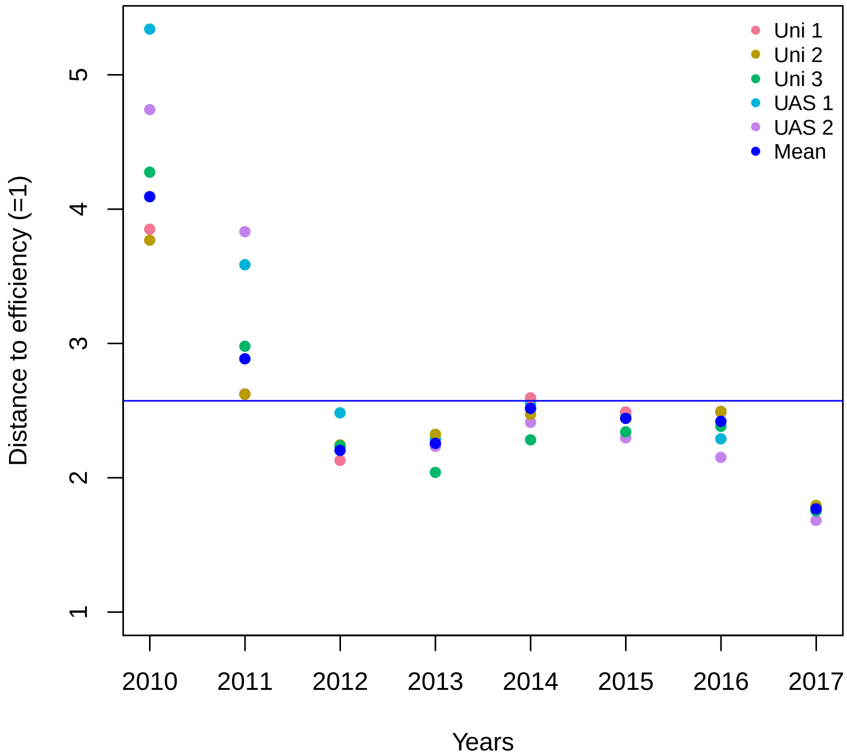
[24] UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

[25] The residuals of the random effects model suggested the existence of heteroskedasticity. As the FGLS panel model is robust against intra-group heteroskedasticity and serial correlation this estimation method was chosen.

[26] For more details regarding the COLS method (corrected ordinairy least squares) please see e. g. Coelli and Perelman (1999, pp. 330–331) or Bogetoft and Otto (2011, pp. 201–202).

of applied sciences for social sciences seem to be less involved in research than all other types of universities and universities of applied sciences. The highest difference could be found for universities for natural sciences (Focus 4, Uni 2).

Figure 3: Estimated average efficiency values (by focus) 2010–2017



Note: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: Own estimation with R-package plm (Croissant and Millo, 2008) and figure generated with R (R Core Team, 2019).

As with regard to efficiency, the mean values differentiated by the focus of the universities and universities of applied sciences are visualised in Figure 3.[27] Two main developments can be observed: The spread of the average efficiency values declined during the observation period implying that the universities and universities of applied sciences became more similar. On the same time, the majority of universities and universities of applied sciences managed to reduce their inefficiencies, so that the overall mean value of efficiency reached the best level in 2017. The highest decline in inefficiency was realised by universities of applied sciences for social sciences (UAS 1) followed by those for technical sciences (UAS 2). The smallest efficiency gains were obtained by universities for natural sciences (Uni 2) and for social sciences (Uni 1). In 2017, the lowest inefficiency value could be assigned to the universities of applied sciences for technical sciences (UAS 2). The highest distance to efficiency was estimated for universities for natural sciences (Uni 2).

[27] All efficiency values can be found in Table 13 in the Appendix.

These SFA results seem to be contradictory to the DEA efficiency results of subsection 3.2 and the Malmquist Index of subsection 3.3, where the UAS 1 group held still the most efficient units in 2017 after the highest efficiency losses between 2010 and 2017 according to the Malmquist index. The Uni 1 members, however, displayed the lowest efficiency values in 2017 in combination with the highest efficiency gains. The single commonality between both estimation methods seems to be the overall alignment process and the similar efficiency distribution for most focus groups (see Table 7). Testing for group differences in the SFA efficiencies delivers similar results as under the DEA method: There were no significant differences in efficiencies between the different types of universities and universities of applied sciences except for universities of applied sciences for social sciences (UAS 1). This group was characterised by significantly different efficiencies compared to universities of applied sciences for technical sciences (UAS 2), universities for social sciences (Uni 1) and universities for engineering (Uni 3).

The differences in the efficiency results between DEA and SFA are analysed in more detail in the next section.

Table 7: Group differences in efficiency (2010–2017)

	p-Values	Distribution
UAS - Uni	0.0745	similar
UAS 1 - UAS 2	0.0403	different
Uni 1 - Uni 2	0.0963	similar
Uni 1 - Uni 3	0.8395	similar
Uni 2 - Uni 3	0.3875	similar
UAS 1 - Uni 1	0.0030	different
UAS 1 - Uni 2	0.0590	similar
UAS 1 - Uni 3	0.0301	different
UAS 2 - Uni 1	0.4847	similar
UAS 2 - Uni 2	0.5741	similar
UAS 2 - Uni 3	0.8138	similar

Note: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: Own estimations based on MWK (2019) and R (R Core Team, 2019), the table was generated with xtable (R Core Team, 2019, Dahl et al., 2019).

4.3 Differences and commonalities with DEA

In Figure 4 the efficiency values for 2017 of the DEA method are contrasted with the 2017's values of the SFA method. Values below the bisecting line through the origin indicate, that the estimated inefficiency is higher with the DEA method than with the SFA method. For values above the line it is the other way round, i. e. the SFA values are higher than the DEA values.

Only a few points are on the line, indicating that the estimated efficiency values are identical for both methods. Especially, the most efficient university of applied sciences for social sciences (UAS 1) under SFA could also be found in the most efficient group under DEA.[28] However, the other universities and universities of applied sciences that formed

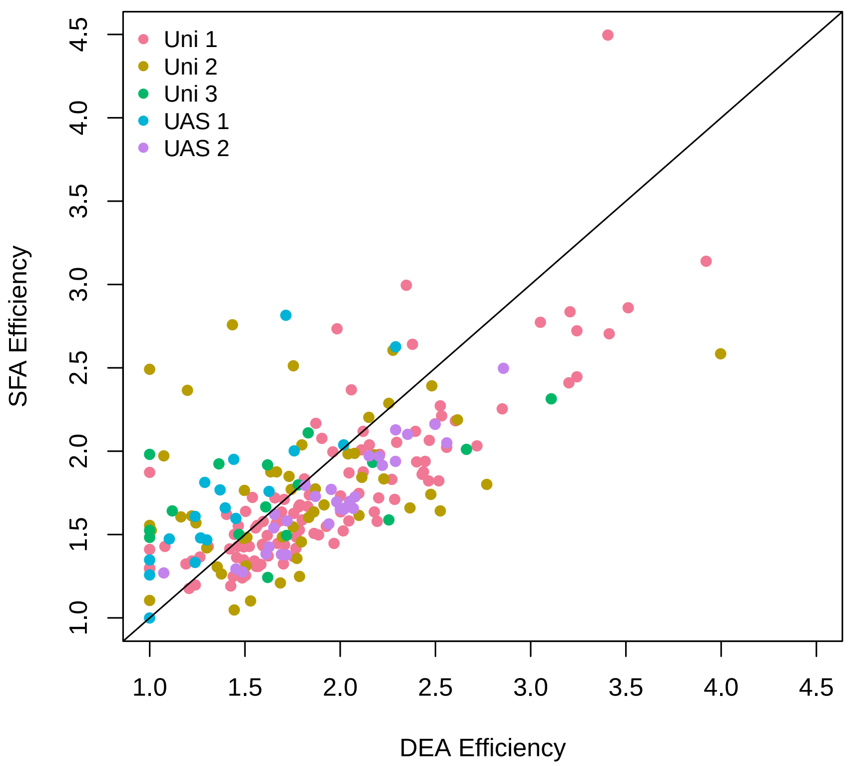
[28] Due to the definition of the COLS method, only one university or university of applied sciences can be the benchmark with an efficiency of 1.

the benchmark group in the DEA, exhibited in the SFA in parts quite high distances to the efficiency of 1.

An other striking feature is the difference in efficiency values when differentiated by the focus of the higher education institutions: all inefficiency values for the universities of applied sciences for social sciences (UAS 1) were with the SFA method higher than with the DEA method. Contrary to that, almost all (29 out of 30) universities of applied sciences for technical sciences (UAS 2) had higher inefficiencies under DEA than under SFA. Similar results were obtained for the universities of social sciences (Uni 1): here 77.4 % of all group members were better off when the efficiency was estimated with SFA. In general, the DEA method produced in 154 out of 230 cases higher inefficiency values than the SFA method, so that the overall efficiency in the DEA model is lower.

Thus, the partially very different assessment of efficiency by both methods probably leads to the contradictory results identified above.

Figure 4: Efficiency values of DEA and SFA for 2017



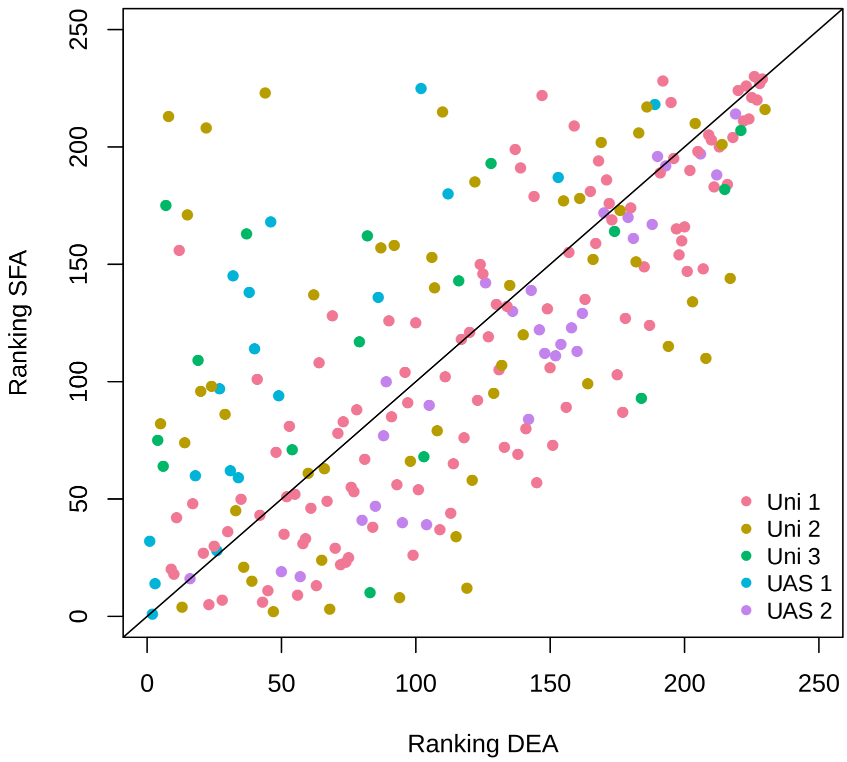
Note: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: Own estimation and figure generated with R (R Core Team, 2019).

The findings of substantial differences between DEA and SFA in the ranking is confirmed by Barra et al. (2018): In their results, the Top 10 universities are only present in one of the ranking methods and not in the other and only one university has the same position regardless of the applied method. They conclude that analytical methods used play a crucial role in the production of university rankings, which means that university rankings must be treated with extreme caution (Barra et al., 2018).

