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Competitive positioning of German Universities: Deliberate Decision, Fate, or Fiction?

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Abstract

With the increasing autonomy, the competitive pressure on German universities is rising. More freedom comes along with a higher obligation to position oneself in the (German) tertiary education and research market. We investigate to what extent a (competitive) positioning of German universities can be detected and how their positioning changes over time. Using non-parametric productivity estimation, we analyze 79 Germany universities based on information about the German University Statistics (Hochschulstatistik) provided by the German statistical office (Statistisches Bundesamt). Our (preliminary) results show that a clear positioning according to productivity statistics remains vague. The resulting competitive dynamics remains low, whereas the Excellence Initiative only induced an anticipation effect in the competitive dynamics. Overall, the scope of (most) universities for a competitive repositioning seems to be low.

Keywords: Competition, German Universities, Efficiency, Positioning, DEA

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1 Introduction

The time of insouciance of a solid state-financed university system seems to be long gone. Before the Bologna process in 1999, state funding was not based on performance for most universities in Germany (Krücken and Meier, 2006; Frølich et al., 2010; Musselin, 2018). In the last three decades, performance-based funding has been gradually gaining in importance, to gauge their relative performance yardstick competition has been introduced (Olivares and Wetzel, 2014; Lehmann et al., 2018; Agasisti and Johnes, 2009; Agasisti, 2009; Aghion et al., 2010), budgets for basic funding have declined (Krücken, 2021; Wiener et al., 2020) while their allocation is increasingly being awarded on the basis of performance-related factors (Auranen and Nieminen, 2010; Wiener et al., 2020).

The underlying idea of structural reforms concerning the Germany university sector was to increase universities' productivity by giving them more autonomy in their strategic decision making. Competitive programs, such as the Excellence Initiative, were launched to boost the best-performing universities to world-class level (Buenstorf and Koenig, 2020; Mergele and Winkelmayer, 2021; Gawellek and Sunder, 2016). The opportunity to be among the elite universities has given potentially eligible universities a clear incentive to compete for excellence funding. But also non-elite universities were forced to position themselves in the growing competition.

Whereas many studies aim at measuring productivity advances in the university system induced by the increase in autonomy and the launched competitive grants,[1] we intend to identify to what extent German universities can be assigned to specific competitive groups of universities and whether they have changed their positioning in the recent decades since the German universities have obtained more autonomy. In contrast to existing studies that try to classify universities using different clustering techniques (Gryshchenko et al., 2021; Herberholz and Wigger, 2021), we decided to apply a non-parametric productivity estimation method to identify distinct competitive groups of universities. Universities are active in several competitive arenas such as teaching, research, and (technology) transfer activities. In this study we focus on teaching and research. We neglect transfer due to a lack of the availability of a comprehensive dataset on this competition arena.[2] The non-parametric procedure allows us to endogenously determine groups of competitive fields, based on the data from the Federal Statistical Office of Germany (Destatis).

The classification of universities in competitive fields and efficiency classes, generated by a DEA-based Clustering method, allows us to track the mobility of universities across such classes, which in turn reveals the general competitive mobility of German universities over time. The results suggest that in general the mobility is low, with less than a third of universities changing classes on average—though only slightly. In the teaching arena, the dynamics is steadily declining over time with a small, negligible exception during the phase of Excellence Initiative; in research, we observe an increasing dynamics right before the Excellence Initiative funding period, thereafter, the dynamics decline.

In the following, we sketch the competitive history of German universities, the German university system as a whole, and we give a short review on relevant university classification studies (Section 2). Section (3) provides an illustration of the non-parametric classification technique we apply for identifying competitive groups, in Section (4) we present results, which we discuss in Section (5). Section (6) concludes.

[1] See e.g. Cantner et al. (2023) for an overview of empirical productivity studies.

[2] Although some of the transfer output measures, such as patents, spinoffs or collaborated projects with companies, is available, the majority of universities do neither report all spin-offs. There neither is a comprehensive database documenting the collaborated projects with industry.

2 German Universities Competitive Positioning

In this section, we offer contextual information about German universities and briefly characterize the evolution of their positions within the field. We address two guiding questions: What was the competitive context before receiving more autonomy (before 2000)? In what respect have universities gained autonomy (from 2000 onwards)?

Competitive context before 2000

The history of German universities is remarkably rich. The University of Berlin, founded by Wilhelm von Humboldt in 1810, for instance, was the first research university with the hitherto unknown principle of the unity of teaching and research that was emulated in other national systems, thereafter (Rothblatt and Wittrock, 1993). The doctorate, which symbolizes the strong research orientation of German universities in the 19th century, is an invention of this model. Likewise, the upgrading of technical schools to universities in the late 19th century was new and led to the creation of the knowledge-based industry of that time (Meyer-Thurow, 1982). Today's highly acclaimed American research universities are based on the basic principles of the German university of the 19th century (Ben-David and Freudenthal, 1991). After the Second World War, however, German universities lost much of their global appeal. This became apparent with the advent of global university rankings in the early 2000s. The disappointment was huge when the best German university was ranked 48th in the first Shanghai ranking in 2003, with only three other universities in the top 100. This led to numerous efforts to improve the global positioning of German universities, most notably the Excellence Initiative, which we will also discuss in this paper. Before conducting our analysis, we will highlight some contextual information about the German system in order to understand the competitive environment of its universities and mention some relevant studies that attempt to classify German universities according to their competitive positioning.

The German higher education system is predominantly public. This is especially true for comprehensive and research-intensive universities. The majority of private universities are technical colleges with specialized programs. Public universities are characterized by strong state governance. However, university governance has undergone several changes in the last 20 to 30 years, leading to an increasing autonomy of universities[3] Due to its federal character, laws regulating universities can vary widely, and international comparisons of the governance of German universities must take this into account (Aghion et al., 2010; Seeber et al., 2015). The 16 federal states (Länder) are primarily responsible for the legal regulation and financing of universities. Compared to the states, the federal government plays a minor role, especially in the area of legal regulation. This has not always been the case. From 1969 to 2006, the federal government's influence was greater due to its responsibility for the framework regulation of higher education, which was abolished in 2006. This change allowed all states and their universities to introduce tuition fees. However, attempts to introduce tuition fees in seven of the sixteen states between 2006 and 2007 were short-lived in the German higher education system and eventually abolished (Hüther and Krücken, 2014). Traditionally, the fundamental division in the German system has been between universities and universities of applied sciences (*Fachhochschulen*). Whereas universities have the primary mission to do research and teaching—having the exclusive right to award doctoral degrees, universities of applied sciences (*Fachhochschulen*) primary goal was in teaching. As there has always been a clear formal distinction between different types of universities, for instance, with respect to related missions, teaching responsibilities of professors (professors at universities teach eight or nine hours per

[3]For a comprehensive overview of the German higher education system, see Hüther and Krücken (2018).

semester, those at *Fachhochschulen* sixteen or eighteen), study programs (medicine, law, traditional humanities, and most natural sciences can only be studied at universities) the level of competition has been relatively low between these groups. The reason for this was a strong political will to create a certain homogeneity within the groups, a goal that has never been reached. Contrary to the idea of a comprehensive university, which was considered the ideal including technical universities with a strong focus on engineering and applied sciences, some universities were originally founded as hybrids between universities and polytechnics (*Gesamthochschulen*), which are smaller universities that cannot cover the main university subjects such as medicine and law, or universities with a strong focus on teacher training. Because of the strong dependence on state funding, the largely uniform legislation of universities within a state, and the waiving of tuition fees, the level of competition among universities remained relatively low for a long time, particularly when being compared to universities in other countries such as the United States (Clark, 1986).

