Higher Education Institutions and Regional Development

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Regional Interaction and Regional Research Funding – A Data Envelopment Analysis for Germany
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Geographical proximity in the knowledge transfer process
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Introduction

Typically science research addresses the question of third party funding acquisition in institutions as a major question, given the fact that the total budget share of competitive external research funding for universities has risen, e.g. in Germany from 10 to about 25 percent on average. The further question of regional interaction and possible "location advantages" are of high interest for research (i.e. how to increase university-industry cooperation, cp. Marquesa, Carac and Diz, 2006; Giuliania and Arzab, 2009; Broström, 2010; De Fuentes and Dutrénit, 2012; Freitas, Geuna and Rossie, 2013).

Many general assumptions connect higher third party funding volumes (at least from industry sources) to the general economic status of the region a research institution is situated in. Further assumptions connect this hypothesis to the Mathew Principle, postulating that those institutions in economically well-positioned regions have a sort of head start over other science institutions in poorer regions due to a presumed higher regional external funding.

These assumptions are tested in this contribution with a correlation and data envelopment analysis regarding *regional* research funding (industry, foundations, others) compared with national and international research funding (federal, European) for 87 German universities and universities of applied sciences.

Therefore, the 2012 DFG national report on research funding with data for 2009 is used. Besides the *regional towards national* view ("starting point perspective"), also the opposite view of a "research transfer perspective" from international and national research funding *into regional* research budgets is analyzed. Both perspectives are tested for regional correlation and distribution.

1 Problem Definition

The basic core assumption of the following analysis is the *distinction* of competitive outside (external) research funding for higher education institutions into (more) regional sources on the one hand and national and international sources on the other hand.

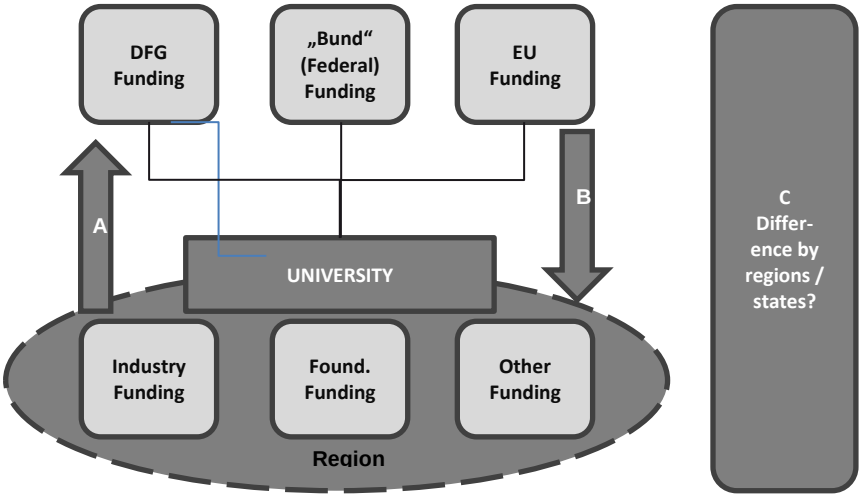

Figure 1. Problem Structure for University Funding Sources.

According to this distinction actually two "production hypotheses" (A) and (B) can be formulated (without any normative or other prerogative evaluation, this is for theoretical evaluation only – the further interpretation and importance weighting has to be applied on other accounts):

(A) HEI are "producing" national and international competitive research funding (output) by using regional research funds as for example industry or foundation money as inputs. This is only a partial view as for sure most institutions also use as more important input the existing block grant funding from the states (base budget). But nevertheless this production view represents the "insinuation" if uneven starting condition in the face of different distributions of such regional research funding.

(B) Secondly, a top-down perspective can be employed by assuming a production context in HEI using national and international research funding (and the research *results* out of these) as input in order to produce regional co-operation and research transfer in the forms of research project funded by industry and regional actors such as foundations or other actors providing research budgets.

Finally, in a third perspective (C) the question can be asked how the initial funding distributions and correlations as well as efficiency results are distributed by regions (here: states).

2 Research Method and Data

As a research method besides plain correlation and distribution analysis of research funding sources the *data envelopment analysis* (DEA) for relative efficiency calculation is applied, first proposed by Charnes, Cooper and Rhodes (1978). A CCR model with *constant* returns to scale is applied in an input minimizing variation.

The software BANXIA Frontier Analyst is used. For further outlines regarding the application of DEA in higher education settings see for example Cooper, Seiford and Tone (2007) for basic methodology aspects, Worthington and Higgs (2010) for university application in Australia, McMillan and Datta (1998) for Canada, Hashimoto and Cohn (1997) in Japan or Klumpp (2013) in Europe.

The basic data implemented for this analysis are reported in the 2012 research funding report by Deutsche Forschungsgemeinschaft (DFG) (2012), detailing annual institutional data for 2009. Some institutions are excluded because they listed less than at least one regional and one national or international funding budget, leaving data for 87 university institutions from all 16 states (Länder) in Germany. The complete dataset is reported below in table 3 in the annex.