The difference in the rankings for this study are visualised in Figure 5. If the rankings would be identical or similar, all points would be situated on or near the bisecting line through the origin. For points in the upper triangular space, the university or university of applied sciences takes a better position in the DEA ranking than in the SFA ranking. In the lower triangular space, the ranking of the SFA is better than of the DEA. The farther away a point is from the bisecting line, the more different is the position between both rankings.

Figure 5: Rankings according to DEA and SFA for 2017



Note: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: Own estimation and figure generated with R (R Core Team, 2019).

In most cases, the universities and universities of applied sciences were ranked rather different depending on the applied method. There were 12 extreme cases with a difference of more than 100 positions in the rankings. They appear mostly on the upper triangular part, that is the SFA method seems to have the tendency to rank some universities far better than the DEA method. The high deviation mainly applied to universities for natural sciences (Uni 2) with 6 out of the 12 ranking outliers; the remaining extreme cases consists of 3 universities of applied sciences for social sciences (UAS 1), 2 universities for engineering (Uni 3) and 1 university for social sciences (Uni 1). For universities of applied sciences for technical sciences (UAS 2), at least no extreme difference in the rankings could be identified.

Only 0.2 % of the universities and universities of applied sciences are ranked similar in both methods with a maximum difference of 10 positions. The highest similarities can be found for the group of universities for social sciences (Uni 1) and universities of applied sciences for technical sciences (UAS 2): 31.3 % and 31.3 % of their respective group members took similar positions in both rankings. In contrast, the ranking positions for universities for engineering (Uni 3) differed only in 6.2 % of the cases less than 11 positions.

Finally, the ranking positions were tested for correlation.[29] The test results confirm that there existed no significant similarities between both rankings.

5 Conclusion and discussion

The main findings of the DEA method are that in 2017 the DEA benchmark group with an efficiency of 1 was not dominated by field of education and research nor by focus, i. e. no fundamental differences in efficiency between universities and universities of applied sciences could be identified. However, the inefficiency of UAS 1 was generally lower and also differed significantly from the other focus groups in many cases. The findings of 2017 were the outcome of an alignment process taking place between 2010 and 2017, in which mainly universities with very high inefficiencies (especially Uni 1) were able to improve, while the majority of universities and universities of applied sciences, especially UAS 1 universities of applied sciences, suffered efficiency losses. Efficiency was determined positively by market share, i. e. the larger a subject group, the more likely it was to operate efficiently.

The application of the SFA lead to somewhat different results, as the level of efficiency was basically ranked differently. While the difference in efficiency values decreased as well, the overall development was positive, i. e. the different focus groups of universities and universities of applied sciences were able to improve their efficiency. However, no significant group differences in efficiencies could be found except for the universities of applied sciences for social sciences (UAS 1).

As a consequence, a comparison of the DEA and SFA efficiency values shows that the ranking and the level of efficiency depends very much on the choice of method. For monitoring purposes, the different uncorrelated rankings of the DEA and SFA method stress the necessity to settle on one method and to stick to it. In addition to the pros and cons of both methods already mentioned above, the advantage of the DEA approach is that it is easier to handle and requires no methodological knowledge. Furthermore, it could be calculated directly when the key figures are compiled.

Irrespective of the different rankings resulting from DEA and SFA, two central findings can be noted that are equally valid for both methods: (1) There are no significant differences in efficiency between universities and universities of applied sciences. The differences only become visible when differentiating by focus. Thus, differences in efficiency are more a question of focus and the underlying structure of areas of education and research. (2) Between 2010 and 2017 there has been an alignment between the different types of universities, in the way that the universities and universities of applied sciences became more similar in their efficiency.

[29] As the efficiency values were according to the Shapiro-Wilk normality test not normally distributed, the Spearman's rank correlation rho test and the Kendall's rank correlation tau test were used to test for H_0: no association between the paired samples. With a p-value of 0.8 for both tests the H_0 of no association between the paired samples cannot be rejected.

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Appendix

Table 8: Universities and universities of applied sciences considered in the data set

Abbreviation	Name	Uni/UAS
HS BS WFB	HS Braunschweig/Wolfenbüttel	UAS
HS EL	HS Emden/Leer	UAS
HS Han	HS Hannover	UAS
HS HHG	HS Hildesheim/Holzminden/Göttingen	UAS
HS OS	HS Osnabrück (Stiftung)	UAS
HS WOE	HS Wilhelmshaven/Oldenburg/Elsfleth	UAS
TU BS	TU Braunschweig	Uni
TU CL	TU Clausthal	Uni
U GÖ	U Göttingen (Stiftung)	Uni
U Ha	U Hannover (LUH)	Uni
U HI	U Hildesheim (Stiftung)	Uni
U LG	U Lüneburg (Stiftung)	Uni
U OL	U Oldenburg	Uni
U OS	U Osnabrück	Uni
U VEC	U Vechta	Uni

Source: MWK (2019).

Table 9: Numbers attributed to the area of education and research

Number	Area of education and research	Number	Area of education and research
010	Language and cultural knowledge general	370	Chemistry
020	Evang. theology	390	Pharmacy
030	Catholic theology	400	Biology
040	Philosophy	410	Geosciences
050	History	420	Geography
070	Library science, documentation, journalism (media science)	440	Human medicine in general
080	General and comparative literature and linguistics	445	Health sciences in general
090	Altphilology (classical philology)	540	Veterinary medicine general
100	Germanic studies	610	Agricultural, forestry and nutritional science
110	Anglistics, American studies	615	Land management, environmental design
120	Romance studies	620	Agricultural sciences
130	Slavic studies, Baltic studies, Finno Ugrian studies	640	Forestry, wood industry
140	Non-European language and cultural knowledge (Islamic religion teacher)	650	Nutritional and household science
160	Cultural studies (cultural anthropology, ethnology)	670	Engineering. general
170	Psychology	680	Mining, metallurgy
180	Educational sciences	690	Engineering
190	Special education	710	Electrical engineering
200	Sport	720	Traffic Engineering, Nautical
220	Legal, economic and social science	730	Architecture
230	Political sciences	740	Room planning
235	Social sciences	750	Civil engineering
240	Social services	760	Mapping
250	Law	780	Arts and media studies
290	Economics	790	Eductive arts
310	Economic engineering	800	design
330	Mathematics, natural sciences, general	820	Dramatic art, film and television, theatre studies
340	Mathematics	830	Music, musicology
350	Computer science		
360	Physics		

Source: MWK (2019).

Table 10: DEA efficiency values for 2017

University	VRS	CRS	Students	Focus	University	VRS	CRS	Students	Focus
HS.Han.240	1.00	1.14	1391	UAS 1	U.HI.670	1.78	2.37	102	Uni 3
HS.HHG.445	1.00	1.37	321	UAS 1	U.OL.110	1.78	2.13	570	Uni 1
HS.OS.220	1.00	1.18	5078	UAS 1	TU.BS.100	1.79	2.24	441	Uni 1
TU.BS.690	1.00	1.00	4642	Uni 3	U.Ha.420	1.79	2.77	367	Uni 2
U.GÖ.360	1.00	1.86	1255	Uni 2	TU.BS.290	1.79	2.21	1560	Uni 1
U.Ha.690	1.00	1.16	3698	Uni 3	U.OL.340	1.80	2.15	882	Uni 2
U.Ha.760	1.00	1.70	293	Uni 3	U.GÖ.340	1.80	2.33	838	Uni 2
U.HI.790	1.00	1.02	87	Uni 1	U.OS.235	1.80	2.23	898	Uni 1
U.HI.830	1.00	1.55	107	Uni 1	U.HI.40	1.81	2.00	174	Uni 1
U.HI.350	1.00	1.80	673	Uni 2	U.Ha.250	1.81	2.01	2385	Uni 1
U.LG.240	1.00	1.00	475	Uni 1	HS.BS.WFB.350	1.82	2.21	1079	UAS 2
U.OL.40	1.00	1.36	565	Uni 1	U.LG.250	1.83	2.80	576	Uni 1
U.VEC.340	1.00	1.00	265	Uni 2	U.Ha.710	1.83	2.33	2085	Uni 3
U.OL.360	1.01	1.59	856	Uni 2	TU.BS.360	1.84	3.86	499	Uni 2
U.Ha.360	1.07	1.61	1131	Uni 2	U.OL.200	1.84	2.68	377	Uni 1
HS.Han.620	1.07	1.84	328	UAS 2	U.OL.20	1.86	2.27	327	Uni 1
U.HI.240	1.08	1.19	574	Uni 1	TU.BS.410	1.86	3.38	242	Uni 2
HS.Han.290	1.10	1.28	1549	UAS 1	U.Ha.110	1.86	2.40	428	Uni 1
TU.CL.670	1.12	2.00	1313	Uni 3	U.GÖ.200	1.86	2.44	424	Uni 1
U.Ha.410	1.16	1.92	464	Uni 2	TU.CL.370	1.87	6.62	293	Uni 2
U.VEC.235	1.19	1.23	445	Uni 1	HS.OS.830	1.87	3.22	445	UAS 2
U.Ha.350	1.20	1.24	1525	Uni 2	TU.BS.235	1.87	2.07	714	Uni 1
U.VEC.180	1.21	1.36	971	Uni 1	U.GÖ.180	1.89	2.69	394	Uni 1
U.OL.330	1.22	3.22	510	Uni 2	U.GÖ.50	1.90	2.47	851	Uni 1
U.HI.170	1.22	1.28	794	Uni 1	U.LG.615	1.92	2.80	1364	Uni 2
HS.HHG.240	1.24	1.62	1383	UAS 1	U.OL.100	1.93	2.50	842	Uni 1
HS.BS.WFB.290	1.24	1.49	3314	UAS 1	HS.Han.690	1.94	2.67	1898	UAS 2
U.OS.445	1.24	1.70	379	Uni 1	HS.WOE.690	1.95	4.60	264	UAS 2
U.GÖ.400	1.24	2.07	1780	Uni 2	U.Ha.230	1.96	2.25	810	Uni 1
U.VEC.240	1.26	1.33	1952	Uni 1	U.OS.120	1.97	2.77	302	Uni 1
HS.EL.240	1.27	1.68	1048	UAS 1	HS.EL.330	1.98	4.18	566	UAS 2
HS.OS.10	1.29	1.67	335	UAS 1	U.VEC.830	1.98	16.96	35	Uni 1
U.GÖ.640	1.30	1.82	1549	Uni 2	HS.Han.800	2.00	2.91	1277	UAS 2
HS.BS.WFB.240	1.30	1.68	1041	UAS 1	U.OL.235	2.00	2.51	680	Uni 1
U.HI.180	1.31	1.34	971	Uni 1	U.OS.290	2.00	2.58	1423	Uni 1
U.OS.400	1.35	2.84	834	Uni 2	U.Ha.200	2.02	3.92	234	Uni 1
TU.BS.710	1.36	1.81	1535	Uni 3	HS.HHG.610	2.02	3.23	593	UAS 2
HS.BS.WFB.220	1.37	1.61	2297	UAS 1	HS.HHG.610.1	2.02	3.23	177	UAS 1
U.VEC.330	1.38	1.90	346	Uni 2	HS.EL.690	2.03	2.77	611	UAS 2
HS.BS.WFB.445	1.40	1.72	738	UAS 1	U.OL.370	2.04	5.48	593	Uni 2
U.OL.170	1.40	2.17	231	Uni 1	U.GÖ.120	2.05	4.14	380	Uni 1
TU.BS.180	1.42	1.76	767	Uni 1	U.VEC.100	2.05	2.43	628	Uni 1
U.GÖ.170	1.43	2.01	761	Uni 1	HS.HHG.670	2.05	3.65	1798	UAS 2
U.OS.330	1.43	2.00	130	Uni 2	U.OL.130	2.06	4.16	65	Uni 1
U.Ha.190	1.44	1.77	755	Uni 1	HS.WOE.720	2.07	2.92	620	UAS 2
HS.WOE.290	1.44	1.67	1917	UAS 1	U.Ha.370	2.08	3.71	1361	Uni 2
U.LG.340	1.44	1.92	184	Uni 2	HS.Han.710	2.08	3.50	1263	UAS 2
U.OL.180	1.45	2.00	1649	Uni 1	U.HI.50	2.10	2.68	97	Uni 1
HS.OS.310	1.45	1.92	461	UAS 1	U.OS.420	2.10	3.11	336	Uni 2
HS.OS.310.1	1.45	1.92	461	UAS 2	TU.CL.290	2.11	2.54	919	Uni 1
U.LG.180	1.46	2.16	942	Uni 1	U.Ha.340	2.11	2.59	1658	Uni 2
U.OL.290	1.46	1.72	2389	Uni 1	U.LG.200	2.12	3.29	60	Uni 1
TU.BS.170	1.47	1.97	530	Uni 1	U.GÖ.140	2.12	2.99	592	Uni 1
TU.BS.750	1.47	2.08	1997	Uni 3	U.HI.340	2.15	2.72	470	Uni 2
U.HI.110	1.48	1.70	285	Uni 1	HS.WOE.730	2.15	2.93	553	UAS 2
U.LG.170	1.49	2.02	651	Uni 1	U.Ha.780	2.15	12.40	23	Uni 1
HS.OS.670	1.49	2.05	4159	UAS 2	U.VEC.800	2.17	6.31	76	Uni 1
U.OS.100	1.49	1.81	763	Uni 1	TU.BS.50	2.17	2.65	374	Uni 1
U.OS.110	1.49	1.81	461	Uni 1	TU.BS.730	2.17	3.18	1057	Uni 3
U.OS.370	1.49	3.03	195	Uni 2	TU.BS.200	2.18	3.79	75	Uni 1
TU.BS.20	1.49	1.84	114	Uni 1	TU.CL.340	2.18	3.20	722	Uni 2
U.GÖ.410	1.50	3.62	501	Uni 2	U.OS.30	2.19	3.25	200	Uni 1
U.LG.100	1.50	1.93	320	Uni 1	U.OS.10	2.20	3.28	550	Uni 1
U.HI.220	1.50	1.55	468	Uni 1	HS.BS.WFB.750	2.20	2.93	545	UAS 2
U.GÖ.620	1.51	2.40	2469	Uni 2	U.VEC.50	2.21	2.91	130	Uni 1