Competitive context as of 2000

The situation changed around 2000 when several reforms were introduced piece by piece, meant to increase universities' autonomy. First, as a part of the Bologna process starting in 1999, Germany introduced the bachelor's and master's degree system. Universities and universities of applied sciences (*Fachhochschulen*) were given the right to award the same degrees. Since then, both types of institutions have introduced many new, mostly interdisciplinary programs. A further novelty was that bachelor's and master's degree programs must now be accredited by accreditation agencies and no longer by state ministries. The most important reform to foster competition in research was the Excellence Initiative firstly launched in 2005/06, which was renamed Excellence Strategy in 2016. The aim was to break up the previous homogeneity of universities and to promote the international competitiveness of high-performing German universities by awarding so-called excellence funding.

The Excellence Initiative is only one example of the competitive research funding that has been introduced in the recent years. The central funding agency for this type of funding programs is the *Deutsche Forschungsgemeinschaft* (DFG, German Research Foundation). Since 1996, the DFG not only initiates funding programs, but also monitors them. It regularly releases statistical data on the success of universities in obtaining DFG research funding, which is seen as a performance indicator that makes differences between universities visible to all universities thus intensifying university competition. And there are also other public funding programs to boost competition in teaching or third mission activities. Overall, we observe a trend towards competitive state funding programs for universities whose share in basic funding is more and more coming under pressure.

Formal organizational autonomy has increased not only in terms of course offerings and competitive research funding, but also in two other critical dimensions. Firstly, fixed salaries for nationally competitive university professors have given way to much lower base salaries that can be substantially enhanced by performance bonuses. This allows universities, for example, to recruit high-performing, research-oriented professors that are essential to succeed in the Excellence Initiative. Secondly, in terms of formal governance structures, organizational autonomy has increased as boards of governors have replaced direct ministerial monitoring. Overall, the influence of the state is still strong, though more through funding or goal and performance agreements between the state and the universities than through direct administration.

Although the formal legal university classification is mainly expressed in the distinction between universities and universities of applied sciences, German universities have positioned themselves differently in different areas within the above-mentioned equality paradigm. A study by Krücken (2007) on the transition to bachelor's and master's programs at German universities analyzed the main drivers of this transition. The process can only be explained by the strong interactions within an organizational field. Among the organizations involved, the individual federal states as coercive actors were identified as the main driving force, not bottom-up processes of universities. Compared to the top-down influence of the state, deliberate competitive strategies of the universities played a weaker role than expected. Moreover, the competitive groups in which HEIs position themselves with respect to students are primarily regional, not national or international. The studies by Kosmützky (2012) and Kosmützky (2016), analyzing the mission statements of German universities developed since 2000, show that the missions of these universities are consistent with those of institutions that share similar characteristics within their competitive group (as defined by Lant and Baum (1995)). These groups include, for example, traditional universities, technical universities, and small and medium-sized regional universities. Also Baier and Schmitz (2019) identify a change in the structure and positioning of German universities comparing the two periods 1995-2000 and 2007-2012.[4] For the first period, they show that the field positions of universities differ according to their founding concepts and historical development. Whereas traditional German universities, technical universities, and reform universities, which typically focus onsocial sciences and humanities, have similar field positions, in the first period; in the second, they detect some dynamics within the field. In particular, it appears to be theyounger universities that tend to diversify and specialize in niche markets, whereas universities of the other two groups become rather isomorphic.

While most studies note increased dynamism among German universities, they also emphasize that state influence continues to dominate universities' ability to act. In sum, these studies point to different positioning of universities and the crucial role of the state in such competitive positioning. Since the bulk of these studies argue from a sociological stance, we intend to measure quantitatively from an economic point of view to what extent the introduction of competitive programs, especially the introduction of the Excellence Initiative, unfolds an increased repositioning dynamics among German universities.

3 Non-Parametric Classification Approach

In order to analyze the strategic positioning of universities, a space must first be defined in which this positioning takes place and can be measured. Since we view universities as entities that use certain inputs to produce output, this space is represented as a technology set. The universities' observed input-output combinations, linear or convex combinations constructed from them, as well as unrealized strictly worse combinations of inputs and outputs span this set. This set makes it possible to characterize each university based on its strategic input-output combination and the performance it achieves, expressed as relative productivity. With regard to these two dimensions, universities are likely to be quite similar group-wise and can therefore be assigned to specific competitive fields. Each field gathers universities with rather similar strategic input-output combinations, allows for different relative productivity levels, and contains one best-practice university. The positioning and repositioning of universities may be reflected in universities moving or not moving between these competitive fields over time.

The method we apply to determine the performance of universities as relative productivity and their positioning in competitive fields is non-parametric technique to determine frontier production functions. This procedure assigns to an university a relative productivity value and a vector containing information on the best-practice universities this university is compared to. Based on this information, we construct competitive fields that are spanned by the best-performing universities.

[4] The analysis is based on a dataset of 58 German universities that includes various types of publication and funding data as well as institutional and historical characteristics (e.g., founding dates, socio-geographic location).

As we will show, the procedure is remarkably simple. For comparability reasons, we use the example data from Po et al. (2009) to illustrate the basic idea of their DEA-clustering approach from which we will deviate with regard to the formation of competitive fields.

