Performance-based funding of universities in Germany - an empirical analysis

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This contribution investigates the impact of performance-based funding models used by German states (*Laender*) on the behaviour of universities and universities of applied science using multivariate modelling.
The basis for this analysis is the development of a basic model depicting the production function of higher education institutions (HEI) using indicators commonly applied in performance-based funding models. The quality of this model, as shown by the R^2, is consistently good to very good. The production function shows that universities and universities of applied science seem to work similarly, in principle. Differences can usually only be found in the details – and can then usually by explained by different framework conditions.
Summing up the results for the central areas of performance – teaching and research – evidence is provided that it is the number of professorships and other academic staff, as well as the size of the department, which turn out to be strong drivers for most teaching and research indicators.
The analysis of the impact of performance-based funding (PBF) models shows that a PBF model does not automatically lead to behavioural changes, and this also applies to the share of the PBF budgets in relation to the total budget and the importance of the tolerance band. Moreover, although the specific design of the PBF model may lead to significant effects, these are not always in the expected direction.
Reviewing the effort which is connected to the introduction of a performance-oriented allocation of resources, this leads to the question of whether the effort really is worth it in terms of the associated effects.
Both tuition fees, on the one hand, and target agreements within the university, on the other, do seem worth it in terms of impact. This could be – at least in part – down to their associated signal effects. Also, statements of the "written word" may be easier to understand and interpret for members of universities (who affect the behaviour of the institution) than the effects aimed for by complex metric-based systems.

1. INTRODUCTION[42]

The federal states in Germany have changed university management and the design of incentive schemes in the past two decades to varying degrees. Based on the approach referred to as "New Public Management", German universities were generally given more autonomy, at the same time university funding became more output-oriented. The core question of this paper is twofold: (1) what are the major factors driving core outputs of higher education institutions (HEI) and are there differences between different types of institutions, here universities on the one hand and universities of applied sciences (Fachhochschulen, formerly known as polytechnics). (2) Does the introduction of an output-oriented funding model impact on university behaviour in relation to these core output indicators. Thus, the central question is, whether new public management works in higher education. This paper uses a data set, which covers developments between 2000 and 2008.

To keep this paper brief, section 0 provides a brief overview about key elements of the funding schemes in the 16 states (laender). In Section 0, a basic model for analysing the production function of universities is developed that examines which factors have an impact on different output variables of the universities. Section 0 investigates the effects of introducing a performance-based funding system as well as its design features on the development of the performance of universities and universities of applied science. The findings are summarised in section 0. This is the first attempt of this kind not only for the German university system, but also across Europe.

2. MODELS OF PERFORMANCE-BASED FUNDING AND THEIR *LÄNDER*-SPECIFIC FEATURES IN RELATION TO CORE INDICATORS

The use of performance criteria for the allocation of financial resources is a key element in the implementation of new management models in higher education and is often accompanied by growing university autonomy and an increasingly competitive environment. Here, a part of the state budget to the universities is awarded based on indicator. This type of formula-based funding of higher education therefore covers both the performance-oriented allocation of resources and the allocation of the basic state grant. The latter is not awarded competitively and is almost always based on load.

In recent years, performance-based funding was part of the resource allocation system between a state (Land) and its the universities in almost all states. The specific design of the performance-based funding systems (PBF) and the calculation method varies from state to state and can be sometimes very complex. Not just the design of the PBF systems influences budget allocations to universities, but also the size of state budget allocated via the PBF. Table 1 shows the proportion of total funding for higher education, which was distributed in 2008 on

[42] This paper is based on research that was conducted during a project that was funded by a research grant from the Federal Ministry of Education and Research: „Theorie und Praxis von Anreiz- und Steuerungssystemen im Hinblick auf die Verbesserung der Hochschullehre (QualitAS-Lehre)“ (Theory and practice of incentive and controlling systems to enhance learning and teaching).

the performance-based allocation of funds.[43] The rates vary between 28% in Berlin[44] and 1.4% in Saxony. In Hesse and Thuringia an increase is planned. Hesse was planning to increase the indicator-based share of 16% of the total state budget for higher education in 2008 to 25% in of 2010. In Thuringia two different circuits are applied: on the one hand, 100% of the grants for teaching and research (tolerance band 20%) and on the other hand 10% of the human resources are (re)allocated (tolerance band 3%). In terms of total state subsidy to the university, this means an average share of 12% and 7% respectively. The share of personnel resources should rise to 40% by 2011 (tolerance band 15%), which then makes up 29% of the state grant to universities.

Table 1: Proportion of total state grant distributed via PBF in 2008

State	Share of PBF on total funding	Competition between universities[1]	Reference year(s)	Remarks
BW	20,00 %	Incentive budget: no; Volume budget: yes	2007-2009	
BY	Uni 1,45 %, FH 0,57 %	yes	2010	Innovation funds: 2% Uni , UAS 0,7%
BE	27,78 %	yes	2008	Competition between groups of subjects
BB	20,40 %	yes	2007	
HB	10,00 %	no	2006	suspended since 2008
HH	12,00 %	yes	2007	
HE	16,00 %	no	2008 (up to 25 % in 2010)	
MV	8,00 %	yes	2009	
NI	9,71 %	yes	2008	Competition between groups of subjects
NW	19,42 %	yes	2007	
RP	17,4% (T&R)	yes	2005	One single frame for all HEI
SH	5,00 %	yes	2009	
SL	Uni 11,75 %, FH 11 %	no	2010	in ZV der Uni Saarland geregelt
SN	1,40 %	yes	2006	
ST	5,00%	yes	2011 (up to 15 % in 2013)	
TH	19 % (T&R 12 %, Personell 7 %)	yes	2009 (up to 40 % in 2011)	

Sources: State higher education laws (updated: 1.8.2010); MWFK BW o.J.; SBWF BE o.J.; HIS 2006a, b, c; HIS 2007; HIS 2009; LH Hessen 2010; Hillmer 2008; MIWFT NRW 2007; MWWF K RP 2005; MBKW SL 2007; LR SH o.J.; KM TH 2009; own calculations.
Notes: state subsidy independent of basic grants and special circumstances. For some countries, the proportion was recalculated according to this reference volume. This refers to BE, BB, HE, NI, NRW, RP and TH. Reference year for the unit value and the added empirical calculations is 2008.
1) distribution model / success budget with a comparison between HEIs.