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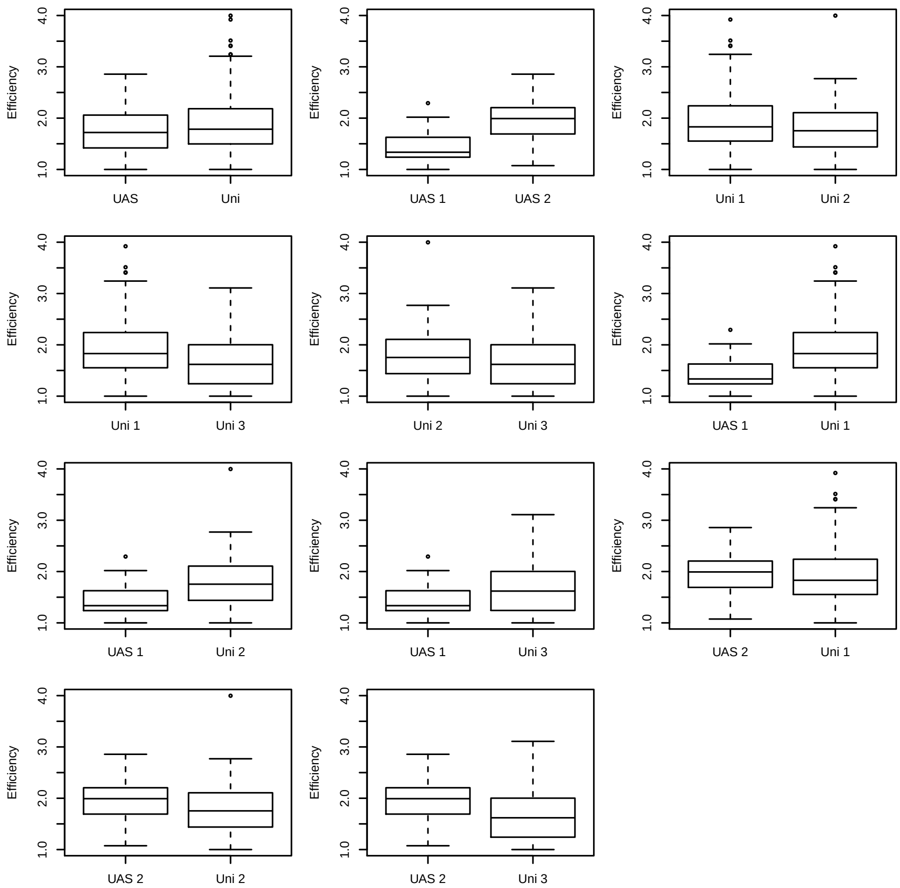
Table 10 – continued from previous page

University	VRS	CRS	Students	Focus	University	VRS	CRS	Students	Focus
U.OL.400	1.51	2.98	905	Uni 2	HS.WOE.750	2.22	3.50	1308	UAS 2
U.HI.100	1.52	1.82	509	Uni 1	U.Ha.400	2.23	5.29	566	Uni 2
TU.BS.390	1.53	4.07	760	Uni 2	U.GÖ.350	2.26	2.87	611	Uni 2
U.VEC.10	1.54	1.71	157	Uni 1	U.Ha.730	2.26	4.05	783	Uni 3
U.Ha.100	1.55	1.97	714	Uni 1	U.OL.50	2.27	3.06	342	Uni 1
U.OL.190	1.56	1.78	860	Uni 1	TU.BS.350	2.28	2.61	1231	Uni 2
U.HI.80	1.56	1.97	413	Uni 1	U.Ha.120	2.29	3.72	134	Uni 1
U.Ha.50	1.56	2.17	491	Uni 1	HS.WOE.670	2.29	3.92	1371	UAS 2
U.OS.170	1.57	2.22	825	Uni 1	HS.WOE.310	2.29	3.09	652	UAS 1
U.HI.200	1.58	2.00	255	Uni 1	HS.WOE.310.1	2.29	3.09	652	UAS 2
U.LG.290	1.59	1.91	2290	Uni 1	U.OS.250	2.30	2.78	2206	Uni 1
U.Ha.180	1.60	1.99	984	Uni 1	U.VEC.200	2.35	2.94	225	Uni 1
U.GÖ.235	1.60	1.81	1520	Uni 1	HS.BS.WFB.710	2.35	3.05	737	UAS 2
TU.CL.690	1.61	3.11	1176	Uni 3	TU.BS.340	2.37	3.11	1132	Uni 2
HS.HHG.800	1.61	2.66	762	UAS 2	U.Ha.40	2.38	3.02	408	Uni 1
U.Ha.290	1.62	2.07	2862	Uni 1	U.GÖ.100	2.40	3.86	1057	Uni 1
U.Ha.750	1.62	2.31	1705	Uni 3	U.HI.30	2.40	3.96	140	Uni 1
U.LG.670	1.62	3.01	477	Uni 3	U.HI.20	2.43	3.51	76	Uni 1
U.OS.180	1.62	2.04	1009	Uni 1	U.OL.800	2.44	3.67	163	Uni 1
HS.HHG.310	1.63	2.20	613	UAS 2	U.OS.50	2.45	3.93	326	Uni 1
HS.HHG.310.1	1.63	2.20	345	UAS 1	TU.BS.110	2.47	3.34	290	Uni 1
U.GÖ.370	1.64	3.69	1098	Uni 2	U.OS.830	2.47	6.88	175	Uni 1
HS.BS.WFB.690	1.65	2.13	1810	UAS 2	U.Ha.650	2.48	5.56	117	Uni 2
HS.Han.290.1	1.66	2.05	303	UAS 2	U.OS.350	2.48	3.19	656	Uni 2
U.LG.10	1.66	2.26	1515	Uni 1	U.OS.20	2.50	3.41	226	Uni 1
U.GÖ.290	1.66	2.05	4263	Uni 1	HS.Han.350	2.50	3.43	478	UAS 2
U.Ha.620	1.67	4.30	553	Uni 2	U.OS.780	2.52	3.73	315	Uni 1
U.GÖ.20	1.67	3.02	649	Uni 1	U.HI.400	2.53	3.79	209	Uni 2
U.HI.420	1.69	2.20	121	Uni 2	U.OS.140	2.53	3.80	286	Uni 1
HS.EL.720	1.69	2.80	327	UAS 2	U.GÖ.250	2.53	3.12	3034	Uni 1
U.GÖ.90	1.69	3.13	151	Uni 1	U.GÖ.110	2.56	3.37	709	Uni 1
U.GÖ.160	1.69	2.43	436	Uni 1	HS.EL.710	2.56	3.58	1104	UAS 2
TU.BS.400	1.70	3.78	919	Uni 2	U.HI.10	2.61	3.29	995	Uni 1
U.OS.200	1.70	2.31	244	Uni 1	U.OL.350	2.62	3.74	1262	Uni 2
U.Ha.235	1.71	1.90	717	Uni 1	U.Ha.670	2.66	7.18	112	Uni 3
U.GÖ.230	1.71	2.29	599	Uni 1	U.OL.790	2.72	3.77	333	Uni 1
HS.EL.290	1.72	2.17	1064	UAS 1	U.LG.350	2.77	4.19	430	Uni 2
U.Ha.740	1.72	2.76	526	Uni 3	U.Ha.20	2.85	3.72	181	Uni 1
HS.OS.610	1.72	2.41	2674	UAS 2	HS.OS.820	2.86	6.67	95	UAS 2
HS.BS.WFB.720	1.72	2.27	1462	UAS 2	U.GÖ.130	3.05	11.25	100	Uni 1
U.OS.360	1.73	4.08	316	Uni 2	U.OL.670	3.11	7.66	92	Uni 3
TU.BS.370	1.74	3.89	829	Uni 2	U.LG.235	3.20	6.13	391	Uni 1
U.OS.340	1.75	2.39	601	Uni 2	U.GÖ.80	3.21	4.29	101	Uni 1
U.VEC.30	1.75	3.46	103	Uni 1	TU.BS.830	3.24	6.29	54	Uni 1
U.HI.360	1.75	5.33	33	Uni 2	TU.BS.40	3.24	6.97	56	Uni 1
U.HI.235	1.76	2.08	374	Uni 1	U.GÖ.40	3.41	4.43	310	Uni 1
HS.Han.70	1.76	2.25	1275	UAS 1	U.OS.40	3.41	4.46	128	Uni 1
U.HI.290	1.77	3.89	104	Uni 1	U.GÖ.830	3.51	8.64	62	Uni 1
U.OL.830	1.77	5.45	232	Uni 1	U.GÖ.780	3.92	6.17	168	Uni 1
U.GÖ.420	1.77	2.29	619	Uni 2	U.HI.370	4.00	5.77	66	Uni 2

Note: The table is sorted in ascending order by the VRS efficiency values. The university description consists of the name of the university and the number of the field of education and research. The term focus represents subject groups: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: MWK (2019), own estimations with R-package Benchmarking (R Core Team, 2019, Bogetoft and Otto, 2019), the table was generated with xtable (R Core Team, 2019, Dahl et al., 2019).