3 Correlation Analysis

First of all a standard correlation analysis was conducted in order to get a first glance at possible connections between the six different funding sources incorporated in the dataset, depicted in table 1.

Table 1. HEI Funding Correlations by Sources.

	DFG	Bund	EU	*Foundations*	*Industry*	*Other*
DFG	-	**0.816**	0.794	*0.705*	***0.840***	*0.507*
Bund		-	**0.854**	*0.578*	*0.741*	*0.535*
EU			-	*0.527*	*0.668*	*0.413*
Foundations				-	*0.559*	*0.348*
Industry					-	*0.533*
Other						-

It can be recognized that:

(i) The correlations among the national and international funding sources (DFG, Bund, EU) are very much correlated, indicating that success in one of the funding schemes goes usually along with success of individual HEIs in the other of the three funding programs.

(ii) (ii) Second also the high correlation of industry funding and at least DFG funding is interesting (though we cannot discern any causal relationships here); high correlations also exist for Bund and EU funding.

(iii) (iii) Foundations as funding sources have mid-level correlations, whereas "Other" funding sources have the lowest correlation level, especially with foundations and also EU funding – indicating that the "Other" funding sources are in essence a "independent" funding scheme not connected strongly to the other funding sources.

4 Data Envelopment Analysis

4.1 Regional Funding Input Efficiency (A)

According to the DEA results the following 20 universities are the most efficient ones in the perspective "A" production setting.

Bamberg U	100.0%	Bayern	Weimar U	94.4%	Thüringen
Bielefeld U	100.0%	Nordrhein-Westfalen	Passau U	73.5%	Bayern
Freiberg TU	100.0%	Sachsen	Chemnitz TU	73.2%	Sachsen
Hamburg U	100.0%	Hamburg	Bayreuth U	71.8%	Bayern
Hamburg UB	100.0%	Hamburg	Cottbus TU	67.9%	Brandenburg
Hamburg TU	100.0%	Hamburg	Augsburg U	67.0%	Bayern
Ilmenau TU	100.0%	Thüringen	Aachen FH	61.0%	Nordrhein-Westfalen
Kiel U	100.0%	Schleswig-Holstein	München HS	59.1%	Bayern
Potsdam U	100.0%	Brandenburg	Clausthal TU	56.4%	Niedersachsen
Marburg U	96.4%	Hessen	Wuppertal U	56.2%	Nordrhein-Westfalen

Nine universities are calculated being most efficient (100%), with three of them being in Hamburg but all other six based in further six different states in Germany, being east and west as well as north and southern regions. Interestingly, three out of these top nine are technical universities and one a university of the armed forces. Further down the list the next eleven represent even a further variety of different states and profiles, including also universities of applied sciences (Fachhochschulen) like the UAS Aachen (FH) and the UAS Munich (HS), whereas most universities from this second group are situated in Bavaria.

The correlation of these "A" efficiency values with e.g. the industry funding amounts per university reveals the below scatter plot (figure 1) and a negative correlation of –0.32.

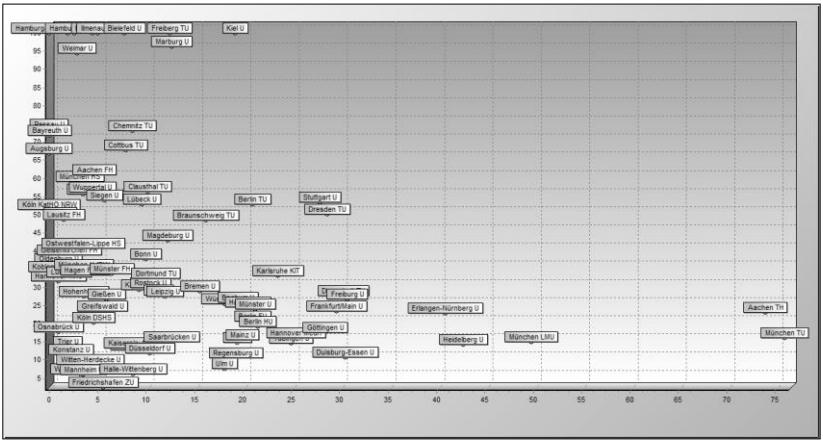

Figure 1. Efficiency-Industry Income Correlation by Institution.

4.2 National Funding Transfer Efficiency (B)

As further results of the DEA calculation, the following 20 universities are the most efficient regarding the perspective "B" production direction (input national and international research funding and output regional funding sources).

In this case, eleven universities are calculated being most efficient (100%), with three of them each being in Bavaria and Northrhine-Westphalia. Again, also a very diverse distribution of the most efficient universities among the different states and regions can be recognized – being just a nominal account without weighting of the very different sizes of states and higher education systems therein. Again

we can find also three universities of applied sciences among the most efficient institutions (Munich, Cologne and Gelsenkirchen); whereas in this case also for the first time very small private institutions such as Wiesbaden EBS and Friedrichshafen ZU are among this leading group.