In Table 2, the weights of each indicator in allocation models for the universities is shown by state. In general, indicators that are attributable to the field of teaching rate slightly higher

43 In the overview indicator-based allocations of the basic grant which are essentially based on load (e.g. student numbers) are not taken into account. PBF models sometimes include load indicators such as indicators for number of professors or number of academic staff, seldom though new entrants. The latter could provide incentives for excessive student recruitment.

44 In Berlin 30% of consumptive grants are awarded based on performance (PBF). With regard to the overall budget, including the investment grants leads the proportion to drop to about 28%.

than indicators that represent aspects of research. Only in Hamburg, Mecklenburg-Western Pomerania and North Rhine-Westphalia (and Thuringia for the human resources) is there an equal balance between the two categories. In most states, in addition gender equality indicators are included, with their weighting ranging from 4% in Lower Saxony up to 31% in Baden-Württemberg. In Hamburg internationalization is another criterion for the allocation of funds. Saxony includes the introduction of new courses and the increase of material and investment ratio in its PBF model.

Compared with the total state subsidy to universities, Bavaria and Saxony allocate a proportion of total grant in the range below 1 percent to teaching, while the proportions in Berlin (13.9%), Brandenburg (10.2%), North Rhine-Westphalia (9.7%) and Rhineland-Palatinate (9.7%) are highest. For the research indicators, a similar picture emerges, although the research area has slightly lower values compared to teaching. The areas gender equality, internationalization and other indicators accounts for shares of less than 5% (see Table 3).

Table 2: PBF indicators of universities and indicator weights on each PBF budget

Universities	Nominal values					In relation to total budget					Reference year(s)
	Teaching	Research	Gender equality	Internat.	Other	Teaching	Research	Gender equality	Internat.	Other	
BW: Volume part	55,00 %	45,00 %				5,50 %	4,50 %				2007-2009
BW: Incentive part	43,75 %	25,00 %	31,24 %			4,38 %	2,50 %	3,12 %			
BY	51,00 %	39,00 %	10,00 %			0,74 %	0,57 %	0,15 %			2006-2010
BE	50,00 %	45,00 %	5,00 %			13,89 %	12,50 %	1,39 %			2009
BB	50,00 %	40,00 %	10,00 %			10,20 %	8,16 %	2,04 %			2006-2007
HB	35,00 %	50,00 %				3,50 %	5,00 %				2006-2008
University of Hamburg	35,00 %	35,00 %	15,00 %	15,00 %		3,50 %	3,50 %				
TU Hamburg- Harburg	35,00 %	35,00 %	10,00 %	20,00 %		4,20 %	4,20 %	1,20 %	2,40 %		2005-2010
HE	Price model										2008/2010
MV	50,00 %	50,00 %				4,00 %	4,00 %				2008-2009
NI	48,00 %	48,00 %	4,00 %			4,66 %	4,66 %	0,39 %			2008-2009
NW	50,00 %	50,00 %				9,71 %	9,71 %				2007
RP	56,00 %	38,00 %			6,00 %	9,74 %	6,61 %			1,04 %	2005
SH	40,00 %	50,00 %	10,00 %			2,00 %	2,50 %	0,50 %			2009
SL: Funds for obligatory Deliverables	55,00 %	30,00 %	12,00 %		2,00 %	6,46 %	3,53 %	1,41 %		0,24 %	2008-2010
SL: Parameter for Minimum deliverables	60,00 %	40,00 %				7,05 %	4,70 %				2008-2010
SN	43,00 %	43,00 %			15,00 %	0,60 %	0,60 %				2008
ST	50,00 %	45,00 %	5,00 %			2,50 %	2,25 %	0,25 %			
TH: Research & Teaching	65,00 %	35,00 %				7,80 %	4,20 %				2008-2010
TH: Staff funding	50,00 %	50,00 %				3,50 %	3,50 %				

Sources: State higher education laws (updated: 1.8.2010); MWFK BW o.J.; SBWF BE o.J.; HIS 2006a, b, c; HIS 2007; HIS 2009; LH Hessen 2010; Hillmer 2008; MIWFT NRW 2007; MWWF K RP 2005; MBKW SL 2007; LR SH o.J.; KM TH 2009; own calculations.

In Table 3, the weights of the indicators for allocation models in universities of applied science are shown by the respective state. Compared to universities it is particularly striking to note the significantly reduced proportion of research-related indicators in the models, which has to do with the fact that universities of applied science usually have no own research areas and have no right to award doctorates. States that provide high levels of research for universities of applied science, have either a multi-circuit model or compensatory allocations (e.g. in Lower Saxony, see Nickel / Ziegele 2008).

Table 3: PFB indicators of universities of applied science and indicator weights on each PBF budget

Universities of Applied Sciences	Nominal values					In relation to total budget					Reference year(s)
	Teaching	Research	Gender equality	Internat.	Other	Teaching	Research	Gender equality	Internat.	Other	
BW: Volume part	80,00 %	20,00 %				8,00 %	2,00 %				2007-2009
BW: Incentive part	80,00 %	10,00 %	10,00 %			8,00 %	1,00 %	1,00 %			
BY	76,00 %	12,00 %	12,00 %			0,43 %	0,07 %	0,07 %			2006-2010
BE	80,00 %	15,00 %	5,00 %			22,22 %	4,17 %	1,39 %			2009
BB	50,00 %	40,00 %	10,00 %			10,20 %	8,16 %	2,04 %			2006-2007
HB: UAS Bremen	85,00 %	15,00 %				8,50 %	1,50 %				2006-2008
HB: UAS Bremerhaven	70,00 %	30,00 %				7,00 %	3,00 %				
HH	40,00 %	20,00 %	20,00 %	20,00 %		4,80 %	2,40 %	2,40 %	2,40 %		2005-2010
HE	Price model					Price model					2008/2010
MV	90,00 %	10,00 %				7,20 %	0,80 %				2008-2009
NI	84,00 %	12,00 %	4,00 %			8,16 %	1,17 %	0,39 %			2008-2009
NW	85,00 %	15,00 %				16,50 %	2,91 %				2007
RP	56,00 %	38,00 %			6,00 %	9,74 %	6,61 %			1,04 %	2005
SH	50,00 %	40,00 %	10,00 %			2,50 %	2,00 %	0,50 %			2009
SL: Funds for obligatory Deliverables	55,00 %	30,00 %	12,00 %		2,00 %	6,05 %	3,30 %	1,32 %		0,22 %	2008-2010
SL: Parameter for Minimum deliverables	40,00 %	40,00 %			20,00 %	4,40 %	4,40 %			2,20 %	2008-2010
SN	76,00 %	24,00 %				1,06 %	0,34 %				2008
ST	50,00 %	40,00 %	10,00 %			4,00 %	0,75 %	0,25 %			2011
TH: Research & Teaching	50,00 %	40,00 %	10,00 %			6,00 %	4,80 %	1,20 %			2008-2010
TH: Staff funding	75,00 %	25,00 %				5,25 %	1,75 %				

Sources: State higher education laws (updated: 1.8.2010); MWFK BW o.J.; SBWF BE o.J.; HIS 2006a, b, c; HIS 2007; HIS 2009; LH Hessen 2010; Hillmer 2008; MIWFT NRW 2007; MWWF K RP 2005; MBKW SL 2007; LR SH o.J.; KM TH 2009; own calculations.