Figure 6: Differences in efficiency between the types of universities (according to their focus) for 2017



Source: Own estimation and figure based on MWK (2019) and R (R Core Team, 2019).

Table 11: Change in efficiency for the years 2010–2017 and between 2010 and 2017

University	Focus	2010	2011	2012	2013	2014	2015	2016	2017	Change 10/17
U VEC 100	Uni 1	1.0	1.0	1.0	1.2	0.9	1.4	0.9	1.2	2.0
U GÖ 830	Uni 1	1.0	1.1	1.1	0.9	1.3	2.7	2.7	1.8	1.9
U GÖ 80	Uni 1	1.0	1.0	0.8	0.0	0.8	1.1	1.7	0.9	1.8
TU BS 40	Uni 1	1.0	1.0	1.9	1.8	2.5	2.7	2.6	2.0	1.7
U OL 235	Uni 1	1.0	1.3	1.4	1.5	1.5	2.1	1.5	1.3	1.6
U Ha 235	Uni 1	1.0	1.0	1.4	2.3	1.5	1.7	1.6	1.3	1.5
U GÖ 100	Uni 1	1.0	0.9	1.1	1.1	1.3	1.6	1.6	1.4	1.5
U LG 200	Uni 1	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.9	1.4
U GÖ 340	Uni 2	1.0	0.8	0.8	0.9	1.0	1.4	1.3	1.1	1.4
U LG 290	Uni 1	1.0	1.3	1.7	2.1	1.9	1.6	1.2	1.1	1.3
U GÖ 200	Uni 1	1.0	1.6	2.3	2.4	2.1	2.9	1.4	1.4	1.3
U Ha 230	Uni 1	1.0	1.1	1.5	1.4	1.2	1.4	1.4	1.2	1.3
U GÖ 250	Uni 1	1.0	1.2	1.4	1.5	1.4	1.9	1.2	1.1	1.2
U OS 330	Uni 2	1.0	0.6	1.4	1.5	1.5	1.4	1.5	0.7	1.2
HS WOE 720	UAS 2	1.0	1.0	1.4	1.5	1.4	1.2	1.1	1.5	1.2
U GÖ 235	Uni 1	1.0	1.1	1.5	1.9	1.4	1.6	1.5	1.1	1.2
U OL 350	Uni 2	1.0	0.8	0.8	0.7	0.7	0.8	1.1	1.0	1.2
U GÖ 780	Uni 1	1.0	1.0	1.0	0.7	1.1	0.8	0.8	1.2	1.2
U LG 10	Uni 1	1.0	1.0	1.4	1.6	1.2	1.8	1.1	1.1	1.2
TU BS 235	Uni 1	1.0	1.0	1.1	1.2	1.3	1.3	1.3	1.1	1.2
U Ha 670	Uni 3	1.0	2.7	1.6	1.1	1.4	1.8	2.5	1.3	1.2
U OL 290	Uni 1	1.0	1.1	1.4	1.1	1.3	1.7	1.1	0.9	1.1
U LG 100	Uni 1	1.0	1.3	1.6	1.4	2.0	1.8	1.1	1.0	1.1
U GÖ 180	Uni 1	1.0	1.0	1.4	1.3	1.6	1.6	1.1	1.1	1.1
U GÖ 290	Uni 1	1.0	1.2	1.3	1.4	1.4	1.5	1.3	1.1	1.1
U LG 615	Uni 2	1.0	1.0	0.8	1.0	1.0	1.1	1.1	1.0	1.1
U HI 10	Uni 1	1.0	0.5	0.6	0.7	0.5	0.9	0.7	0.8	1.1
HS BS WFB 720	UAS 2	1.0	0.7	0.8	0.9	0.9	1.1	0.9	1.0	1.1
U GÖ 410	Uni 2	1.0	0.5	0.4	0.4	0.6	0.7	1.1	0.6	1.1
U HI 240	Uni 1	1.0	1.0	1.0	1.0	1.1	1.2	1.5	1.1	1.1
U OS 235	Uni 1	1.0	1.0	1.4	1.3	1.3	1.6	1.1	1.0	1.1
U OL 170	Uni 1	1.0	0.6	1.3	0.8	0.8	1.0	1.4	0.9	1.1
U OL 180	Uni 1	1.0	0.8	1.2	1.1	1.0	1.3	0.9	0.8	1.1
U OS 100	Uni 1	1.0	1.0	1.3	1.4	1.5	1.5	1.2	1.0	1.1
U Ha 40	Uni 1	1.0	0.8	1.1	1.1	1.0	1.7	1.4	1.0	1.0
TU BS 710	Uni 3	1.0	0.5	0.7	0.6	0.8	0.9	1.1	0.7	1.0
U GÖ 160	Uni 1	1.0	0.9	0.8	0.8	1.0	1.6	1.5	1.0	1.0
U OL 50	Uni 1	1.0	1.2	1.5	1.5	1.2	1.6	1.0	1.0	1.0
TU BS 50	Uni 1	1.0	0.9	1.3	1.1	1.5	2.2	1.2	0.8	1.0
U HI 50	Uni 1	1.0	0.8	0.9	1.0	1.2	1.5	1.2	0.9	1.0
U HI 170	Uni 1	1.0	1.1	0.9	0.9	0.9	1.2	0.9	1.1	1.0
HS Han 350	UAS 2	1.0	1.2	1.3	1.1	1.2	1.4	0.9	1.0	1.0
U OL 360	Uni 2	1.0	0.7	0.6	0.5	0.5	0.7	0.5	0.5	1.0
U OL 330	Uni 2	1.0	1.1	1.0	0.7	0.7	1.0	1.2	0.7	1.0
HS Han 240	UAS 1	1.0	1.5	1.3	1.4	1.0	1.1	0.7	0.7	1.0
U Ha 690	Uni 3	1.0	0.9	0.9	0.9	0.9	1.2	1.4	0.9	1.0
U LG 240	Uni 1	1.0	1.1	2.1	3.0	3.5	1.2	1.0	1.0	1.0
TU BS 170	Uni 1	1.0	1.1	1.1	1.0	0.9	1.1	1.1	1.0	1.0
HS WOE 290	UAS 1	1.0	0.8	1.1	1.1	1.0	1.0	1.4	1.0	1.0
TU BS 350	Uni 2	1.0	0.7	0.8	0.7	0.7	1.2	1.2	0.7	1.0
TU CL 690	Uni 3	1.0	0.6	0.7	0.7	0.6	0.8	0.6	0.6	1.0
U Ha 120	Uni 1	1.0	1.3	2.5	6.9	9.1	2.0	2.3	1.5	1.0
U Ha 180	Uni 1	1.0	1.1	1.6	1.4	1.8	1.7	1.0	0.9	1.0
U GÖ 400	Uni 2	1.0	0.6	0.7	0.8	0.8	1.1	1.2	0.7	1.0
U VEC 180	Uni 1	1.0	1.4	1.2	1.5	1.6	1.7	1.2	1.0	1.0
U Ha 650	Uni 2	1.0	0.8	1.7	1.0	1.3	0.7	0.7	0.8	1.0
U Ha 370	Uni 2	1.0	0.6	0.7	0.8	0.7	0.8	1.0	0.6	1.0
TU BS 830	Uni 1	1.0	0.6	0.4	0.5	0.6	1.1	0.6	0.8	0.9
U OL 110	Uni 1	1.0	1.0	1.1	1.3	1.0	1.5	1.0	0.9	0.9
HS EL 690	UAS 2	1.0	1.0	0.9	1.4	1.5	1.3	1.4	1.2	0.9
HS EL 290	UAS 1	1.0	1.2	1.4	1.0	0.8	1.0	0.8	0.8	0.9
U VEC 240	Uni 1	1.0	1.5	1.3	1.6	1.3	1.5	1.4	0.8	0.9
U HI 220	Uni 1	1.0	0.8	1.0	1.0	1.0	1.2	1.3	0.7	0.9
U GÖ 110	Uni 1	1.0	0.8	1.1	1.0	1.4	1.4	1.2	0.9	0.9

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Table 11 – continued from previous page