We conceive a university as a production system, the main inputs of a university are capital (K) and labor (L). With these inputs, various outputs are produced, among them graduates in the teaching competitive arena and publications in the research competitive arena.[5]

The example data of Po et al. (2009) we present in Table (1)

Table 1
Example data from Po et al. (2009)

U	K	L	Y	U	K	L	Y	U	K	L	Y	U	K	L	Y
U1	1	5	1	U6	3	4	1	U11	6	5	1	U16	9	2	1
U2	2	3	1	U7	3	8	1	U12	7	5	1	U17	10	3	1
U3	3	2	1	U8	4	8	1	U13	7	4	1	U18	11	3	1
U4	5	1	1	U9	5	9	1	U14	7	3	1	U19	10	1.5	1
U5	2	5	1	U10	4	10	1	U15	8	4	1	U20	11	2	1

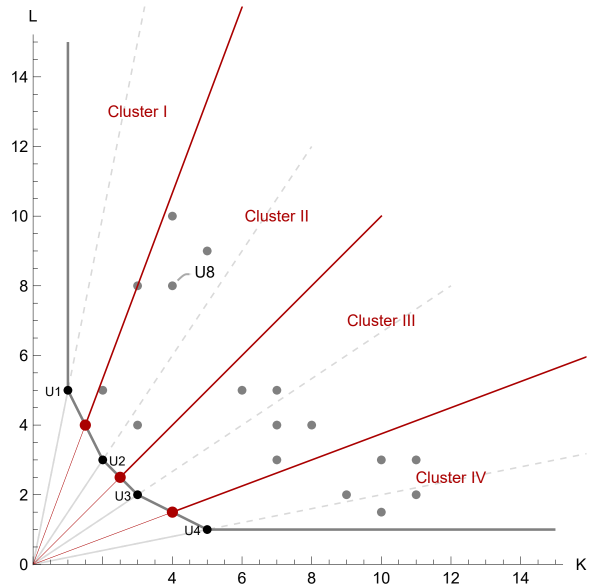
Note: twenty universities employ capital (K) and labor (L) in order to produce out (Y).

Figure (1) illustrates the example data from Table (1) in a K-L diagram. Every point in this diagram indicates a university that employs a given quantity of K and L to produce one unit of output Y. Four best-practice universities can be identified: U1,U2, U3, and U4. They are connected via a gray line which is called best-practice frontier. There is no other university that performs better in both of the two input factors when producing one output unit than these four universities. That is, why the are called best-practice or benchmark decision making units (DMU). Between the four benchmark universities, we cannot decide which one performs better over the other. University U1, for instance, employs more labor input than U2, but, in turn, it employs less input in capital. They are best-performing, because there are no other universities that perform better in both of the two input factors. Compared to U8, U1 employs less in both input factors and therefore dominates U8, according to the Pareto-Koopmans criterion. The slope of the rays of origin (in light gray) indicate the labor-capital ratio (L/K) of the respective benchmark university; therefore, best-practice university U1 can be considered the most labor intensive university, U4 as the most capital intensive university. Simultaneously, these lines represent a production function of the considered benchmark university against which we can now compare and thus classify the remaining lower performing universities. In contrast to Po et al. (2009), we do not classify DMUs on the grounds of the plane between the gray dashed lines through the origin, but we use an approach which we sipmly call *DEA-Max-λ-Clustering*. We explain this procedure in the following.

With the standard non-parametric model by Charnes et al. (1978) presented in Equation (1), we compute the relative performance of each university. The so-called CCR model in its input-oriented form[6] evaluates the productive performance of any university by minimzing its radial distance θ from the best-practice frontier. This frontier envelops the technology set (as defined before) and is

[5]As we leave out the third competitive arena 'transfer' in our empirical analyses, due to the lack of data, we confine this simplified example to only two arenas.

[6]Input-orientation means that inefficiency is measured in input direction in terms too much of input, whereas the output-oriented CCR-model measures inefficiency in the output direction in terms of too little of output.



Note: The solid gray line represents the frontier of the best-performing universities (U1, U2, U3, and U4). Max-λ Clustering. Planes between two red lines an the frontier delimit individual clusters.

Fig. 1. Non-parametric-clustering approach

given by the efficient universities and their constructed convex/linear combinations.[7] This distance of a university from the best-practice frontier is illustrated in Figure (1, solid gray piece-wise linear line).

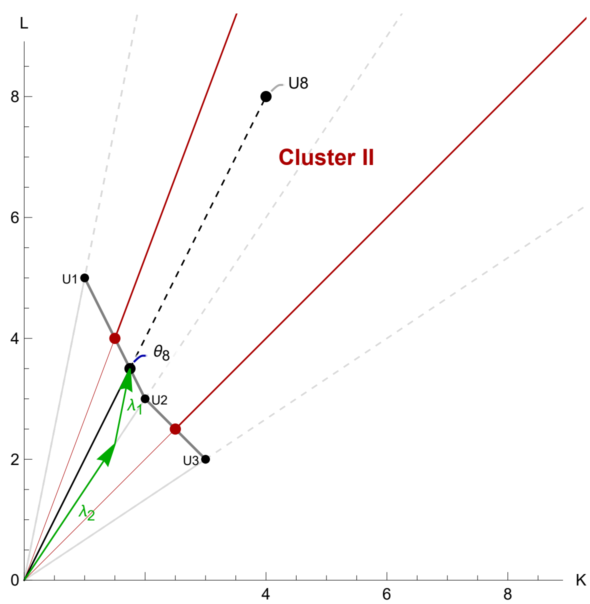
The linear program includes restrictions on inputs x_{ij} for each of the $i = 1, ..., m$ inputs. The weighted sum of inputs across all DMUs j must be less or equal to the input quantity of DMU k, that is, the DMU under consideration. The second constraint addresses output (y). When subtracting the weighted sum of outputs of all DMUs from DMU k's output (y_{rk}), the result must not be greater than zero. The weights labeled λ_i must be positive, the efficiency score θ must be equal or smaller than 1, but not less than zero. The weights λ are the center of our interest. In the linear program (Equation 1), the λs are the unknowns to be computed. They determine the linear combination of benchmarks that finally serves as the 'virtual' benchmark for an inefficient DMU.

The linear program in (1) minimizes the distance θ of an university toward the frontier. Two sets of restrictions have to be obeyed. The first one applies to the input dimension of the technology set, given by the m input sets $\sum_{j=1}^{n} x_{ij}$

$$\begin{aligned} &\min \theta \\ &\quad s.t. \sum_{j=1}^{n} x_{ij}\lambda_j - \theta x_{ik} \leq 0 \quad (\forall i = 1, \cdots, m) \\ &\quad y_k - \sum_{j=1}^{n} y_j \lambda_j \leq 0 \\ &\quad \lambda_j > 0, \quad \theta \leq 1 \end{aligned} \tag{1}$$

[7]The resulting θ is therefore called the radial distance to the frontier, because the extended line goes through the origin.

To be clearer, we zoom in on DMU $U8$ in Figure (1) and just look at the clip in Figure (2). $U8$ is an inefficient DMU as it employs more inputs (K and L, respectively) per unit output than $U1$ and $U2$, respectively. The latter are university $U8$'s benchmark universities. The virtual benchmark is calculated, using the CCR model above, as a linear combination of benchmarks $U1$ and $U2$. The weights for $U8$ are $\lambda_1 = 1/4$ and $\lambda_2 = 3/4$. In other word, 25% of $U1$ plus 75% of $U2$ yields the virtual benchmark θ_8. The efficiency score θ_8 indicates to what extent $U8$ would need to reduce their inputs in order to be efficient. In this example $\theta_8 = .4375$, which means that $U8$ would need to reduce inputs K and L by $(1 - \theta_8 = 56\%)$ in order to meet its virtual benchmark level on the frontier. The green arrows in Figure (2) indicate the two λs, λ_1 and λ_2 that construct the virtual benchmark for $U8$ in point θ_8.