For the proportion of PBF indicators of universities of applied science in relation to their total funding (see Table 3), notice that the teaching shares are higher than in the universities. In Berlin the proportion of teaching indicators accounts for 22.2% of the total grant, in North Rhine-Westphalia 16.5% and in Brandenburg 10.2%. In Bavaria (0.43%) and Saxony (1.06%) the shares are the lowest. The research shares are– just as in the universities – lower than the teaching shares. Here the unit values range between 0.07% and 8.2% in Bavaria in Brandenburg, respectively. The shares for the areas gender equality, internationalization and other indicators are as with the universities lower than 5%.

3. PRODUCTION FUNCTIONS IN THE BASIC MODEL

The following sections examine and contrast the "production function" in the base model of universities and universities of applied science. This juxtaposition aims, in particular, firstly, to identify similarities and differences in the provision of services between the two types of higher education institution, and, secondly, to understand whether the introduction or refinement in the performance-based allocation of funds has similar or different effects on their adaptive behaviour.

The following sections describe the fields of research and teaching separately, each in connection with the output indicators used in the state PBF allocation models. However, the underlying regression model contains the same independent variables. In order to compare the study and research conditions in universities and universities of applied science, three teaching and one research-related indicator (new entrants, students within the prescribed study duration, and graduates on the one hand, and third-party funding on the other hand) will be used.

The quality of the modelling, as shown by the R^2, is consistently good to very good. In relation to the new entrants it is possible to account for over 90% of the variance in both types of HEI, whilst for students within the prescribed study duration and graduates the models account for over 85% of difference. Moreover, the models and the effects of framework conditions (HEI size, size of department, percentage of BA / MA students) and the inputs (professors, academic positions and expenditure for education and research) are roughly comparable. That is to say that universities and universities of applied science seem to work similarly, in principle. Differences can usually only be found in the details – and can then usually by explained by different framework conditions. This will be discussed in more detail below in connection with the regression results for individual output variables.

3.1. Teaching-related indicators

In this section a total of three indicators are considered; each play an essential role in the models of state-level PBF models. Here, the number of new entrants is not really a part of HEI performance, but rather an indicator for "load" or "input". However, since it is used in the state-level PBF models in the context of teaching performance, we will follow this practice. The number of students in the expected study period is an efficiency indicator because it indicates what proportion of students are (still) in their studies; conversely, it also makes it possible to calculate the proportion of students no longer located in the prescribed period of study. The number of graduates indicates the extent to which students successfully complete the studies in a department and is therefore a key element of performance measurement and efficiency, especially if you would weight it, for example, by the extent to which they successfully finish their studies within certain periods of time.

New entrants

Both at universities and at universities of applied science, the number of new entrants is predominantly explained by the number of students (in a discipline), as this has by far the highest beta coefficient (0.84 or 0.89). Albeit, the specific impact on the slope of the line, the B, is slightly different, which points to the fact that universities of applied science – other things being equal – tend to enrol slightly more new entrants than universities.

After the size of a department, the number of professors has the second most impact. This is not surprising, since this value plays a central role in the capacity regulations.[45] Somewhat surprisingly is, however, the fact that the impact of professors at universities is somewhat larger than at universities of applied science, since these –to a much greater extent than the universities of applied science – can be supported through mid-level academic staff.

Indeed, the model shows the number of (other) academic positions at universities in a slightly negative correlation to the number of new entrants; that this input factor has no statistical significance at universities of applied science is in line with expectations. The connection identified for universities might be inter alia explained by student-rich departments such as the humanities and social sciences tending to have somewhat less academic staff than other departments (especially engineering and natural science) or by larger departments tending to

[45] In Germany, capacity regulations set a norm for the relationship between the number of students in department and the number of professors.

have less academic staff than smaller ones. Another explanation might be added by considering the different levels of third-party funding.

Table 4: The basic model for new entrants

New entrants	Universities			Universities of applied science		
	B	Beta	Sig.	B	Beta	Sig.
(Constant)	6269,915			820,825		
Number of students in department	,141	,838	***	,176	,891	***
HEI size	-,002	-,017		-,006	-,066	***
Number of professorships	1,735	,125	***	0,567	,088	***
Number of academic positions	-,089	-,062	***	,002	,001	
Proportion of BA & MA students	-32,017	-,016	*	26,844	,045	***
Expenditure for teaching and research	-,001	-,013		,002	,016	*
Third-party funding	,007	,105	***	,006	,017	*
Engineering	-181,526	-,087	***	-7,359	-,014	
Natural science	-169,579	-,090	***	-21,193	-,040	***
Trend over time	-3,016	-,009		-0,383	-,004	
R^2	,937	,936		,920	,920	

Source: QualitAS-Dataset. Legend: ***) significant on 0.1% level, **) significant on 1% level, *) significant on 5% level.

The funding of universities, measured here in expenditure on education and research, as well as third-party funds,[46] leads to some interesting differences between the types of institutions; and holds, in addition, a surprise. Spending on teaching and research at universities has no significant relationship with the number of new entrants and for the universities of applied science the direction of impact is only weakly positive and the correlation only slightly significant. In contrast, the coefficient of third-party funding, both at universities and at universities of applied science, is significantly positively correlated with the numbers of new entrants; with the role of third-party funding at universities significantly larger and with a higher level of significance than at universities of applied science. This might be plausibly explained by a larger relevance of third-party funding at universities.[47] However, the overarching results for third-party funding only show minimal differences between universities and universities of applied science, so this result is only partly plausible.