University	Focus	2010	2011	2012	2013	2014	2015	2016	2017	Change 10/17
U Ha 710	Uni 3	1.0	0.5	0.6	0.4	0.5	0.7	0.9	0.6	0.9
TU BS 410	Uni 2	1.0	0.7	0.7	0.7	0.7	0.9	0.7	0.5	0.9
TU BS 180	Uni 1	1.0	1.0	1.2	1.1	1.1	1.3	1.0	0.9	0.9
U Ha 760	Uni 3	1.0	0.5	0.6	0.5	0.6	0.5	0.6	0.3	0.9
U Ha 20	Uni 1	1.0	1.3	1.2	0.8	0.8	1.0	1.1	1.0	0.9
TU BS 690	Uni 3	1.0	0.7	0.8	0.7	0.8	1.1	1.1	0.7	0.9
U OL 340	Uni 2	1.0	1.1	1.2	1.1	0.9	1.1	0.9	0.8	0.9
HS WOE 690	UAS 2	1.0	1.0	0.9	0.8	1.0	0.8	0.7	0.8	0.9
U OL 800	Uni 1	1.0	0.5	0.6	0.4	0.4	0.6	0.7	0.9	0.9
TU BS 750	Uni 3	1.0	0.8	0.8	0.7	0.7	1.1	1.0	0.7	0.9
U Ha 740	Uni 3	1.0	0.8	0.9	0.7	1.0	1.1	1.1	0.7	0.9
U Ha 360	Uni 2	1.0	0.7	0.7	0.7	0.7	0.9	1.1	0.6	0.9
U Ha 350	Uni 2	1.0	0.9	0.9	0.9	0.6	1.0	1.2	0.7	0.9
U GÖ 140	Uni 1	1.0	1.0	0.9	0.8	0.9	1.2	1.1	0.7	0.9
U GÖ 90	Uni 1	1.0	0.7	1.0	1.0	1.1	1.0	1.0	0.8	0.9
U LG 180	Uni 1	1.0	1.0	0.9	0.9	0.8	1.2	1.0	0.8	0.9
U HI 290	Uni 1	1.0	0.0	1.0	0.8	0.6	0.4	0.7	0.7	0.9
U OS 290	Uni 1	1.0	0.8	1.1	1.4	1.6	1.5	0.9	0.9	0.9
U Ha 750	Uni 3	1.0	0.8	0.7	0.4	0.4	0.7	1.0	0.6	0.9
U OL 130	Uni 1	1.0	0.8	1.0	1.0	1.2	1.2	0.8	0.6	0.8
TU CL 670	Uni 3	1.0	0.6	0.7	0.6	0.5	0.8	0.9	0.5	0.8
TU BS 400	Uni 2	1.0	0.7	0.7	0.8	0.7	0.8	0.7	0.6	0.8
TU BS 100	Uni 1	1.0	1.0	1.9	1.4	1.3	1.7	1.1	0.9	0.8
U HI 80	Uni 1	1.0	0.0	1.0	1.2	1.1	1.8	1.1	0.9	0.8
U VEC 200	Uni 1	1.0	0.8	0.9	1.0	1.1	1.0	0.7	0.8	0.8
U GÖ 170	Uni 1	1.0	0.9	1.3	1.1	1.2	1.4	0.8	0.7	0.8
U GÖ 40	Uni 1	1.0	0.7	1.0	0.9	1.0	1.2	1.1	0.9	0.8
U GÖ 50	Uni 1	1.0	0.7	0.8	0.7	0.7	1.0	0.8	0.6	0.8
U Ha 290	Uni 1	1.0	0.8	1.2	1.5	1.6	1.4	1.1	0.9	0.8
TU BS 360	Uni 2	1.0	0.6	0.6	0.5	0.6	0.7	0.6	0.5	0.8
U OS 780	Uni 1	1.0	1.4	1.5	1.1	1.5	1.4	1.1	0.9	0.8
U OL 200	Uni 1	1.0	0.9	1.0	0.9	1.0	0.9	0.7	0.7	0.8
U Ha 340	Uni 2	1.0	1.1	1.0	0.9	0.8	0.9	0.9	0.8	0.8
U HI 340	Uni 2	1.0	0.8	0.9	0.9	0.6	1.0	0.8	0.7	0.8
U Ha 100	Uni 1	1.0	1.4	1.5	1.3	1.2	1.2	0.8	0.7	0.8
U OS 110	Uni 1	1.0	0.9	1.2	1.3	1.3	1.2	1.1	0.7	0.8
U LG 350	Uni 2	1.0	0.7	0.8	1.1	1.1	1.0	0.8	0.8	0.8
U OL 100	Uni 1	1.0	1.0	1.1	1.1	1.1	1.3	0.8	0.8	0.8
U OL 20	Uni 1	1.0	1.2	1.1	0.9	0.7	1.2	0.6	0.6	0.8
HS BS WFB 690	UAS 2	1.0	1.1	1.2	1.0	1.0	1.1	0.9	0.7	0.8
U GÖ 20	Uni 1	1.0	0.7	0.7	0.8	0.9	1.0	1.0	0.6	0.8
U OS 200	Uni 1	1.0	0.6	1.0	1.1	1.4	1.1	0.9	0.9	0.8
U GÖ 360	Uni 2	1.0	0.5	0.5	0.5	0.5	0.5	0.7	0.5	0.8
U OS 250	Uni 1	1.0	0.9	0.9	1.0	0.8	1.0	0.8	0.6	0.7
U GÖ 370	Uni 2	1.0	0.5	0.7	0.7	0.6	0.7	0.9	0.6	0.7
TU BS 370	Uni 2	1.0	0.5	0.6	0.6	0.5	0.8	0.6	0.5	0.7
HS Han 620	UAS 2	1.0	0.8	0.7	0.9	0.9	1.1	1.2	0.7	0.7
U Ha 50	Uni 1	1.0	1.0	1.2	1.1	1.0	1.2	1.1	0.7	0.7
U OL 670	Uni 3	1.0	0.5	0.7	0.4	0.7	1.2	0.7	0.9	0.7
U HI 235	Uni 1	1.0	0.5	0.7	0.7	0.5	0.6	0.6	0.6	0.7
U OS 50	Uni 1	1.0	0.9	1.1	0.9	1.1	1.0	0.7	0.7	0.7
HS HHG 610	UAS 1	1.0	1.1	1.0	0.9	1.0	0.8	0.7	0.8	0.7
HS HHG 610	UAS 2	1.0	1.1	0.9	0.9	1.0	0.8	0.7	0.8	0.7
HS EL 710	UAS 2	1.0	1.0	1.1	0.9	1.1	1.4	0.9	0.8	0.7
HS OS 670	UAS 2	1.0	1.1	0.9	1.0	0.9	1.0	0.8	0.7	0.7
U OL 370	Uni 2	1.0	0.9	0.8	0.6	0.6	0.8	0.8	0.5	0.7
U OL 790	Uni 1	1.0	1.0	1.0	0.9	1.1	1.1	0.8	0.8	0.7
HS OS 610	UAS 2	1.0	1.0	1.2	1.5	1.2	1.1	0.8	0.8	0.7
U OL 400	Uni 2	1.0	0.5	0.7	0.6	0.7	0.7	0.8	0.5	0.7
U Ha 250	Uni 1	1.0	1.1	1.4	1.2	0.9	1.0	1.0	0.6	0.7
U Ha 620	Uni 2	1.0	0.5	0.7	0.4	0.5	0.5	0.7	0.4	0.7
HS BS WFB 290	UAS 1	1.0	0.8	0.9	0.9	0.7	0.7	0.6	0.6	0.7
HS Han 710	UAS 2	1.0	0.8	0.8	0.9	1.0	1.0	0.7	0.8	0.7
U OS 340	Uni 2	1.0	0.7	1.0	1.1	0.8	1.0	0.7	0.6	0.7
U HI 180	Uni 1	1.0	0.6	0.7	0.7	0.5	0.7	0.6	0.5	0.7
U OL 190	Uni 1	1.0	0.9	0.9	0.7	0.5	0.6	0.5	0.5	0.7
HS BS WFB 240	UAS 1	1.0	1.0	0.0	1.0	1.2	1.4	1.1	1.3	0.7

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Table 11 – continued from previous page

University	Focus	2010	2011	2012	2013	2014	2015	2016	2017	Change 10/17
U OS 420	Uni 2	1.0	0.6	0.7	0.9	0.7	1.0	0.8	0.7	0.7
HS OS 220	UAS 1	1.0	0.8	0.8	0.9	0.7	0.8	0.6	0.5	0.7
U LG 235	Uni 1	1.0	0.8	1.4	0.8	1.4	1.2	1.2	1.0	0.7
U OS 400	Uni 2	1.0	0.6	0.6	0.7	0.6	0.6	0.7	0.5	0.7
U OS 445	Uni 1	1.0	0.7	0.6	1.0	0.6	0.7	0.7	0.5	0.7
U OS 10	Uni 1	1.0	0.6	0.6	0.6	0.6	0.7	0.8	0.6	0.7
U LG 170	Uni 1	1.0	1.2	1.0	1.2	1.4	1.0	0.6	0.7	0.7
U HI 110	Uni 1	1.0	0.8	0.8	0.8	0.9	1.3	1.0	0.6	0.7
U HI 20	Uni 1	1.0	0.7	0.9	0.5	0.8	0.9	0.7	0.8	0.6
HS BS WFB 445	UAS 1	1.0	0.9	0.8	0.7	0.5	0.8	0.5	0.5	0.6
U OS 360	Uni 2	1.0	0.7	0.7	0.6	0.6	0.8	0.8	0.5	0.6
U OS 180	Uni 1	1.0	0.9	1.1	1.0	0.8	0.9	0.7	0.6	0.6
HS Han 70	UAS 1	1.0	1.0	0.9	0.7	0.6	0.9	0.6	0.7	0.6
HS HHG 240	UAS 1	1.0	1.0	1.0	0.9	0.9	0.9	0.7	0.7	0.6
U Ha 410	Uni 2	1.0	0.6	0.6	0.6	0.6	0.7	0.8	0.4	0.6
U OS 350	Uni 2	1.0	0.6	0.6	0.6	0.6	0.7	0.7	0.6	0.6
U Ha 190	Uni 1	1.0	1.4	1.3	0.9	1.0	0.7	0.6	0.5	0.6
TU BS 340	Uni 2	1.0	0.8	0.8	0.8	0.9	1.0	0.7	0.6	0.6
U GÖ 640	Uni 2	1.0	0.4	0.4	0.4	0.4	0.6	0.6	0.3	0.6
TU BS 730	Uni 3	1.0	0.5	0.4	0.6	0.6	0.7	0.5	0.5	0.6
U GÖ 120	Uni 1	1.0	0.7	0.8	0.7	0.9	0.8	0.6	0.7	0.6
U Ha 200	Uni 1	1.0	1.1	1.2	0.8	0.9	0.7	0.7	0.6	0.6
HS BS WFB 350	UAS 2	1.0	1.0	1.0	1.0	0.9	0.9	0.7	0.6	0.6
HS HHG 800	UAS 2	1.0	0.7	0.9	0.9	1.1	1.0	0.6	0.7	0.6
TU BS 110	Uni 1	1.0	0.8	0.9	0.9	1.0	0.9	0.8	0.7	0.6
TU CL 370	Uni 2	1.0	0.7	0.9	0.9	0.8	0.5	0.4	0.4	0.6
U Ha 110	Uni 1	1.0	0.8	1.1	0.8	1.0	0.9	0.7	0.6	0.6
HS EL 240	UAS 1	1.0	1.0	1.1	0.9	0.8	0.9	0.6	0.6	0.6
TU BS 290	Uni 1	1.0	0.7	0.6	0.6	0.6	0.7	0.7	0.5	0.6
U LG 250	Uni 1	1.0	0.9	1.1	1.0	1.1	0.8	0.7	0.6	0.6
HS Han 690	UAS 2	1.0	0.8	1.0	1.0	0.9	1.0	0.6	0.7	0.5
U GÖ 350	Uni 2	1.0	0.7	1.0	0.8	0.7	0.5	0.6	0.5	0.5
HS OS 10	UAS 1	1.0	0.6	0.7	0.8	0.7	0.7	0.6	0.6	0.5
U GÖ 620	Uni 2	1.0	0.6	0.5	0.5	0.6	0.7	0.6	0.4	0.5
HS HHG 310	UAS 1	1.0	1.0	1.0	1.0	0.9	1.2	0.6	0.7	0.5
U HI 100	Uni 1	1.0	0.8	0.8	0.6	0.5	0.8	0.6	0.5	0.5
U OS 170	Uni 1	1.0	0.5	0.7	0.5	0.6	0.8	0.6	0.5	0.5
U VEC 50	Uni 1	1.0	0.7	0.9	0.9	1.2	1.0	0.7	0.6	0.5
HS HHG 670	UAS 2	1.0	0.8	0.7	0.6	0.7	0.8	0.6	0.6	0.5
HS WOE 310	UAS 1	1.0	0.9	0.9	0.8	0.8	0.9	0.5	0.6	0.5
HS WOE 310	UAS 2	1.0	0.9	0.9	0.8	0.8	0.9	0.5	0.6	0.5
TU CL 290	Uni 1	1.0	0.9	0.8	0.8	0.6	0.6	0.5	0.5	0.5
U Ha 780	Uni 1	1.0	0.5	0.8	0.8	2.1	1.1	1.0	0.7	0.5
HS WOE 750	UAS 2	1.0	0.8	0.6	0.6	0.6	0.6	0.5	0.6	0.5
U OS 30	Uni 1	1.0	0.8	0.7	0.7	1.1	0.6	0.6	0.6	0.5
HS BS WFB 710	UAS 2	1.0	0.6	0.8	0.9	0.9	0.6	0.4	0.5	0.5
HS WOE 670	UAS 2	1.0	0.6	0.8	0.6	0.8	0.8	0.6	0.6	0.5
U Ha 400	Uni 2	1.0	0.5	0.8	0.4	0.6	0.6	0.6	0.5	0.5
TU CL 340	Uni 2	1.0	0.7	0.9	1.0	1.0	0.7	0.5	0.5	0.5
U VEC 340	Uni 2	1.0	0.0	0.0	0.0	0.0	1.0	0.5	0.5	0.5
HS HHG 310	UAS 2	1.0	0.9	0.9	0.8	0.7	1.1	0.5	0.6	0.5
U OS 20	Uni 1	1.0	0.6	0.9	0.8	0.7	0.7	0.4	0.5	0.5
HS OS 310	UAS 1	1.0	1.3	0.8	0.7	0.7	0.7	0.5	0.5	0.5
HS OS 310	UAS 2	1.0	1.3	0.8	0.7	0.7	0.7	0.5	0.5	0.5
HS WOE 730	UAS 2	1.0	0.5	0.6	0.5	0.6	0.9	0.5	0.6	0.5
U Ha 420	Uni 2	1.0	0.7	0.6	0.5	0.7	0.5	0.6	0.4	0.5
HS EL 330	UAS 2	1.0	0.8	1.1	0.7	0.8	0.8	0.5	0.5	0.5
U VEC 235	Uni 1	1.0	0.9	0.5	0.8	1.0	1.0	1.0	1.2	0.4
U OS 370	Uni 2	1.0	0.6	0.6	0.6	0.7	0.6	0.5	0.3	0.4
U VEC 30	Uni 1	1.0	0.7	0.6	0.0	0.6	0.5	0.4	0.3	0.4
U Ha 730	Uni 3	1.0	0.4	0.4	0.3	0.5	0.5	0.5	0.5	0.4
U OS 830	Uni 1	1.0	0.7	0.8	0.6	0.8	0.6	0.5	0.5	0.4
U OS 120	Uni 1	1.0	0.9	0.7	0.7	0.6	0.6	0.5	0.5	0.4
U LG 670	Uni 3	1.0	0.6	0.9	0.7	0.7	0.6	0.5	0.4	0.4
HS EL 720	UAS 2	1.0	0.6	1.0	1.0	0.6	0.7	0.6	0.6	0.4
TU BS 390	Uni 2	1.0	0.6	0.8	0.5	0.5	0.9	0.3	0.4	0.4
HS Han 290	UAS 1	1.0	0.9	0.8	0.7	0.4	0.4	0.4	0.3	0.4