Note: This diagram is a clip from Figure (1) to explain the weights calculated with the CCR model in Equation (1).

Fig. 2. Inefficient DMU $U8$ and its virtual benchmark θ_8

Now, it becomes very simple to explain what we mean with the *Max-λ-Clustering Method*. As long as λ_2 is greater than λ_1, university $U8$ is closer to the production function of benchmark university $U2$ than to the one of $U1$. Suppose the benchmarks of $U8$ were universities $U2$ and $U3$, then $U8$ would still belong to Cluster II in our example, as long as λ_2 is greater than λ_3. More general, as long as an inefficient benchmark is located between the two indicated red lines, it belongs to Cluster II in our example.

4 Positioning of German Universities

In this section, we apply our conceptual idea of the *Max-λ-Clustering Method* to German university data. After briefly addressing the data, we identify competitive fields for the two competitive arenas 'Teaching' and 'Research'. Once, the positioning of universities has been identified, we can trace the dynamics of universities' competitive positioning.

4.1 German University Data

All the data we use for our analysis either stems from the Federal Statistical Office of Germany (Destatis) or from Scopus (Elsevier). Unfortunately, both are confidential and costly so that we cannot provide the raw data. The German university statistics provides information for more than 300 organizations that are classified as educational organizations, research organizations or both that belong to the tertiary education sector in Germany. Thereof, we focus on publicly funded universities that are dedicated to both, teaching and research, in number, 73 universities. Aside from fiscal information, it also contains information about the number of students, graduates, or academic staff. As input we select the variable 'Academic Staff' and the annual global university funds (General expenditure plus Third-party funding minus Personnel expenditure) without expenditures for personnel to avoid double counting, as output measure for 'Teaching' we use the number of graduates (Destatis), for research the number of a university's annual publication record from Scopus. The limiting database is the one from the statistical office, as it starts in 2000 and ends in 2019, to date. The descriptive statistics can be consulted in Table (2).

Table 2
Descriptive statistics – University inputs and outputs

Input/Output	Obs.	Mean	Min.	Max.	Std. Dev.	Skewness	Kurtosis
Academic staff	1,593	587.0	16.	3,316.0	461.9	1.9	9.3
General expenditure	1,594	170,089.0	1,459.1	916,315.0	189,475.0	1.5	4.6
plus Third-party funding	1,594	230,817.0	1,608.0	1,206,059	242,868.0	1.5	4.7
Graduates	1,593	2,683.4	23.	10,591.0	1,905.4	1.1	4.2
Publications	1,592	1,322.7	1.	8,431.0	1,250.0	1.6	6.5

Note: (Input) academic staff: personnel engaged in teaching and research; (input) general expenditure: basic state funding; plus third-party funding: general expenditure plus third-party funding; (output) graduates: number of graduates. All input variables are from Destatis. (Output) publications: number of publications (Scopus).

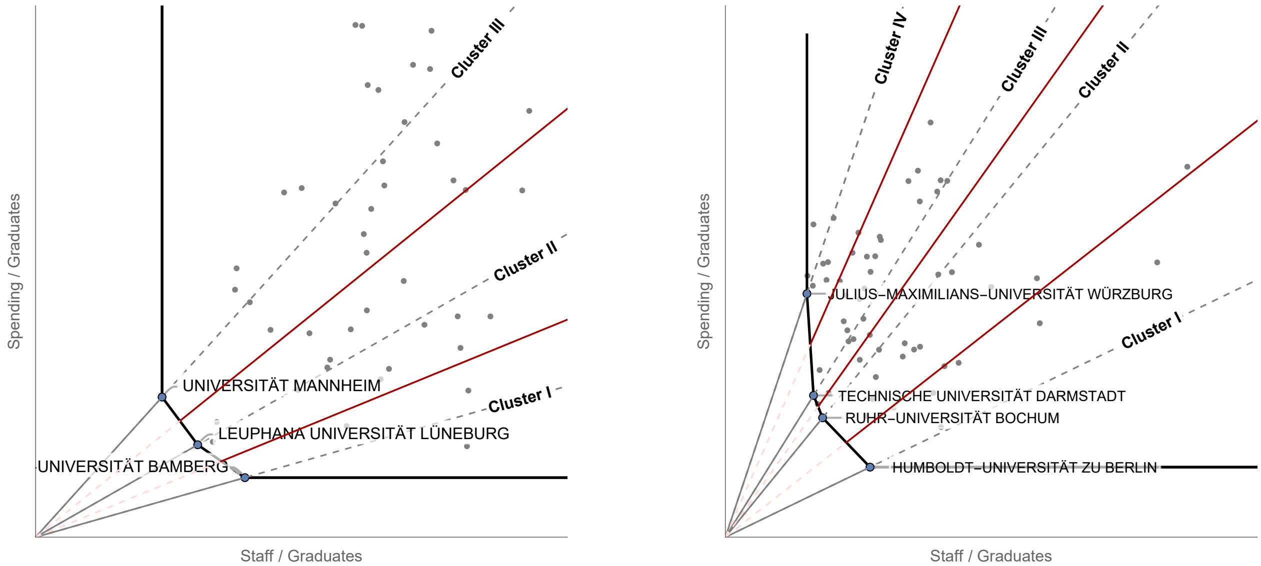
4.2 Competitive Fields – DEA-Max-λ-Clustering

Before running the computations by universities as suggested in the linear model in Equation (1), we smoothed the data using a Gaussian filter with radius= 2. Furthermore, Both output variables are forwarded by three years, as we assume that the productive effect of inputs takes time.

Figures (3) illustrates the frontiers and the identified clusters in 'Teaching' and 'Research' for the intital year 2000. For 'Teaching', the suggested clustering procedure leads to three endogenous clusters. Since the ratio of axes yields (Spending/Graduates/Staff/Graduates=) Spending/Staff, the three clusters are determined by the capital-labor ratio of the respective benchmark university, where the University of Bamberg reports the lowest capital-labor ratio (Cluster I), with the University of Lüneburg second-placed (Cluster II), and the University of Mannheim with the highest capital-labor ratio (Cluster III). Regarding the competition arena 'Research', the procedure renders four clusters with different levels in capital-labor ratio: Humboldt University Berlin with the lowest and the Julius-Maximilian University with the highest capital-labor ratio.

So far, we illustrate the technical procedure of our clustering attempt with DEA. Note that the attempt at clustering did not result in clearly delineated competitive groups of universities that could be identified by visual inspection. The preliminary results can be described as in the following: teaching has become relatively more capital intensive; there is no clear differentiation of

Fig. 3. DEA-Clusters – Teaching and Research



(a) DEA-Clusters Teaching 2000 **(b)** DEA-Clusters Research 2000

universities; concerning research, the heterogeneity between universities appears more pronounced than in teaching. A technical note has to be made at this point: the none-parametric approach (DEA) is rather sensitive to single entities. Consequently, it is also very sensitive to the number of identified clusters (i.e. competition fields).