The influence of the proportion of bachelor and master students on the number of new entrants differs for each type of HEI.[48] While universities of applied science display a positive correlation, it is negative for universities. This could be explained by the fact that the conversion to bachelor and master degrees has different effects on the average duration of

[46] In principle, additional financial indicators would be total expenditure and total staff budget for a faculty; however, neither indicators are used here due to multicollinearity.

[47] In a previous analysis that does not distinguish between universities and universities of applied science, slight differences to these results were evident. Similarly, strong correlations were visible in Dohmen (2015) based on the third-party funding, while staff costs were significant for the universities.

[48] During the period of investigation, Germany was still undergoing a transition between the old-type long degrees (Diplom) and bachelor and master structures.

study and thus on the number of studies remaining in a HEI. Alternatively, this could also be caused by the fact that the universities of applied science consistently responded faster to the change, while a few of the major universities converted rather slowly to the new structures. It is striking that the effect sizes, despite the different direction of impact, are quite close to each other (-.32 and +.26 for universities and universities of applied science, resp.).

In line with the expectations, the subject groups engineering and natural sciences show a strong negative impact on the number of new entrants, which can be explained both by different norms for student-staff ratios and a higher proportion of practical seminars and tutorials compared to the humanities and social sciences (the reference group), and by the higher average number of student entrants in these two subject groups, which are moreover also tend to be larger.[49]

HEI size correlates for both types of HEI slightly negatively with the number of new entrants, i.e. larger institutions do not automatically enrol more students. However, this shows that the departments of an institution can follow different lines. The slightly negative impact of HEI size is only statistically significant for universities of applied science.

In conclusion, there are considerable similarities in the direction of impact of the factors influencing the numbers of new entrants at universities and universities of applied science. Of particular interest is the differing role of financial resources between the two types of HEI.

Students within the prescribed study duration

The number of students within the prescribed study duration is a "throughput" indicator, which can also be understood as an indicator for efficiency. For the students within the prescribed study duration (PSD), the number of students in the respective departments are not included in the model due to strong correlation (multicollinearity).

Of particular importance for the number of students in PSD is – not surprisingly – the number of professors, which has a much stronger correlation than the other indicators for both types of HEI. The positive and significant role of the staff: student ratios is further amplified by the effect shown by the number of (other) academic staff, i.e. staffing a university obviously has a particularly strong influence on this "throughput" indicator. Additional teaching staff – professor and academic staff (here ignoring student assistants for teaching) – thus has a noticeably positive effect on the compliance with the prescribed period of study. Subsequent sections will show also that, although not quite as strong, this is true for the number of graduates, too. Additionally, larger HEIs have on average a significantly higher proportion of students in PSD in their departments than smaller HEIs, which can be seen as an indication of potential economies of scale.

It is striking that for universities all other factors, provided they are statistically significant, have negative correlations. This is especially true for the two disciplines engineering and natural sciences, but also of the proportion of bachelor and master students and the two financial indicators. In other words, apparently the humanities have structurally better results

[49] This result suggests to investigate these fields separately, but this does not occur in this study.

for the indicator students in PSD compared to the other two disciplines, and this applies – taking into account the results described below in terms of the number of graduates – to two of the three examined teaching indicators.50 The – only slightly negative and weakly significant – relationship between spending on education and research as well as third-party funding and the number of students within the prescribed study period at universities is somewhat surprising. A possible explanation for the role of spending on education and research would be that here the expenditure on research have a higher impact or indeed have simply increased more than spending on teaching (see for more detail Dohmen/Krempkow 2014).

Table 5: The basic model for students within the prescribed study period

Students within the prescribed study duration	**Universities**			**Universities of applied science**		
	B	**Beta**	**Sig.**	**B**	**Beta**	**Sig.**
(Constant)	-160763,822		***	-42307,441		***
Number of students in department	n/a	n/a	n/a	n/a	n/a	n/a
HEI size	,088	,200	***	,076	,219	***
Number of professorships	32,080	,572	***	13,525	,548	***
Number of academic positions	,860	,147	***	1,738	,171	***
Proportion of BA & MA students	-708,214	-,086	***	-103,686	-,045	***
Expenditure for teaching and research	-,011	-,041	*	,031	,062	***
Third-party funding	-,011	-,043	*	,018	,015	
Engineering	-2283,980	-,272	***	-420,891	-,209	***
Natural science	-2615,206	-,343	***	-452,501	-,222	***
Trend over time	80,822	,057	***	21,289	,058	***
R^2	,857	,856		,874	,873	

Source: QualitAS-Dataset. Legend: ***) significant on 0.1% level, **) significant on 1% level, *) significant on 5% level.

While negative correlations for the engineering and natural sciences as well as for the proportion of BA / MA students are visible regarding the universities of applied science, the direction of spending and the effect on education and research is positive and highly significant. Third-party funding is not significantly related to the number of students within the prescribed study duration.

The time trend is – as also in the number of graduates shown below – positive for both types of HEI; with some differences in terms of the effect size.

Graduates

Although number of graduates as indicator has some parallels to the two previous indicators new entrants or students within the prescribed study duration, there are also some important differences. In all cases, the framework conditions (number of students by departments) and

50 In the undifferentiated analysis this applied to all three teaching-related indicators (Dohmen 2015).

human resources (professors and academic staff) are positively correlated with the number of graduates for universities and for universities of applied science.

The most important role is played by the number of professors – an additional professor leads to three additional graduates – followed by additional academic staff. An additional academic staff increases the number of graduates at universities but by just 0.1, while each additional student in a department increases the number of graduates by 0.06. In other words: in order to "produce" an additional graduate, a university on average should either increase the number of professors by 0.35, the number of academic staff by 9 or the Number of students in department by 16 –in each case other things being equal. At universities of applied science, the corresponding coefficients are: 0.87 professors, 7 academic staff or 9 students.

Table 6: The basic model for graduates

Graduates	Universities			Universities of applied science		
	B	Beta	Sig.	B	Beta	Sig.
(Constant)	-50844,854		***	-9581,971		***
Number of students in department	,062	,587	***	,110	,678	***
HEI size	-,006	-,089	***	-,005	-,063	***
Number of professorships	3,017	,345	***	1,156	,217	***
Number of academic positions	,106	,116	***	,143	,065	***
Proportion of BA & MA students	92,740	,072	***	57,625	,117	***
Expenditure for teaching and research	,000	-,004		-,002	-,023	*
Third-party funding	-,003	-,079	***	,004	,015	
Engineering	7,239	,006		-45,956	-,105	***
Natural science	-93,482	-,079	***	-40,567	-,092	***
Trend over time	25,382	,115	***	4,793	,060	***
R^2	,891	,890		,849	,848	

Source: QualitAS-Dataset. Legend: ***) significant on 0.1% level, **) significant on 1% level, *) significant on 5% level.