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Table 11 – continued from previous page

University	Focus	2010	2011	2012	2013	2014	2015	2016	2017	Change 10/17
U HI 830	Uni 1	1.0	0.6	0.8	0.4	0.5	0.6	0.5	0.3	0.4
U OL 830	Uni 1	1.0	0.7	0.6	0.6	0.6	0.7	0.6	0.4	0.4
U GÖ 130	Uni 1	1.0	0.5	0.4	0.3	0.5	0.4	0.4	0.4	0.4
U HI 40	Uni 1	1.0	0.6	0.5	0.6	0.3	0.3	0.3	0.3	0.4
HS Han 800	UAS 2	1.0	0.8	0.8	0.6	0.8	0.6	0.5	0.5	0.4
U OL 40	Uni 1	1.0	1.2	1.0	0.8	0.8	0.9	0.7	0.4	0.3
U HI 350	Uni 2	1.0	0.9	0.8	0.6	0.4	0.5	0.8	0.3	0.3
U HI 400	Uni 2	1.0	0.4	0.5	0.3	0.4	0.4	0.4	0.4	0.3
U GÖ 230	Uni 1	1.0	0.4	0.4	0.4	0.3	0.5	0.3	0.2	0.3
U VEC 830	Uni 1	1.0	0.6	0.3	0.4	0.3	0.5	0.7	0.3	0.3
HS OS 830	UAS 2	1.0	2.3	0.2	0.3	0.4	0.3	0.2	0.2	0.2
HS BS WFB 220	UAS 1	0.0	0.0	0.0	1.0	0.8	1.2	1.3	1.1	0.0
HS BS WFB 250	UAS 1	1.0	0.7	0.6	0.0	0.0	0.0	0.0	0.0	0.0
HS BS WFB 670	UAS 2	1.0	1.2	0.3	0.3	0.3	0.0	0.0	0.0	0.0
HS BS WFB 750	UAS 2	0.0	0.0	0.0	1.0	1.5	0.8	0.5	0.7	0.0
HS BS WFB 800	UAS 2	1.0	0.4	0.5	0.5	0.0	0.0	0.0	0.0	0.0
HS Han 290	UAS 2	0.0	0.0	1.0	1.2	0.6	0.8	0.7	0.6	0.0
HS HHG 220	UAS 1	1.0	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0
HS HHG 445	UAS 1	0.0	0.0	0.0	1.0	0.7	0.7	0.7	0.7	0.0
HS HHG 780	UAS 2	1.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0
HS OS 10	UAS 2	1.0	0.6	0.7	0.0	0.0	0.0	0.0	0.0	0.0
HS OS 820	UAS 2	0.0	0.0	0.0	1.0	2.2	1.8	2.1	2.0	0.0
HS WOE 750	UAS 1	1.0	0.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0
TU BS 20	Uni 1	0.0	1.0	1.5	1.2	1.3	1.5	0.8	0.9	0.0
TU BS 200	Uni 1	0.0	0.0	1.0	0.6	0.6	0.9	0.9	0.8	0.0
TU CL 350	Uni 2	1.0	0.6	0.6	0.6	0.9	0.0	0.0	0.0	0.0
TU CL 360	Uni 2	1.0	0.7	0.8	0.9	0.9	0.0	0.0	0.0	0.0
TU CL 410	Uni 2	1.0	0.9	1.0	0.6	0.8	0.0	0.0	0.0	0.0
TU CL 680	Uni 3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
U GÖ 420	Uni 2	0.0	1.0	1.3	1.3	1.6	1.7	1.3	1.0	0.0
U Ha 30	Uni 1	1.0	0.9	1.1	0.9	0.0	0.0	0.0	0.0	0.0
U HI 30	Uni 1	0.0	0.0	0.0	0.0	1.0	1.3	0.8	1.1	0.0
U HI 200	Uni 1	0.0	1.0	1.0	0.9	0.8	1.1	0.9	0.7	0.0
U HI 360	Uni 2	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0
U HI 370	Uni 2	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.1	0.0
U HI 420	Uni 2	0.0	1.0	0.0	1.0	1.2	1.3	1.1	0.7	0.0
U HI 670	Uni 3	0.0	1.0	1.1	1.2	1.4	1.7	1.2	0.8	0.0
U HI 790	Uni 1	0.0	1.0	1.4	0.0	1.4	0.0	1.4	0.7	0.0
U LG 20	Uni 1	0.0	0.0	0.0	1.0	1.8	1.6	1.3	0.0	0.0
U LG 340	Uni 2	0.0	1.0	1.0	0.8	1.1	1.0	0.7	0.6	0.0
U OS 40	Uni 1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0
U OS 90	Uni 1	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0
U OS 140	Uni 1	0.0	1.0	0.6	0.4	0.4	0.4	1.2	1.1	0.0
U VEC 10	Uni 1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0
U VEC 110	Uni 1	1.0	0.0	1.0	0.8	1.4	1.3	1.0	0.0	0.0
U VEC 220	Uni 1	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
U VEC 330	Uni 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
U VEC 400	Uni 2	1.0	0.8	0.7	0.6	0.6	0.7	0.5	0.0	0.0
U VEC 420	Uni 2	1.0	0.7	0.9	0.8	0.4	0.4	0.8	0.0	0.0
U VEC 615	Uni 2	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U VEC 780	Uni 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U VEC 800	Uni 1	0.0	1.0	0.4	0.5	0.6	0.7	0.7	0.6	0.0

Note: The table is sorted in decreasing order by the last column. The university description consists of the name of the university and the number of the field of education and research. The term focus represents subject groups: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: Own estimations based on MWK (2019) and R-package Benchmarking (R Core Team, 2019, Bogetoft and Otto, 2019), the table was generated with xtable (R Core Team, 2019, Dahl et al., 2019).

Table 12: Regression results of the distance function general FGLS panel model

	Estimate		Std. Error
(Intercept)	5.175	***	0.69
Graduates.n	1.181	***	0.073
Public.funding	-0.502	***	0.08
Public.fundingxGraduates	-0.034	***	0.008
Time	0.029	***	0.003
factor(Focus)2	0.21	***	0.055
factor(Focus)3	0.318	***	0.047
factor(Focus)4	0.426	***	0.054
factor(Focus)5	0.382	***	0.067
Observations	1840		
Multiple R-Squared	0.9		

Signif. codes: * Pr(>|z|)<0.05; ** Pr(>|z|)<0.01; *** Pr(>|z|)<0.001.

Focus 1: UAS 1 (university of applied sciences for social sciences), Focus 2: UAS 2 (university of applied sciences for technical sciences, Focus 3: Uni 1 (university for social sciences and arts), Focus 4: Uni 2 (university for natural sciences), Focus 5: Uni 3 (university for engineering).

Source: Own estimation with R-package plm (R Core Team, 2019, Croissant and Millo, 2008), the table was generated with xtable (R Core Team, 2019, Dahl et al., 2019).

Table 13: SFA efficiency values 2010–2017

University	Focus	2010	2011	2012	2013	2014	2015	2016	2017
HS HHG 445	UAS 1				1.41	1.00	1.00	1.41	1.00
U LG 340	Uni 2		2.09	1.44	1.35	1.80	1.67	1.47	1.05
TU BS 390	Uni 2	2.87	2.02	1.84	1.64	1.65	2.65	1.00	1.10
U VEC 340	Uni 2	3.36					2.68	1.47	1.10
U VEC 180	Uni 1	2.17	2.20	1.37	1.82	2.42	2.58	1.75	1.18
U GÖ 170	Uni 1	2.23	1.83	2.00	1.69	2.18	2.12	1.63	1.19
U OS 445	Uni 1	2.02	2.12	1.43	2.25	2.31	1.78	1.97	1.20
U HI 420	Uni 2		3.40		1.91	3.66	2.54	2.51	1.21
U LG 170	Uni 1	3.38	2.92	1.62	1.99	2.42	1.69	1.38	1.24
U LG 670	Uni 3	3.60	2.48	2.69	2.37	2.01	2.01	1.86	1.24
U Ha 190	Uni 1	2.44	3.69	2.35	1.79	2.08	1.50	1.70	1.25
U Ha 420	Uni 2	3.97	2.43	1.55	1.59	1.95	1.43	2.15	1.25
U LG 100	Uni 1	2.22	2.06	1.83	1.78	2.15	1.98	1.66	1.25
HS OS 220	UAS 1	4.31	2.33	1.84	1.97	2.18	2.01	1.66	1.26
U VEC 330	Uni 2								1.26
HS Han 620	UAS 2	3.75	2.46	1.35	2.08	1.86	1.75	2.08	1.27
HS OS 670	UAS 2	3.67	3.26	1.67	1.84	1.86	1.73	1.82	1.28
U HI 830	Uni 1	4.27	2.29	2.45	1.39	1.71	2.08	1.85	1.29
HS OS 310	UAS 2	5.61	5.25	2.04	1.83	2.21	1.63	1.56	1.29
U HI 790	Uni 1		4.11	3.84		1.86		2.67	1.30
U OS 400	Uni 2	2.30	1.98	1.43	1.86	1.66	1.65	1.90	1.31
U HI 80	Uni 1	4.61		1.46	2.13	2.47	2.68	2.07	1.31
U OS 170	Uni 1	5.26	1.73	1.70	1.29	1.48	1.88	1.70	1.31
U GÖ 620	Uni 2	4.52	2.81	1.96	1.96	2.37	2.31	1.93	1.31
U HI 200	Uni 1		2.24	1.66	1.46	1.99	1.84	2.09	1.32
U OS 200	Uni 1	2.57	1.59	1.40	1.72	1.89	1.57	1.67	1.32
U VEC 235	Uni 1	5.06	3.35	2.61	3.09	4.66	2.61	1.88	1.33
HS HHG 240	UAS 1	4.01	2.62	1.90	1.63	2.03	1.88	1.93	1.33
U Ha 100	Uni 1	2.82	3.07	2.40	2.07	2.35	1.95	1.87	1.34
U HI 170	Uni 1	3.07	2.24	1.29	1.35	1.52	1.85	1.75	1.34
U OS 100	Uni 1	2.42	1.66	1.64	1.85	2.14	1.93	2.04	1.35
HS Han 240	UAS 1	3.15	2.98	2.22	2.33	2.37	2.16	1.67	1.35
U OS 110	Uni 1	3.01	1.95	1.91	2.03	2.55	2.08	2.64	1.35
U GÖ 420	Uni 2		1.68	2.04	1.92	2.45	2.61	2.23	1.36
U LG 180	Uni 1	2.00	1.83	1.36	1.35	1.68	1.84	1.86	1.36
U VEC 240	Uni 1	2.57	2.66	1.94	2.52	2.78	2.40	2.63	1.37
U VEC 30	Uni 1	4.26	3.72	2.04		2.83	2.43	2.57	1.37
U OS 180	Uni 1	3.85	2.67	2.39	2.11	2.00	1.95	2.01	1.37
HS OS 610	UAS 2	2.85	2.52	2.08	2.56	2.24	1.95	1.87	1.38
HS EL 720	UAS 2	6.24	2.58	3.28	3.74	1.70	1.64	1.73	1.38
HS HHG 800	UAS 2	3.28	2.04	1.68	1.78	2.08	2.11	1.58	1.38
U LG 240	Uni 1	1.10	1.31	1.69	2.36	3.77	1.82	1.57	1.41
TU BS 180	Uni 1	2.49	1.85	1.60	1.61	1.97	2.14	1.84	1.42
U HI 290	Uni 1	4.00		2.52	1.99	2.53	2.10	1.77	1.42
U GÖ 640	Uni 2	5.13	2.73	2.73	2.53	3.24	2.89	2.36	1.42
TU BS 20	Uni 1		2.49	1.88	1.69	2.23	2.34	1.72	1.42
HS HHG 310	UAS 2	4.18	3.20	2.02	2.12	1.88	2.64	1.82	1.42
U HI 240	Uni 1	4.34	2.67	1.83	1.84	1.90	2.21	1.90	1.43
U HI 100	Uni 1	5.52	2.85	2.01	1.78	1.66	1.95	2.11	1.43
U HI 180	Uni 1	4.00	1.95	1.61	1.58	1.62	1.90	1.80	1.43
U OL 290	Uni 1	2.65	2.29	1.92	1.52	1.97	2.28	1.97	1.43
U HI 110	Uni 1	4.13	2.41	1.62	1.86	1.97	2.37	2.60	1.43
U Ha 180	Uni 1	1.88	2.01	1.95	1.97	2.68	2.22	2.01	1.43
U GÖ 230	Uni 1	8.15	2.94	2.05	2.26	2.15	2.65	2.47	1.44
U LG 290	Uni 1	1.95	1.82	1.74	2.20	2.51	1.84	1.87	1.44
U GÖ 20	Uni 1	4.58	2.37	1.68	1.97	2.15	2.34	2.49	1.45
U OS 120	Uni 1	5.11	3.59	2.04	2.11	1.89	1.82	2.04	1.45
U OL 340	Uni 2	3.01	2.23	1.77	1.63	1.92	1.93	1.97	1.46
HS BS WFB 240	UAS 1	3.99	2.58		1.00	1.82	1.58	1.69	1.47
HS Han 290	UAS 1	8.07	4.44	3.14	3.09	2.76	2.32	2.16	1.47
U OS 370	Uni 2	3.79	2.72	2.12	2.74	2.91	2.54	2.55	1.48
HS EL 240	UAS 1	4.26	3.12	2.34	2.06	2.59	2.25	2.24	1.48
U OL 400	Uni 2	2.77	2.12	1.85	1.94	2.08	2.10	2.26	1.48
U Ha 690	Uni 3	5.77	4.02	2.42	2.09	1.92	1.81	1.88	1.48
U OL 830	Uni 1	4.24	2.91	2.12	2.40	2.37	2.64	2.70	1.49
TU BS 400	Uni 2	3.09	2.36	1.73	2.13	2.23	2.22	1.98	1.49