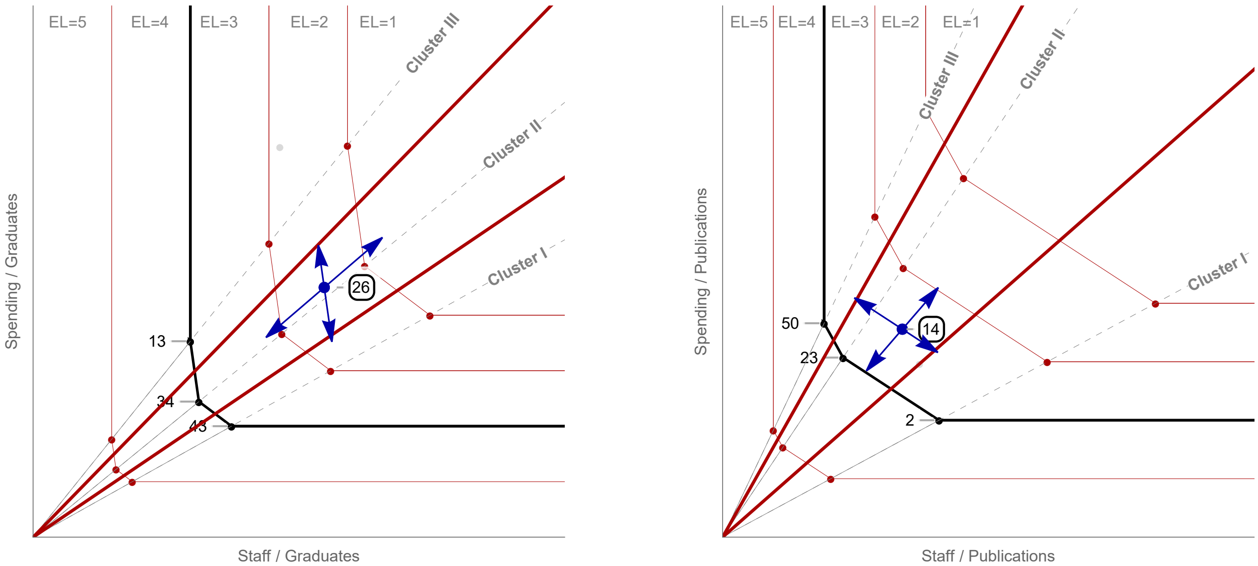
4.3 Classification of Competition Fields and Efficiency Classes

Because DEA is sensitive to individual changes, for example, when benchmark universities change over time, i.e. an efficient university becomes inefficient, vice versa, we calculate the benchmark frontier on university averages. More precisely, we use the average of inputs 'staff' and 'spending', as well as of outputs, i.e. number of graduates in case of 'Teaching' and number of publications in case of 'Research' by university. This successively yields an average frontier as depicted in Figure (4), the left panel indicate the average frontier in the competition arena 'Teaching' and the right of the arena 'Research'. The solid black line indicates the average frontier built by the, on average, best-performing universities (13, 34 and 45) in the competition field 'Teaching' and likewise in 'Research' (50, 23, 2) . The solid red lines in both sub figures of Figure (4) span three clusters (competition fields). Technically, they delimit a certain range of the capital-labor ratio (Spending/Personnel)[8] The kinked red lines parallel to the average frontier line express different efficiency levels. Each of those mark a certain efficiency level (EL=1 to EL=5). The latter are calculates as five equally sized percentiles. For readability, we only show one inefficient university in each panel, university 26 in the left and university 14 in the right panel. This shall illustrate the further procedure how we intend to track the dynamics of universities with respect to their competition field and their efficiency gains/losses.

We can now track whether or to what degree universities switch between the generated grid cells. University 26, for instance, can either switch from cluster II to cluster I (or cluster III), from

[8]The slope of each red line going through the origin can be calculated by dividing a co-domain value by the corresponding domain value: Spending/Graduates divided by Staff/Graduates.

Fig. 4. DEA-Clusters Average Values – Teaching and Research



(a) DEA-Clusters 'Teaching' average **(b)** DEA-Clusters 'Research' average

efficiency level EL=4 to efficiency level EL=3 (or any other efficiency class EL) or both. As the grid is fixed over time, we will also observe when universities go beyond the average frontier (EL=1 and EL=2).

4.4 Switching between competition fields and Mobility

Having determined the procedure how to track universities' competitive positioning over time, with respect to their competition field and their efficiency level (=efficiency classes), we can now look at the overall dynamics of universities' competitive positioning.

To do so, we construct a transition matrix that counts the number of universities in a given competition field that switched to another competition field or stayed in its competition field. Afterwards, we calculate the underlying dynamics in each field. For doing so, we construct a mobility index as in the following:

$$M_P = \frac{n - \mathrm{Tr}(n)}{n} \tag{2}$$

with n as the number of universities and Tr as the trace (the sum of elements on the diagonal) of the transition matrix. It calculates the share of universities in cells that are off the diagonal. In other words, we receive the share of universities that switch from one to another competition field. Since we assigned every university in each period to a specific grid competition field (CF), we can track all universities accordingly.

Switching Comeptition Fields (CF)

Table (3) documents how many universities switched competition fields in the two competition arenas 'Teaching' and 'Research'. In 'Teaching' 77% of universities that were in competition field I remain in its field, only 23% switched to comeption field CF=II; 79% of universities in comeption field CF=II remained in there, only 3% shifted to the less capital-intensive field CF=I. 99% of universities in CF=III remained in this field. In case of the competition arena 'Research', 95% stayed in CF=I, 83% in CF=II, and 94% in CF=III.

Table 3
Average Switching of Competition Fields

(a) Teaching

	I	II	III
I	0.77	0.23	0
II	0.03	0.79	0.17
III	0	0.01	0.99

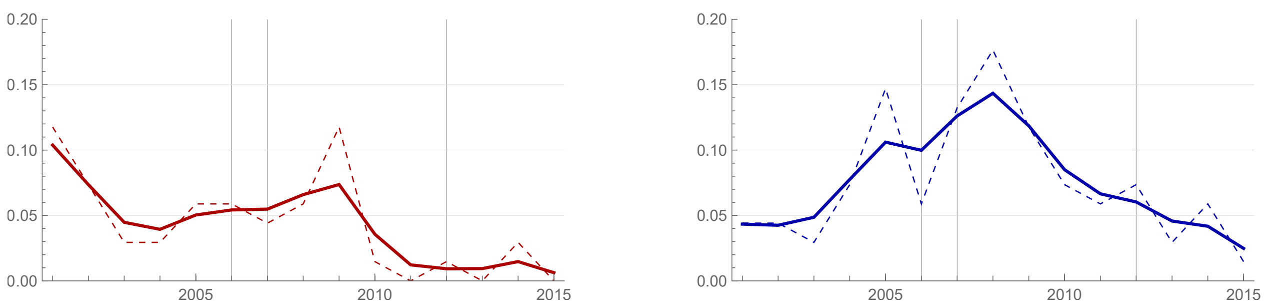
(b) Research

	I	II	III
I	0.95	0.05	0
II	0.04	0.83	0.12
III	0	0.06	0.94

Note: Three competition fields in each arena (I, II, and III). Each row adds up to one indicating the percentage of universities that were in a given competition field and switched to another. E.g. in competition arena 'Teaching', 77% of universities that were in CF=I remained in the same competition field, 23% changed to CF=II.