For both types of higher education, the number of graduates also increases with the number of students in bachelor and master programs. This is plausible insofar as the prescribed and the real average study duration is shorter in these study programs and thus faster than for other study programmes.

A final set of similarities are the highly significant, slightly negative correlation of larger size and – other things being equal – lower number of graduates in the natural sciences compared to the humanities and social sciences. By contrast, in this regard university engineering courses show no significant deviations; whereas the number of graduates in engineering at universities of applied science is significantly lower.

Contradicting correlations are evident regarding the number of graduates and spending on education and research and on third-party funding. While third-party funding available to universities has a highly significant, slightly negative correlation with the number of graduates, for universities of applied science spending on education and research correlate significantly and slightly negatively with the number of graduates. As a result, we can state that student-

staff ratios for both status groups and economies of scale at the departmental level are important drivers for higher numbers of graduates. The role of the proportion of BA / MA students is of great interest for the following observations as HEIs that have changed faster will draw financial advantage from a PBF model – at least temporarily, if the number of graduates is used as an important indicator.
The adverse role of third-party funding on the number of graduates at universities points to a possible slight trade-off between teaching and research.

3.2. Third-party funding as research-related output indicator

Some notable differences between the types of HEI are visible with regard to the relationships between the independent variables and the third-party funding of a department. At universities, the number of other academic staff and expenditure on research and teaching of particular are of particular positive significance. Furthermore, in the subject areas of engineering and natural sciences, especially for structural reasons, higher third-party funding is obtained than in the humanities and social sciences. The number of female professors is negatively correlated with third-party funds.
The above-mentioned structural differences in the subject areas can be observed at a similar magnitude for the universities of applied science. Furthermore, spending on teaching and research and other academic staff play a considerable, but somewhat less important role in determining third-party funding. Unlike the universities, the number of professors shows a positive correlation with the amount of third-party funding at the universities of applied science. In addition, the size of the department is not correlated negatively with third-party funds. Also in contrast to the universities, there is no negative correlation with the percentage of BA / MA students. The time trend is positive at both, universities and universities of applied science, although it is much more pronounced for the latter.

Table 7: The basic model for the acquisition of third-party funding in a department

Third-party funding	**Universities**			**Universities of applied science**		
	B	**Beta**	**Sig.**	**B**	**Beta**	**Sig.**
(Constant)	-532296,171		***	-83963,286		***
Number of students in department	-,389	-,145	***	,055	,093	*
HEI size	-,061	-,035	*	-,027	-,099	***
Number of professorships	-,370	-,002		2,468	,126	**
Number of academic positions	12,097	,521	***	1,729	,213	***
Proportion of BA & MA students	-1141,391	-,035	**	3,698	,002	
Expenditure for teaching and research	,505	,492	***	,118	,297	***
Third-party funding	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Engineering	7656,987	,229	***	418,095	,261	***
Natural science	4558,548	,150	***	227,716	,141	***
Trend over time	264,051	,047	***	41,863	,143	***
R^2	,776	,775		,437	,435	

Source: QualitAS-Dataset. Legend: ***) significant on 0.1% level, **) significant on 1% level, *) significant on 5% level.

The strong relationship between expenditure for research and teaching on the one hand and the other academic positions on the other could be done to the so-called Matthews Effect (see the results of similar analyzes in Jansen et al. 2007).

The discrepancy between the (negative) correlation between the number of professors and the positive correlation of other academic positions for third-party funding could either indicate that the latter are particularly important for writing applications and the acquisition of third-party funding – or that this employee category benefits disproportionately from third-party funding being used in the recruitment of additional staff, while this does not affect the number of professors or only to a limited extent. The latter assumption seems more plausible.

3.3. Summary

In the previous section, three teaching and one research indicator were investigated as to how central factors in the higher education system act on them.

For teaching two efficiency indicators and a "load indicator" were considered. Especially in the case of the two efficiency indicators the special importance of the student-staff ratio was demonstrated, both in connection to the number of professors and the number of other academic staff, as well as the relevance of scale and size effects in relation to the size of a department. The latter may be justified on the basis that choice is connected with the number of students in department and thus larger departments have an indirect advantage in terms of attractiveness. Either they manage to get better by keeping students or they are able to "recruit" students from other HEI during their studies. The size of the HEI seems consistently rather less conducive and is negatively correlated with the dependent variable in all four cases.

The two financial indicators "expenditures for teaching and research", and third-party funds appear to have a minor impact on the instructional efficiency of a department, and some had rather disadvantage impacts on the teaching indicators. Additionally, the indicators give evidence here for differences in the direction of impact between universities and universities of applied science.

The significant differences in the subjects group coefficients for engineering and natural sciences compared to the humanities and social sciences, as well as in relation to each other suggest that there may be still other deviations, which should be more precisely examined here. This could not be done in the context of this paper.

Overall, the particular importance of human resources was evidenced for third party funding as key indicator of research output,[51] and here above all, the staffing and financial volume associated with professorships. Expenditure on teaching and research are mainly positively correlated with third-party funds, which suggests that here a decisive course in favour of third-party funds is often taken.

Summing up the results for both areas – teaching and research – then it is the number of professorships and other academic staff, as well as the size of the department which turn out

[51] The number of publications or patents plays a very minor role in the state-level PBF models, therefore it is not considered in this study. However, the number of publications, their quality and reception in the academic community are significant output criteria are will be taken into account in subsequent studies.

to be strong drivers for most teaching and research indicators. These three variables are almost universally positive or only show negative correlations sporadically.

In contrast, the impact of part of the state subsidy allocated as variable or flexible financial resources on the output values is more difficult to determine.[52] Third-party funds are indeed positively linked to research output, but less so with respect to the teaching indicators. This is more the case for the universities than for the universities of applied science. Here, the difference in emphasis on research and teaching between the two types of higher education could play an important role; but what cannot be excluded is that the different subject area profiles of these two types of HEI are the cause of impact. Humanities and social sciences are significantly more present at universities than at universities of applied science, which usually have their focus on engineering and natural sciences.

The relevance of the subject areas is also reflected in the fact that the effective direction of impact for engineering and natural science at both types of HEI's mostly negative concerning the teaching indicators and more positive concerning research indicators – with differences in detail.