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Table 13 – continued from previous page

University	Focus	2010	2011	2012	2013	2014	2015	2016	2017
U Ha 290	Uni 1	3.26	1.94	2.12	3.05	2.90	1.90	2.01	1.49
U Ha 740	Uni 3	2.15	1.81	1.42	1.38	1.94	2.04	2.25	1.49
U GÖ 180	Uni 1	2.04	1.82	1.93	1.73	2.12	2.27	1.97	1.50
U OL 180	Uni 1	2.96	1.95	1.67	1.53	1.67	1.97	1.80	1.50
TU BS 750	Uni 3	5.68	3.02	2.16	2.18	2.21	2.19	2.11	1.50
U Ha 110	Uni 1	3.57	2.66	2.33	1.95	2.56	1.99	2.26	1.51
U Ha 200	Uni 1	3.13	3.29	2.65	2.14	2.40	1.84	2.05	1.52
U OL 360	Uni 2	2.53	2.57	2.46	1.90	1.91	2.15	1.61	1.52
TU BS 690	Uni 3	4.18	2.38	1.85	1.57	1.78	1.94	2.11	1.53
TU BS 100	Uni 1	3.39	2.51	2.68	2.15	2.38	2.70	2.34	1.53
HS BS WFB 690	UAS 2	3.48	2.98	2.39	2.16	2.44	2.13	2.27	1.54
U OL 190	Uni 1	3.48	2.72	1.98	1.60	1.49	1.75	1.74	1.54
U OS 340	Uni 2	3.35	2.13	2.07	2.25	2.51	2.19	2.10	1.55
U OL 100	Uni 1	3.60	2.45	2.07	1.94	2.38	2.52	2.09	1.55
TU BS 170	Uni 1	2.63	2.15	1.75	1.73	1.78	1.83	1.82	1.55
U GÖ 360	Uni 2	2.97	1.80	1.62	2.11	1.70	1.95	1.93	1.55
U Ha 50	Uni 1	3.32	2.58	2.15	2.14	2.28	2.56	2.46	1.56
HS Han 690	UAS 2	4.58	2.74	2.39	2.50	2.66	2.28	1.86	1.56
U GÖ 290	Uni 1	2.57	2.25	1.93	2.29	2.21	2.22	2.15	1.57
U GÖ 400	Uni 2	2.91	2.29	1.96	2.75	2.35	2.36	2.37	1.57
U OS 30	Uni 1	6.18	2.87	1.95	2.02	3.00	1.84	2.28	1.58
U GÖ 235	Uni 1	2.46	1.87	1.98	2.77	2.35	2.65	2.73	1.58
U GÖ 120	Uni 1	4.35	2.18	1.76	1.70	2.27	1.96	1.87	1.58
HS BS WFB 720	UAS 2	3.45	2.52	1.37	1.69	1.89	2.03	1.86	1.58
U GÖ 160	Uni 1	2.60	1.99	1.41	1.50	2.07	2.59	2.49	1.59
U OS 235	Uni 1	2.94	2.13	1.88	1.87	2.16	2.50	2.25	1.59
U Ha 730	Uni 3	3.78	1.69	1.15	1.22	2.08	1.81	2.27	1.59
HS OS 310	UAS 1	6.92	6.47	2.52	2.26	2.72	2.01	1.92	1.60
TU BS 360	Uni 2	3.28	2.54	2.08	1.82	2.70	2.51	2.08	1.60
U Ha 410	Uni 2	2.68	1.91	2.03	2.03	2.14	2.22	2.56	1.60
HS BS WFB 290	UAS 1	5.45	2.84	2.33	2.46	2.76	2.18	2.10	1.61
U OL 330	Uni 2	2.76	2.84	2.05	2.06	2.16	2.25	2.60	1.61
U OS 420	Uni 2	3.67	1.99	1.86	2.50	2.08	2.23	2.21	1.61
HS Han 290	UAS 2			2.33	2.94	2.07	2.13	2.55	1.62
U OL 170	Uni 1	1.60	1.18	1.80	1.41	1.41	1.97	2.35	1.62
U HI 235	Uni 1	4.65	1.98	1.59	1.74	1.75	2.04	2.17	1.63
TU BS 200	Uni 1			2.26	1.66	1.52	2.23	2.41	1.63
U GÖ 90	Uni 1	2.70	1.84	2.24	2.37	2.96	2.27	2.34	1.63
U OL 20	Uni 1	4.24	3.44	2.47	2.16	2.28	2.76	2.25	1.64
U OS 290	Uni 1	3.12	1.89	1.87	2.33	2.87	2.53	2.21	1.64
TU BS 410	Uni 2	2.59	2.21	1.54	2.16	2.19	3.01	2.17	1.64
U HI 220	Uni 1	2.65	2.13	1.48	1.45	1.94	2.54	2.81	1.64
TU CL 670	Uni 3	4.16	3.69	2.63	2.41	2.64	2.65	2.05	1.64
U HI 400	Uni 2	6.42	2.55	2.05	1.40	1.78	1.74	2.36	1.64
HS HHG 610	UAS 2	3.52	3.24	2.04	1.95	2.06	1.78	1.93	1.65
HS Han 800	UAS 2	5.59	4.02	2.72	2.36	2.74	2.27	2.35	1.65
HS WOE 720	UAS 2	2.56	1.71	1.59	1.67	1.54	1.50	1.64	1.66
HS BS WFB 445	UAS 1	6.11	3.60	2.10	2.06	2.15	2.45	1.96	1.66
TU BS 340	Uni 2	4.17	2.55	1.82	1.96	2.23	2.54	2.46	1.66
HS EL 690	UAS 2	3.15	2.25	1.39	2.24	2.31	1.85	2.97	1.66
TU CL 690	Uni 3	4.23	3.22	2.37	2.60	2.58	2.23	1.59	1.66
U OL 110	Uni 1	3.06	2.40	1.80	2.03	1.97	2.39	2.32	1.67
U LG 250	Uni 1	4.82	2.91	2.56	2.31	2.61	2.00	1.94	1.67
U LG 615	Uni 2	2.02	2.75	1.74	2.43	2.18	2.00	2.06	1.68
TU BS 290	Uni 1	5.39	2.93	1.95	2.14	2.00	2.30	2.49	1.68
HS EL 330	UAS 2	5.36	3.81	3.50	2.43	2.88	3.02	2.17	1.70
HS HHG 670	UAS 2	5.04	3.18	1.95	1.96	2.36	2.54	2.17	1.70
U Ha 120	Uni 1	2.52	2.93	3.20	11.21	11.16	2.48	3.53	1.71
U Ha 235	Uni 1	2.21	1.50	1.51	2.31	2.14	2.22	2.43	1.71
U LG 10	Uni 1	2.27	1.71	1.69	1.87	1.71	2.37	1.92	1.72
U OS 10	Uni 1	5.52	2.98	2.26	2.38	2.48	2.19	2.55	1.72
U VEC 10	Uni 1						3.30		1.72
HS Han 710	UAS 2	3.46	2.41	1.72	2.03	2.34	2.39	2.05	1.73
HS OS 830	UAS 2	13.13	23.35	2.18	2.39	3.22	2.60	2.00	1.73
U OL 235	Uni 1	2.18	2.06	1.88	1.79	1.94	2.46	2.36	1.73
U GÖ 200	Uni 1	2.15	2.26	2.27	2.35	2.54	2.79	2.23	1.73
U OL 200	Uni 1	3.29	2.22	1.99	1.88	2.30	2.00	1.93	1.74

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Table 13 – continued from previous page