The mobility index in Equation (2) provides a glance at the dynamics as depicted in Figure (5). Panel (a) shows the mobility in 'Teaching', panel (b) the mobility in 'Research'. Solid lines indicate smoothed values with a Gaussina filter of 2, dashed lines represent the original values of the index in Equation (2).

Fig. 5. Mobility Indices – Competition Fields



(a) Mobility in Teaching **(b)** Mobility in Research

Note: Solid lines represent the smoothed time series with a Gaussian filter of 2. The dashed line indicates the original value as calculated in Equation (2).

The interpretation of the mobility index is very simple. The index runs from zero to one. As pointed out, the total of the diagonal elements indicates the number of universities that do not change their competition field. Hence, the mobility index in Equation (2) computes the share of switching universities by year. It can also be interpreted as indicator for the competitive dynamics of the university sector. Correspondingly, the vertical axis in Figure (5) indicates the percentage of universities that change their competition field. Panel (a), referring to arena 'Teaching', starts with about 11% of universities that switched their competition field in 2001. Until 2004, this shares steadily declines. Note that the gray vertical grid lines indicate the three years in which excellence initiative programs were launched. From 2005 to 2009, the mobility increases, after which it appears to fade out. In the competition arena 'Research', the mobility index starts at about 4%, steadily increasing till 2008 to almost about 15% to gradually fall back to 3% in 2015.

Overall, the mobility in ‘Teaching’ has been steadily decreasing, while in ‘Research’ the mobility increased before the excellence initiatives and gradually declined thereafter.

Switching Efficiency Classes (EC)

Next, we look at university dynamics in terms of changes in their efficiency level. Such kind of shifts are shifts towards the origin, which indicates less inputs per unit output (See Figure 4). In both arenas, ‘Teaching’ and ‘Research’, we computed five efficiency classes (i.e. 20% percentiles) and assigned every university to its efficiency class relative to the average efficiency frontier.

Table 4
Average Switching in Efficiency Levels (EL)

(a) Teaching

	1	2	3	4	5
1	0.77	0.22	0.01	0	0
2	0.11	0.63	0.26	0	0
3	0	0.07	0.69	0.23	0
4	0	0	0.06	0.77	0.17
5	0	0	0.01	0.08	0.92

(b) Research

	1	2	3	4	5
1	0.88	0.1	0.02	0	0
2	0.08	0.74	0.19	0	0
3	0	0.15	0.63	0.2	0.01
4	0	0.01	0.12	0.74	0.12
5	0	0	0	0.09	0.91

Note: we computed five efficiency classes (EL) competition fields in each arena (I, II, and III). Each row adds up to one indicating the percentage of universities that were in a given competition field and switched to another. E.g. in competition arena ‘Teaching’, 77% of universities that were in CF=I remained in the same competition field, 23% changed to CF=II.

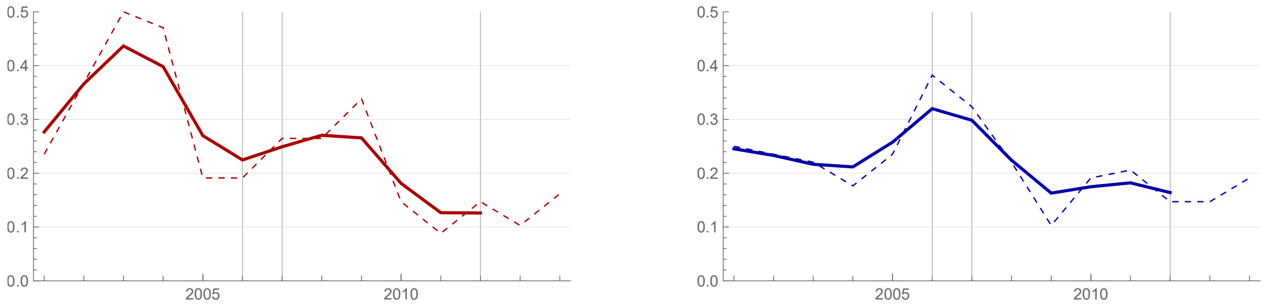
Table (4) documents the average transition matrices for ‘Teaching’ and ‘Research’, respectively. As in the previous subsection, rows sum up to one. Matrix elements indicate the percentage of universities of an efficiency class that either stayed or switched their efficiency class. In ‘Teaching’, 77% of universities that were assigned to efficiency class 1 stayed in this class. Comparing all diagonal elements shows that at least two thirds of universities did not manage to change their relative efficiency level (EC). In ‘Research’, the dynamics appear the same, more than two thirds remain at their efficiency level, on average.

Figure (7) depicts the mobility index for switching efficiency levels with respect to the two arenas competition ‘Teaching’ and ‘Research’. The range of efficiency mobility in ‘Teaching’ was between 30 and 42% before the excellence initiative. Starting in 2006, the mobility increased slightly, till 2009 and decline to about 12% at the end of the time span. With regard to ‘Research’, the mobility had been lower at the beginning (about 22%,) it increased to about 30% till the beginning of the excellence initiative, and fell to about 14% at the end of the period.

Switching between both – Competition and Efficiency Classes

To illustrate the dynamics taking both, competition fields and efficiency classes, into account, we need to combing the two classifications in order to represent the grid as shown in Figure (4). With three competition fields and five efficiency classes, we obtain 15 possible categories (grid elements). Instead of a matrix, we illustrate the transition matrices in the form of a lattice. Figure (9) presents the two respective lattices, the left describing the average transition dynamics in ‘Teaching’, the