The HEI size is almost consistently negatively correlated with the output indicators, in contrast to the size of a department, where the correlation is usually positive.

The results confirm in this way the basic finding of earlier analyses by Dohmen (2014, 2015), but now more differentiated and specified in detail concerning the effects on the output values of the universities and universities of applied science.

4. WHAT EFFECTS DO THE PERFORMANCE-ORIENTED FUNDING MODELS HAVE ON UNIVERSITY RESOURCES?

As described above, almost all states have changed their funding system and in the last fifteen years they have awarded a portion of their funds to HEIs on the basis of metrics which are included in a system of performance-based resource allocation. In this, there was a trend from input to the partial output orientation. The analyses in the previous sections are relevant for the subsequent analyses as the effect of the introduction and design of the performance-based funding allocation models builds on these higher education "production functions". Specific elements of the PBF models and the accompanying regulation changes will be added to the model to investigate their impact on input and output factors in university behaviour. This is highly relevant as most PBF models and indeed the implementation of New Public Management assumes certain effects on university efficiency.

4.1. Introduction of a PBF model

The question arises whether the introduction of a performance-based allocation of funds has had observable effects on the behaviour of universities of applied science or departments. The following tables show that the introduction of a PBF models was only occasionally

[52] Reminder: The total and staff expenses were not included in the model due to multicollinearity - especially with the indicators of staffing levels.

accompanied by significant changes in the output indicators. Furthermore, throughout the quality of the basic model is not changed and remains robust.

Table 8: The effects of the introduction of the PBF on output indicators in universities

Universities	1st grade students			Students in Standard study time"			Graduates			Third Party funding		
	B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.
Application of PBF	,846	,000		79,107	,010		-2,306	-,002		-1072,946	-,033	*
R2		,936			,856			,890			,776	

Source: QualitAS-Dataset.
Legend: ***) significant at 0,1% Level, **) significant at 1% Level, *) significant at 5% Level.

More in detail, Table 8 does show only one significant change in the regression results at universities, which is also the case for the universities of applied science, by and large (see Table 9). However, a weakly significant change, albeit with a slightly negative direction can be seen for the level of third party funding at universities, whereas at the universities of applied sciences the number of graduates and the level of third party funding correlate negatively with the introduction of PBF. This means that the level of third party funding develops better in states without a PBF system, this is valid for both types of universities. This also applies to the number of graduates. If one assumes a causality, then the introduction of PBF would have taken an unfavourable influence in this regard. Alternatively, it might well be that the number of graduates at UAS in the states with PBF is comparatives less favourably to the numbers of graduates in other states. The same might apply to the level of third party funding in both types of HEI, whereas the slope is much stronger at the universities compared to the UAS.

Table 9: The effects of the introduction of the PBF on output indicators in universities of applied science

Universities of Applied Sciences	1st grade students			Students in Standard study time"			Graduates			Third Party funding		
	B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.
Application of PBF	-4,841	-,009		11,407	,005		-10,432	-,023	*	-60,035	-,036	*
R2		,920			,873			,849			,436	

Source: QualitAS-Dataset.
Legend: ***) significant at 0,1% Level, **) significant at 1% Level, *) significant at 5% Level.

4.2. Budget relevance of PBF

In addition to the mere event of introducing a performance-based allocation, their configuration can also affect the behaviour of universities. Therefore, the following two substantive aspects are considered: the proportion of funding distributed via performance criteria and the importance of the introduction of a tolerance band (inside of which budget re-allocations are permissible), which exist in some states models. The purpose of a tolerance band to prevent any loss of revenue affecting the functionality of the university "unduly".

It could be expected that a higher budget share of PBF in relation to the total state budget for universities has a greater incentive effect than a smaller fraction. It should be noted that the proportion of funding distributed via PBF is usually only a few percent. Equally, limiting the redistributive impact with a tolerance band can be assumed to affect the motivation of universities, because the associated loss risk is smaller, the striker the tolerance band.

Table 10: The influence of the budget relevance of PBF on output indicators in universities

Universities	1st grade students			Students in Standard study time"			Graduates			Third Party funding		
	B	**Beta**	**Sig.**	**B**	**Beta**	**Sig.**	**B**	**Beta**	**Sig.**	**B**	**Beta**	**Sig.**
PBF in relation to total grant	-182,398	-,049	***	-1622,018	-,032	*	-169,867	-,070	***	-325,914	-,005	
Maximum redistribution after cut-backs	-32,083	-,017	*	164,747	,021		-32,884	-,026	*	-1233,593	-,039	*
R²		,940			,852			,899			,773	

Source: QualitAS-Dataset.
Legend: ***) significant at 0,1% Level, **) significant at 1% Level, *) significant at 5% Level.

Table 10 shows that on the one hand a higher budget share of the PBF to the total budget of universities is consistently accompanied by significant differences on teaching outputs compared to universities with a lower share of redistribution. On the other hand, these are always negative correlations. Thus, the number of new students at universities with a higher PBF contribution to the budget is lower than at universities with a smaller proportion. The same applies with respect to the students within the prescribed study duration and the number of graduates.

A similar picture, though usually with weaker significance levels, can be seen with regard to tolerance bands. Again these are usually negative correlations, i.e. wider tolerance bands are associated with lower student numbers and lower numbers of graduates. No significant effects are related to the number of students within the prescribed study duration.

As expected, the inclusion of these two variables results in slight increase in model fit; the R^2 values are usually only a few tenths of a percentage point higher, although in individual cases they may increase by up to two percentage points.

At the universities of applied science, the effects are less pronounced (see Table 11); but the effects on the quality of the model are sometimes significantly higher – which among other things, is because the explanatory power is lower than for the universities.

Table 11: The influence of budget relevance of PBF on universities of applied science

Universities of Applied Sciences	1st grade students			Students in Standard study time"			Graduates			Third Party funding		
	B	**Beta**	**Sig.**	**B**	**Beta**	**Sig.**	**B**	**Beta**	**Sig.**	**B**	**Beta**	**Sig.**
PBF in relation to total grant	-43,743	-,026	**	251,395	,021		4,298	,003		116,355	,022	
Maximum redistribution after cut-backs	-9,795	-,019	*	-80,062	-,040	***	-2,457	-,006		87,402	,055	**
R²		,929			,880			,852		,485	,482	

Source: QualitAS-Dataset.
Legend: ***) significant at 0,1% Level, **) significant at 1% Level, *) significant at 5% Level.