University	Focus	2010	2011	2012	2013	2014	2015	2016	2017
U Ha 650	Uni 2	2.02	3.83	3.36	2.35	2.89	1.83	1.92	1.74
U HI 50	Uni 1	4.03	1.93	1.56	1.79	2.03	2.51	3.27	1.75
HS HHG 310	UAS 1	5.35	4.20	2.50	2.61	2.32	3.25	2.25	1.76
U GÖ 410	Uni 2	3.74	2.79	1.98	2.13	2.46	2.18	3.19	1.77
HS BS WFB 220	UAS 1				2.69	2.53	2.47	2.49	1.77
HS WOE 690	UAS 2	3.22	2.72	2.44	1.66	2.27	1.79	1.83	1.77
TU BS 370	Uni 2	3.41	2.26	2.13	2.26	2.01	2.76	2.10	1.77
TU CL 370	Uni 2	3.91	3.21	3.04	3.94	3.33	2.35	2.27	1.77
HS BS WFB 350	UAS 2	5.16	3.88	2.87	3.02	3.01	2.31	2.48	1.80
U HI 670	Uni 3		2.02	1.74	2.97	4.98	2.54	2.82	1.80
U LG 350	Uni 2	3.47	2.30	1.74	2.66	2.84	2.45	2.38	1.80
HS OS 10	UAS 1	4.77	2.06	2.15	1.91	2.69	2.24	2.17	1.81
U Ha 250	Uni 1	4.84	3.54	3.42	3.01	3.17	3.01	3.41	1.81
TU BS 110	Uni 1	4.47	3.80	2.45	2.55	2.72	2.72	3.00	1.82
U OS 780	Uni 1	4.48	4.43	2.98	2.73	3.12	3.19	2.97	1.82
U OL 50	Uni 1	2.94	2.87	2.52	2.55	2.15	2.87	2.27	1.83
U HI 40	Uni 1	9.72	4.17	2.24	2.90	1.91	2.08	2.00	1.83
U Ha 400	Uni 2	4.52	2.29	2.75	1.87	2.42	2.32	2.70	1.83
U Ha 340	Uni 2	3.87	3.46	2.38	2.25	2.26	2.07	2.50	1.84
U OS 360	Uni 2	3.83	2.79	2.01	2.49	2.25	2.90	2.78	1.85
U HI 20	Uni 1	3.37	2.76	1.78	1.69	2.71	3.16	2.79	1.86
U VEC 100	Uni 1	2.86	1.52	1.20	1.60	1.41	1.90	1.82	1.87
U OL 40	Uni 1	6.19	4.54	3.00	2.83	3.06	2.96	2.61	1.87
U GÖ 370	Uni 2	2.82	1.72	1.86	2.44	2.18	2.11	2.98	1.87
U Ha 620	Uni 2	4.60	2.55	2.76	2.18	2.45	2.46	3.01	1.88
U LG 200	Uni 1	2.26	1.82						1.88
U OL 800	Uni 1	4.26	4.17	3.05	2.85	1.24	1.71	1.94	1.88
HS WOE 750	UAS 2	5.37	3.19	1.67	1.90	1.80	2.01	2.11	1.91
U Ha 750	Uni 3	6.63	3.82	3.37	2.13	2.16	2.25	2.68	1.92
TU BS 710	Uni 3	4.64	2.32	2.00	2.13	2.87	2.65	2.57	1.92
TU BS 730	Uni 3	4.72	2.11	1.45	2.21	2.27	2.57	2.29	1.93
U HI 30	Uni 1					2.13	2.62	2.23	1.94
U OS 50	Uni 1	3.82	3.15	2.56	2.41	2.99	2.74	2.13	1.94
HS WOE 670	UAS 2	4.84	2.82	2.57	2.19	2.68	2.84	2.65	1.94
HS WOE 290	UAS 1	4.17	2.32	2.30	2.36	3.00	2.96	3.13	1.95
TU BS 50	Uni 1	3.41	2.41	2.50	2.11	3.18	4.17	3.49	1.96
HS BS WFB 750	UAS 2				2.91	4.16	2.15	1.99	1.97
U Ha 360	Uni 2	3.10	2.49	2.35	2.57	2.45	2.25	2.54	1.97
HS WOE 730	UAS 2	6.60	2.94	2.06	1.76	2.23	2.74	2.18	1.97
TU CL 340	Uni 2	4.70	4.40	4.44	3.37	3.70	2.85	2.10	1.98
U VEC 50	Uni 1	7.22	2.98	2.51	2.91	3.37	3.05	3.35	1.98
U Ha 760	Uni 3	3.74	3.33	3.37	2.37	2.78	2.21	2.15	1.98
U VEC 800	Uni 1		5.28	1.76	1.82	2.36	2.49	2.99	1.98
U OL 370	Uni 2	3.14	3.27	2.14	2.37	2.53	2.72	2.96	1.98
U Ha 370	Uni 2	3.17	2.76	2.79	2.97	2.99	2.97	3.07	1.99
U Ha 230	Uni 1	2.68	1.99	1.92	1.97	2.26	2.43	2.60	2.00
HS Han 70	UAS 1	6.50	3.84	2.60	1.91	2.12	2.36	2.30	2.00
TU CL 290	Uni 1	7.32	4.51	3.04	3.14	3.07	2.59	2.57	2.01
U Ha 670	Uni 3	1.94	5.20	2.54	2.61	2.47	3.11	4.52	2.01
U GÖ 110	Uni 1	3.03	2.16	2.23	2.18	2.87	3.20	3.15	2.02
U OL 790	Uni 1	4.83	4.05	2.57	2.46	2.58	3.00	2.53	2.03
U GÖ 340	Uni 2	2.64	2.15	1.70	1.77	2.36	2.19	1.95	2.04
U Ha 780	Uni 1	4.31	2.51	2.28	3.24	6.69	3.34	3.50	2.04
HS HHG 610	UAS 1	4.34	4.08	2.51	2.40	2.54	2.20	2.38	2.04
HS EL 710	UAS 2	4.34	3.29	2.97	2.29	3.68	3.55	3.12	2.05
U OS 250	Uni 1	5.10	3.14	2.57	2.99	2.90	2.94	3.37	2.05
U OS 830	Uni 1	5.71	3.42	2.57	2.65	4.15	2.77	2.95	2.07
U GÖ 50	Uni 1	4.14	2.28	2.24	1.77	2.27	2.87	2.53	2.08
HS BS WFB 710	UAS 2	5.07	3.10	3.02	3.50	3.65	3.00	2.58	2.10
U Ha 710	Uni 3	5.13	3.58	2.40	2.03	2.49	2.14	2.89	2.11
U GÖ 140	Uni 1	4.60	4.20	2.97	2.40	3.27	3.59	3.39	2.12
U GÖ 100	Uni 1	2.71	1.78	1.91	1.96	2.65	2.35	2.66	2.12
HS WOE 310	UAS 2	6.22	4.15	2.82	2.38	2.74	2.86	2.48	2.13
HS Han 350	UAS 2	4.25	3.87	2.62	2.30	2.85	3.12	2.97	2.16
U OS 20	Uni 1	5.04	3.00	3.10	3.57	3.41	3.32	2.85	2.16
TU BS 235	Uni 1	3.67	2.40	2.20	2.30	3.29	2.20	2.97	2.17
U HI 10	Uni 1	3.53	1.63	1.65	1.75	1.16	2.08	2.48	2.18

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Table 13 – continued from previous page

University	Focus	2010	2011	2012	2013	2014	2015	2016	2017
U OL 350	Uni 2	2.56	2.51	2.12	2.14	2.69	2.70	2.63	2.19
U HI 340	Uni 2	5.49	3.07	2.31	2.10	1.86	2.33	3.42	2.20
U GÖ 250	Uni 1	3.27	2.77	2.29	2.37	2.52	3.22	2.82	2.21
U Ha 20	Uni 1	5.15	4.17	2.61	1.71	1.69	2.93	3.10	2.25
U OS 140	Uni 1		2.90	30.19	6.55	63.61	17.76	3.30	2.27
U GÖ 350	Uni 2	5.15	3.60	3.34	3.41	3.58	3.42	3.48	2.29
U OL 670	Uni 3	3.80	1.97	1.73	1.27	2.00	3.55	2.51	2.31
U Ha 350	Uni 2	3.86	2.70	2.36	2.29	3.11	2.46	3.26	2.37
U OL 130	Uni 1	4.72	4.69	2.66	3.10	4.59	4.36	2.69	2.37
U OS 350	Uni 2	5.89	2.90	2.31	2.93	3.18	3.34	3.44	2.39
U LG 235	Uni 1	3.89	3.41	4.29	3.90	4.78	3.13	3.73	2.41
TU BS 830	Uni 1	3.00	2.06	1.00	2.26	2.47	4.04	2.67	2.45
U HI 350	Uni 2	6.71	3.74	3.64	3.17	3.35	2.49	3.40	2.49
HS OS 820	UAS 2				1.28	2.60	2.37	3.50	2.50
U HI 360	Uni 2			2.36					2.51
U HI 370	Uni 2							3.32	2.58
TU BS 350	Uni 2	3.88	2.31	1.92	1.77	2.58	3.06	3.39	2.61
HS WOE 310	UAS 1	7.67	5.12	3.47	2.94	3.38	3.53	3.06	2.63
U Ha 40	Uni 1	3.80	2.32	1.98	2.29	2.77	3.39	3.68	2.64
U OS 40	Uni 1						4.32		2.70
TU BS 40	Uni 1	2.43	2.80	2.69	3.49	4.10	4.33	4.10	2.72
U VEC 830	Uni 1	9.45	3.98	1.85	2.14	2.31	2.99	5.45	2.73
U OS 330	Uni 2	8.50	2.77	3.13	3.35	3.30	4.39	3.62	2.76
U GÖ 130	Uni 1	6.76	3.79	2.09	2.45	3.45	2.81	4.08	2.77
HS EL 290	UAS 1	5.00	3.76	3.31	2.39	2.74	3.32	3.45	2.82
U GÖ 80	Uni 1	3.94	2.51	1.29		2.72	3.03	6.69	2.84
U GÖ 830	Uni 1	6.56	2.54	2.68	1.72	3.69	5.00	5.22	2.86
U VEC 200	Uni 1	4.30	2.50	2.05	2.65	3.11	2.37	2.53	3.00
U GÖ 780	Uni 1	4.51	3.32	2.74	1.85	2.71	2.14	2.57	3.14
U GÖ 40	Uni 1	6.34	2.96	2.77	2.45	3.12	3.78	4.41	4.50
HS BS WFB 250	UAS 1	6.46	3.31	2.90					
HS BS WFB 670	UAS 2	7.29	6.46	2.37	1.39	1.80			
HS BS WFB 800	UAS 2	7.52	1.99	1.99	2.01				
HS HHG 220	UAS 1	2.71	1.75	1.14					
HS HHG 780	UAS 2	5.57	2.35	1.48					
HS OS 10	UAS 2	3.86	1.67	1.75					
HS WOE 750	UAS 1	5.24	3.15	1.84					
TU CL 350	Uni 2	3.79	2.61	2.40	2.77	3.36			
TU CL 360	Uni 2	3.91	3.16	2.77	3.59	3.95			
TU CL 410	Uni 2	5.16	3.23	2.63	2.30	3.03			
TU CL 680	Uni 3	6.38	4.01	2.62	2.97	2.85			
U Ha 30	Uni 1	4.90	4.38	3.19	3.50				
U LG 20	Uni 1				1.75	2.78	2.90	3.05	
U OS 90	Uni 1						1.98	2.10	
U VEC 110	Uni 1	6.20		2.48	2.23	3.67	3.65	2.95	
U VEC 220	Uni 1							2.83	
U VEC 400	Uni 2	4.60	2.92	1.97	2.23	2.37	3.09	2.45	
U VEC 420	Uni 2	2.83	1.98	1.98	2.04	2.25	2.34	2.17	
U VEC 615	Uni 2	1.00	1.00						

Note: The table is sorted in ascending order by the efficiency values in 2017. The university description consists of the name of the university and the number of the field of education and research. The term focus represents subject groups: UAS 1: social sciences, UAS 2: technical sciences (incl. design), Uni 1: social sciences (incl. law) and arts, Uni 2: natural sciences (incl. computer sciences), Uni 3: engineering.

Source: Own estimations based on MWK (2019) and R (R Core Team, 2019), the table was generated with xtable (R Core Team, 2019, Dahl et al., 2019).