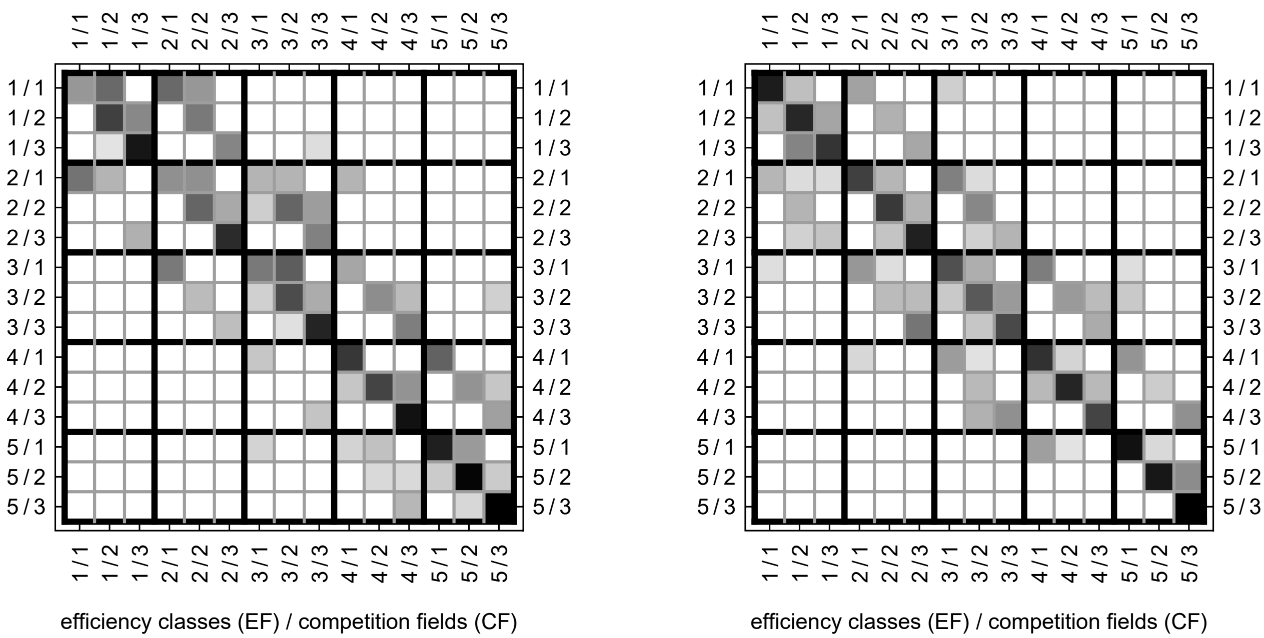
Fig. 7. Mobility Indices – Efficiency Levels



(a) Mobility in Teaching **(b)** Mobility in Research

Note: Solid lines represent the smoothed time series with a Gaussian filter of 2. The dashed line indicates the original value as calculated in Equation (2).

Fig. 9. Mobility Indices – Efficiency Levels

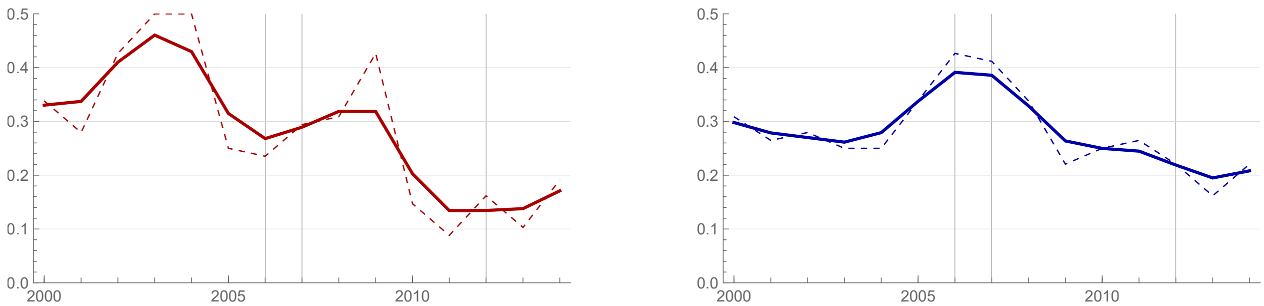


(a) Mobility in Teaching **(b)** Mobility in Research

Note: Frame ticks indicate efficiency class (EF) - competition field (CF) combinations. Efficiency classes run from lowest (=1) to highest (=5), competition fields from labor intensive (=1) to capital intensive (=4 in 'Teaching' and =3 in 'Research').

right with respect to 'Research'. Tick labels indicate the combination of categories. For example 1/3 indicates efficiency class 1 and competition field 3. Solid black grid lines indicate efficiency levels, each comprising 9 fields. The darker the color of a filled square the higher the percentage of universities in this field, changing or remaining. In both arenas, we observe that most of the filled squares locate on this block-wise diagonal, which repeats our insight above that a vast majority of universities do not change their efficiency class, on average. Regarding the three by three sub matrices of each efficiency level, for instance, all cells labeled $2/i$ on the vertical as well as the horizontal axis, with $i = \{1, 2, 3\}$ as respective competition field, the diagonal again represent the share of universities not switching their competition field, while the off-diagonal elements indicate

Fig. 11. Mobility Indices – CF - EF



(a) Mobility in Teaching **(b)** Mobility in Research

Note: Solid lines represent the smoothed time series with a Gaussian filter of 2. The dashed line indicates the original value as calculated in Equation (2).

changes in the competition field within efficiency class 2. In each of the efficiency fields, there appears to be some dynamic. Calculating the mobility index over the years will give us more insight into the competitive dynamics.

In Figure (11), we present the corresponding mobility indices for 'Teaching' and 'Research' over the considered time span. The trend of the mobility in 'Teaching' is negative. With a minor exception during the initiation of the excellence initiative in 2006, the comptitive dynamics have declined over the whole time span. Compared to the year 2003 with a maximum value of about 46% (smoothed data), the dynamics lost more than 30 percentage points in 2012.

With respect to 'Research', the mobility index started out with about 30% to reach its all-time high of 39% in 2006, the beginning of the excellence initiative, thereafter falling down to a mobility level of 20%.

5 Deliberate Decision, Fate, or Fiction

With the simple analysis above, we shed some light on the question whether German universities manage to position themselves sustainably in competition with their recently obtained autonomy? We pointed out that German universities perform quite differently in terms of research and teaching. They differ notably in design and historical development. Despite their ostensible gain in autonomy, state influence has remained dominant. The less surprising it is that the dynamics of changing structures as we observe are weak; only a few patterns could be discovered, albeit less in the field of teaching than in research: the mobility of universities in their competitive positioning and their efficiency class increased slightly, which primarily manifests in an anticipation effect, before the start of the Excellence Initiative – as far as the arena "Research" is concerned. In "Teaching" the induced mobility has increased during the first and second round of the excellence initiative, while declining in the last years. This makes us conclude that even though large-scale higher education policy measures such as the Excellence Initiative and the Teaching Quality Pact on structural development have a visible impact on universities competitive positioning, their influence on the competitive dynamics is rather low.

To what extent is the competitive positioning a deliberate strategic choice? As the results show, only a small fraction of universities appear to manage to change their competitive positioning. It is rather few universities that appear to accomplish a substantial repositioning by a conscious strategic choice. Universities are involved in multiple competition (Krücken, 2021), such as numerous competitions initiated by state actors (e.g. Excellence Initiative, Quality Pact for Teaching) or competitions not directly initiated by state actors (e.g. international rankings, competition for (star) scientists); this multiplicity opens up some new opportunities for decision-making, while it makes the scope of a deliberate strategic choice towards a repositioning rather limited.