A significant effect is found based on the proportion of the PBF in total grants for new entrants (with a negative value). Negative correlations are primarily evident between a higher tolerance band and the number of students within the expected study duration, to a lesser extent also for the new entrants. Therefore, only in relation to new entrants do the values for both indicators work in the same direction, i.e. both a higher budget share of the PBF and a higher tolerance band in the redistribution show a negative correlation; with other indicators, there is no case in which both variables significantly correlate, and even if you did require this link, they show consistently different directions (positive vs. negative) of effect. A higher tolerance band is, however, accompanied by positive variations in third-party funding.

In summary, these two design features, budget relevance of PBF and tolerance band within PBF, correlate only to a limited extent with the four output indicators – and if so, then they are more likely negative than in a positive context. Further analyses will have the task to clarify whether these are causal developments or output-related differences.

4.3. The design of the PBF

As shown above, there PBF models of the states differ, on the one hand, by indicators and by the budget-relevance given to each indicator, on the other hand. This raises the question of whether a higher value of an indicator, considering its content or its respective budget relevance is accompanied by a major change in the indicator value. It would be as expected that a higher weighting of the indicator for graduates, for instance, would lead to the number of graduates rising more sharply than at a lower weight; the same applies for the other indicators.

Table 12 examines the impact of higher PBF values for the various indicators in terms of their effects on the respective "outcome" indicators in the interaction. At first glance it is clear that there are a number of significant correlations. Considering the singular contexts, i.e. the theoretically expected positive correlation between the value of an indicator in the PBF model and the performance of the relevant output indicator, then it is surprising that no such a positive correlation is found here. Otherwise either no significant correlations (new entrants and graduates) or negative correlations, as with the students within the expected study duration, are apparent.

In addition, the teaching-related indicators for graduates and students within the expected study duration show predominantly or exclusively negative correlations, while the number of graduates is mostly positively correlated with it. This is true – with few exceptions – in the same way for third party funding as research-related indicator.

In a second step, additional steering elements are taken into account, which might be expected to have effects on the behaviour of universities. These include global (i.e. lump sum) budgets, tuition fees and various forms of target agreements. A closer look shows that regarding the universities – unlike the universities of applied science (see below) – none of the instruments has a significant effect throughout (i.e. for all four indicators) and also that for none of the indicators all four instruments show significant correlations simultaneously. Global budgets show no significant correlations, for the three other instruments two significant correlations can be found, usually with different directions. The tuition fees introduced in some states are positively correlated with the number of graduates; the introduction of mandatory internal university target agreements is negatively correlated with number of new entrants, but positively with the level of third party funds. The implementation of internal university-level PBF shows significant negative correlations with the number of graduates and third party funds.

Table 12: The effects of a different model designs on the universities

	1st grade students			Students in Standard study time"			Graduates			Third Party funding		
	B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.
Share of Inddicator 1st grade students in relation to total PBF	1389,008	,045		16085,726	,129	*	-2028,286	-,101	*	-117235,938	-,231	***
Share Indicator on Graduates in relation to total PBF	-2905,540	-,423	**	-16323,446	-,582	*	1357,297	,302		71806,211	,629	*
Share Indicator on Students in standard study time in relation to total PBF	-3838,135	-,372	**	-20213,008	-,480	*	2318,388	,344	*	144519,885	,842	***
Share on foreign students indicator on total PBF	-2609,753	-,146	**	-15397,586	-,211	*	872,073	,074		92469,896	,311	***
Share of PhD-indicator on total PBF	1319,982	,087	**	3746,901	,061		-1036,368	-,105	**	-69267,984	-,276	***
Share of indicator on Third Party Funding on total PBF	575,739	,064	*	4257,982	,116	*	-487,983	-,083	*	-22381,499	-,149	*
Share of habilitations indicator on total PBF	3511,707	,102	***	12084,090	,086	*	-1979,809	-,088	*	-126438,148	-,221	***
Share of indicator on female Professors on total PBF	639,539	,047	*	417,823	,007		103,016	,011		-25531,622	-,112	**
Total number of indicators of PBF-model	-66,018	-,206	*	-465,876	-,355	*	56,011	,267	*	3508,760	,657	***
Lump-sum budget	-17,398	-,008		29,239	,003		-51,204	-,035		-1421,261	-,039	
Tuition fees	-20,022	-,009		-184,271	-,019		80,669	,053	***	-199,447	-,005	
Mandatory intra-university target agreements	-293,069	-,147	***	-428,380	-,053		19,890	,015		7412,232	,223	***
Mandatory intra-university PBF	112,124	,059		607,908	,078		-156,124	-,125	*	-15251,090	-,479	***
R^2		,947			,853			,907			0,819	

Source: QualitAS-Dataset.
Legend: ***) significant at 0,1% Level, **) significant at 1% Level, *) significant at 5% Level.

Looking particularly at third party funding as research-related indicator, the values indicate that a positive effect is associated with several high-share values for teaching indicators and a negative impact with high percentage values for research-related indicators. A significant positive correlation is also apparent for the number of PBF indicators in the model, i.e. more complex models appear to promote particularly efforts to gain more third party funding. A possible explanation would be that third party funding is more easily to attract than to achieve improvements of teaching indicators; however, this question needs further investigation.

Regarding model quality, consistently higher R^2 are found than in the less detailed models, i.e. including the share values of the PBF criteria and additional steering instruments improved the explanatory power of the model slightly; albeit the basic model already explained a high proportion of the variance between universities.

Also at the universities of applied science very few significant correlations are visible concerning the actual design of the PBF models. It is striking, however, that significant correlations with the change in the number of graduates are visible, and mostly positive correlations with four of the six independent variables. The number of graduates also reacted – and even with a relatively high beta – positively with an indicator for the proportion of graduates in the PBF model; the same goes for the indicator-share for third-party funds. Only the proportion of the indicator female professors is relative negatively to the development in the number of graduates. This also applies to the portion of the indicator for students within the expected study duration. A fairly high beta (.33) is visible for the number of indicators in the PBF model and the evolution of the number of graduates.

Considering the other, more fundamental steering instruments (global budgets, tuition fees, and the two forms of compulsory internal university target agreements or internal PBF), then significant correlations between tuition fees (in the states which introduced them) and all three teaching indicators are visible; with the effect direction twice (new entrants and graduates) positive and once (students within the prescribed study duration) negative. Moreover, all four instruments (global budget, tuition fees and mandatory internal university target agreements or mandatory internal PBF) only show simultaneously significant changes for graduates, albeit in different effect directions. Global budget and internal PBF have a negative and tuition fees and university-internal target agreements a positive effect.