To what extent is the competitive positioning of universities fate? In their competitive positioning, universities still maintain highly diverse initial conditions concerning their organizational context, subject areas, and the financial resources available from their respective states, which are critical in shaping their competitive circumstances. One theoretical explanation for this apparent stability might be organizational path dependencies, which impact the development of the positioning of universities (Mahoney and Thelen, 2009). Another theoretical explanation is the "red queen" effect: when a competitor improves its performance but still does not achieve a better relative positioning because other competitors have improved equally (Barnett, 2008). This implies that the dynamics underlying stability might be more robust than be seen at first sight.

To what extent is the competitive positioning of universities fiction? According to the results of the analysis, the notion of competitive field dynamics affecting the positioning of German universities is, so far, largely fiction. The strong influence of state governance and path dependencies of universities may pose a challenging case for non-legislative (competitive) positioning that constrains the dynamics of competitive diversification. Nevertheless, it is conceivable that the competitive diversification dynamics and the competitive positioning of universities will intensify in the future. The evolution of a competitive positioning for universities is an ongoing process, and from an international perspective, German universities may be considered just in an early stage of competitive diversification dynamics.

6 Conclusion

This paper is a first attempt to shed light on the competitive positioning of German universities. At the beginning of the new millennium, the Bologna Process brought about significant changes in the governance structure of the higher education system. Universities were granted more autonomy and at the same time were required to be more competitive.

Against this background, this paper asks to what extent German universities have used this newly gained freedom to position themselves strategically in the German higher education landscape. Based on university-level data from the Federal Statistical Office of Germany (Destatis) supplemented by publication data (Scopus, Elsevier), we adapt a non-parametric benchmark approach (DEA) to cluster 79 German universities according to their (relative) competition field and their relative efficiency level. We track the mobility of universities across these classes and derive a mobility index to measure the competitive dynamics over time.

The results show that the dynamics are rather low. In teaching the competitive dynamics steadily decline, except for a rather negligible increase during the Excellence Initiative. In research, we discover an anticipation effect in this dynamic, after which it sharply declines. Hence, we observe a positive impact of this policy support program on competitive dynamics, although this effect is short-lived and primarily concerns research. As to switching competition fields, a vast majority of universities do not change their positioning. The same holds for switching efficiency classes. Even when taking both movements together, asking whether a university either switched its competition field or its efficiency class, the dynamics remain sluggish.

The reasons for the low dynamics can have different causes. First and foremost, it could be possible that the data we use does not capture the effects intended by the policy support, as it is purely output related, it does not capture any quality-related aspect; second, as the measure is a relative measure, the "red queen" effect covers camouflages performance gains; third, the liberalization process of the higher education reforms gives universities only ostensible autonomy. The sluggishness of the competitive dynamics casts doubt on the scope of deliberate strategic decision making of universities. Bureaucratic institutions, dependence on external, mainly governmental, funding, whose allocation may conflict with political goals, and not least the multiplicity of competition, which forces universities to compete in more than one arena, limit the chances for repositioning and make self-determined, strategic behavior a fate, if not a fiction.

Appendices

A Included Universities

WESTFÄLISCHE WILHELMS-UNIVERSITÄT MÜNSTER	EBERHARD KARLS UNIVERSITÄT TÜBINGEN
HUMBOLDT-UNIVERSITÄT ZU BERLIN	UNIVERSITÄT VECHTA
FRIEDRICH-ALEXANDER-UNIVERSITÄT ERLANGEN-NÜRNBERG	UNIVERSITÄT KASSEL
UNIVERSITÄT ROSTOCK	TECHNISCHE UNIVERSITÄT DRESDEN
GOTTFRIED WILHELM LEIBNIZ UNIVERSITÄT HANNOVER	OTTO-VON-GUERICKE-UNIVERSITÄT MAGDEBURG
RUHR-UNIVERSITÄT BOCHUM	UNIVERSITÄT HOHENHEIM
UNIVERSITÄT MANNHEIM	UNIVERSITÄT ERFURT
UNIVERSITÄT KOBLENZ-LANDAU	TECHNISCHE UNIVERSITÄT MÜNCHEN (TUM)
RHEINISCHE FRIEDRICH-WILHELMS-UNIVERSITÄT BONN	UNIVERSITÄT PADERBORN
GOETHE-UNIVERSITÄT FRANKFURT AM MAIN	CARL VON OSSIETZKY UNIVERSITÄT OLDENBURG
EUROPA-UNIVERSITÄT VIADRINA FRANKFURT (ODER)	TU COTTBUS-SENFTENBERG (BTU)
TECHNISCHE UNIVERSITÄT BRAUNSCHWEIG	UNIVERSITÄT GREIFSWALD
UNIVERSITÄT LEIPZIG	UNIVERSITÄT POTSDAM
TECHNISCHE UNIVERSITÄT CHEMNITZ	TECHNISCHE UNIVERSITÄT CLAUSTHAL
UNIVERSITÄT BREMEN	BERGISCHE UNIVERSITÄT WUPPERTAL
TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG	UNIVERSITÄT BAYREUTH
UNIVERSITÄT OSNABRÜCK	HELMUT-SCHMIDT-UNIVERSITÄT
TECHNISCHE UNIVERSITÄT KAISERSLAUTERN	UNIVERSITÄT ZU KÖLN
TECHNISCHE UNIVERSITÄT HAMBURG	UNIVERSITÄT SIEGEN
UNIVERSITÄT ULM	HEINRICH-HEINE-UNIVERSITÄT DÜSSELDORF
TECHNISCHE UNIVERSITÄT DARMSTADT	UNIVERSITÄT KONSTANZ
OTTO-FRIEDRICH-UNIVERSITÄT BAMBERG	UNIVERSITÄT HAMBURG
TECHNISCHE UNIVERSITÄT BERLIN	UNIVERSITÄT MÜNCHEN (LMU)
UNIVERSITÄT TRIER	FRIEDRICH-SCHILLER-UNIVERSITÄT JENA
CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL	TECHNISCHE UNIVERSITÄT ILMENAU
PHILIPPS-UNIVERSITÄT MARBURG	FREIE UNIVERSITÄT BERLIN
JULIUS-MAXIMILIANS-UNIVERSITÄT WÜRZBURG	UNIVERSITÄT REGENSBURG
MARTIN-LUTHER-UNIVERSITÄT HALLE-WITTENBERG	JOHANNES GUTENBERG-UNIVERSITÄT MAINZ
UNIVERSITÄT PASSAU	GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN
UNIVERSITÄT DUISBURG-ESSEN	TECHNISCHE UNIVERSITÄT DORTMUND
UNIVERSITÄT BIELEFELD	UNIVERSITÄT DES SAARLANDES
UNIVERSITÄT STUTTGART	LEUPHANA UNIVERSITÄT LÜNEBURG
UNIVERSITÄT AUGSBURG	U KARLSRUHE (KIT)
TH AACHEN	
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN	

Table 5
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