Table 13: The effects of different model designs on the outputs of universities of applied science

	1st grade students			Students in Standard study time"			Graduates			Third Party funding		
	B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.
Share Inddicator 1st grade students in relation to total PBF	-142,862	-,020		-452,100	-,017		-115,242	-,019		295,926	,013	
Share Indicator on Graduates in relation to total PBF	-55,253	-,046		-167,930	-,037		209,044	,206	**	-2798,854	-,742	***
Share Indicator on Students in standard study time in relation to total PBF	-178,566	-,067		-486,917	-,048		115,768	,052		-7433,013	-,891	***
Share on foreign students indicator on total PBF	-129,832	-,038		-682,295	-,053	*	253,164	,089	**	-2840,289	-,267	***
Share of indicator on Third Party Funding on total PBF	-150,809	-,043		-462,443	-,035		235,281	,080	*	-4138,416	-,377	***
Share of indicator on female Professors on total PBF	-72,583	-,035		-98,505	-,012		-136,080	-,077	*	-2837,046	-,432	***
Total number of indicators of PBF-model	-,325	-,003		-14,163	-,037		27,311	,327	***	-213,444	-,688	***
Lump-sum budget	-7,654	-,013		66,726	,031		-47,509	-,099	***	-8,109	-,005	
Tuition fees	16,090	,024	*	-88,394	-,035	**	17,963	,032	*	13,787	,007	

	1st grade students			Students in Standard study time"			Graduates			Third Party funding		
	B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.
Mandatory intra-university target agreements	-6,304	-,012		48,973	,024		39,439	,088	***	232,350	,140	***
Mandatory intra-university PBF	15,196	,029		108,522	,054		-33,750	-,076	*	663,700	,405	***
R²		,929			,816			,890			,524	

Source: QualitAS-Dataset.
Legend: ***) significant at 0,1% Level, **) significant at 1% Level, *) significant at 5% Level.

The differentiated analysis of the factors impacting on third party funds leads to a significant improvement of the explanatory power by approximately 10 percentage points to 52.4%. It is striking, however, that higher share values are almost exclusively associated with significant negative correlations among changes in third-party funding, independent from whether they are related to teaching or research outputs. Only mandatory internal target agreements and/or PBF models show positive correlations.

A comparison between universities and universities of applied science shows significant differences, and in particular the development in the number of graduates seems to respond to the specific design of the PBF models in both cases, and primarily in the expected direction of increase. Also, the introduction of instruments in these two types of higher education appears to lead to significantly measurable reactions, although at universities of applied science half positive and half negative effects whilst the effects for universities are mainly negative in direction.

5. SUMMARY

Considering the analysis in relation to its overall effects, then the basic model, which relates to framework conditions and main input factors, explains between 80% and up to about 90% of the variance between the universities as well as the universities of applied science. The only exception concerns the level of third party funds at universities of applied science (43.5%). The remaining explanatory power of the PBF and/or other steering instruments is correspondingly low for most parts, although these usually somewhat increased in the overall fit of the model. Unsurprisingly, the explanatory power increased by more, the smaller the R^2 was in the basic model, i.e. the improvement is particularly high for third party funding of UAS.

Looking at the different components, the basic model, the introduction or refinement of the PBF and other control instruments, then the following picture emerges:

The staff-related inputs (especially number of professors and academic staff), as well as the financial resources (spending on education and research, partially also third-party funds) usually show positive correlations with teaching-related indicators as well as with third party funding as the only research-output indicator taken into consideration here. Strikingly, however, is that additional third-party funding and additional professors correlated negatively with the number of graduates at universities. An important, and often positive role is played by the size of the department, from which – at least to a limited extent – economies of scale can be expected, which, however, cannot be observed between the number of students in the department and the level of third party funding (all other things equal). The total size of the university, in contrast, turns out almost always to be little conducive. Engineering and natural science almost always show lower values in teaching and higher values in the research indicator third party funding (except for number of professors) than social sciences and arts and humanities (as reference category).

Introducing a PBF does not automatically lead to behavioural changes, and this also applies to the share of the PBF budgets in relation to the total budget and the importance of the tolerance band. Although the specific design of the PBF model may lead to significant effects, these are not always in the expected direction. Instead, there are sometimes counterintuitive relationships such that high share values of teaching indicators associated negatively with the change of teaching indicators and high share values of research indicators associated negatively with the development of the research indicator third party funding. Moreover, there are cross-effects, i.e. high percentage values of teaching-related indicators show positive correlations with research indicators and vice versa.

Looking at other instruments, introduced in relation to New Public Management, tuition fees show significant correlations to the number of graduates in universities and universities of applied science as well as on the number of first-grade students in UAS, whereas the correlation to the number of students in the prescribed study duration at UAS is negative.

Compulsory internal university target agreements as well as compulsory internal PBF-models show varying effects between the two types of universities. While the former seem to affect the behaviour of universities and UAS equally positively in relation to third party funding, its link to the teaching area is invisible, apart from a positive effect on the number of graduates at universities of applied science and a negative relationship to the number of new enrolments at the universities. A mandatory internal university PBF evidently has adverse effects for third party funding at universities, but positive at UAS, whereas the relationship to graduate is negative at both types.

These findings show a rather complex and often inconclusive pattern, which may be due to the limited time frame between the introduction of PBF-models and the end of the time-span of the data underlying this analysis, the years 2000 until 2008. However, the direction of the relationships is often not in the expected direction, but rather into the opposite direction, i.e. teaching-related indicators do not correspond with improvements of teaching output indicators and research indicators not with research output. Interestingly, in particular the number of performance indicators shows predominantly significant effects, the complexity and the importance of individual indicators could contradict each other in their overall impact.

Only two patterns seem to hold. Firstly, there are strong indications for a trade-off between teaching and research (third party funding) – whereas, however, the core input factors, professors and other research staff, are conducive for both activities. Secondly, universities and universities of applied science do not operate along the same lines, but “produce” at least to some extent on different “production functions”, particularly when it comes to the effects of performance-based funding. This clearly suggests to employ different schemes for both types of universities.

Reviewing the effort which is connected to the introduction of a performance-oriented allocation of resources, therefore, leads to the question of whether the effort really is worth it in terms of the associated effects.

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