The correlation of the described "B" efficiency values with e.g. the industry funding amounts per university reveals the below scatter plot (figure 2) also with a negative correlation tendency.

Hamburg TU	100.0%	Hamburg	Friedrichs. ZU	100.0%	Baden-Württemberg
Passau U	100.0%	Bayern	München HS	92.8%	Bayern
Bayreuth U	100.0%	Bayern	Hamburg UB	75.0%	Hamburg
Augsburg U	100.0%	Bayern	Köln FH	59.8%	Nordrhein-Westfalen
Köln U	100.0%	Nordrhein-Westfalen	Köln DSHS	54.1%	Nordrhein-Westfalen
Lausitz FH	100.0%	Brandenburg	Ulm U	53.4%	Baden-Württemberg
Ostwestf. HS	100.0%	Nordrhein-Westfalen	Gelsenk. FH	46.5%	Nordrhein-Westfalen
Münster FH	100.0%	Nordrhein-Westfalen	Mannheim U	43.7%	Baden-Württemberg
Witten U	100.0%	Nordrhein-Westfalen	Duisburg-E. U	41.5%	Nordrhein-Westfalen
Wiesb. EBS	100.0%	Hessen	Wuppertal U	36.3%	Nordrhein-Westfalen

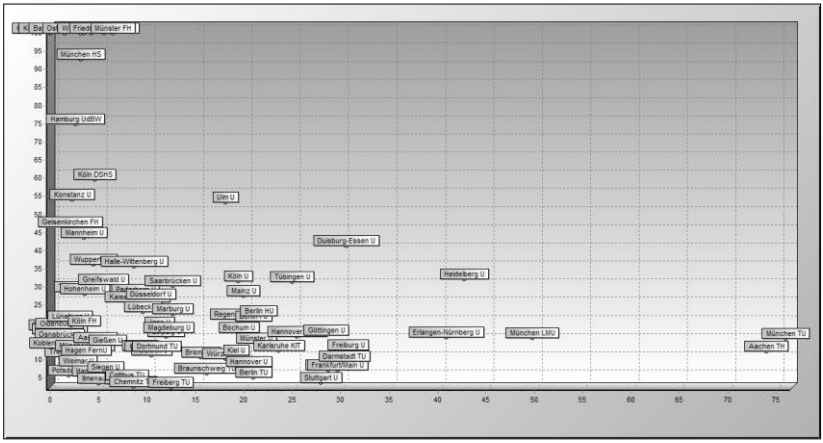

Figure 2. Efficiency-Industry Income Correlation by Institution.

4.3 Distribution and Differences by Region (C)

The third research problem regarding possible differences of funding sources and efficiencies as outlined above is concluded with the average funding sources data per university in the 16 different regions (states) in Germany as well as average efficiencies per institution in table 2 below. The first column further provides the general size indicators of the state higher education systems, indicating the total acquired external research budget (sum over all reported universities) and the number and type of institutions.

It is crucial to comprehend that not all about 400 institutions of higher education in Germany are reported but only 87, therefore major gaps in overall funding volumes as well as possible distortions regarding average institutional numbers might occur, especially as mainly the larger (research oriented) universities are reported and a distinctively smaller share of the Fachhochschulen (UAS) which make up about two thirds of the German HEI body.

Table 2. HEI Average Funding Amounts and Efficiencies by State.

	Total	DFG	Bund	EU	Foundations	Industry	Other	Eff. A	Eff. B
Baden-Württemberg	708 M€ - 9 U	30.4	14.9	6.9	7.6	16.9	1.9	19.4%	37.4%
Bayern	746 M€ - 10 U, 1 UAS	26.2	10.4	6.1	4.6	19.2	1.3	45.1%	45.7%
Berlin	430 M€ - 3 U	56.9	30.2	15.6	10.5	21.2	8.8	31.0%	15.9%
Brandenburg	75 M€ - 2 U, 1 UAS	4.8	10.9	3.7	0.8	3.8	0.9	72.2%	36.7%
Bremen	48 M€ - 2 U	3.6	2.2	1.5	0.7	1.0	0.2	33.6%	14.5%
Hamburg	143 M€ - 3 U	24.4	11.5	8.0	1.2	2.4	0.1	100.0%	60.2%
Hessen	345 M€ - 6 U	21.7	10.5	5.5	1.9	15.2	2.8	35.0%	27.7%
Mecklenburg-Vorpommern	74 M€ - 2 U	9.1	10.8	3.7	3.7	8.0	1.7	26.8%	21.1%
Niedersachsen	552 M€ - 9 U, 1 UAS	21.1	11.0	4.8	2.4	13.7	2.2	30.9%	14.5%
Nordrhein-Westfalen	1083 M€ - 15 U, 6 UAS	18.3	10.3	4.0	3.2	12.2	3.5	35.5%	38.9%
Rheinland-Pfalz	141 M€ - 4 U, 1 UAS	8.7	5.0	2.2	2.3	6.7	3.3	25.2%	21.3%
Saarland	48 M€ - 1 U	20.5	7.4	1.4	3.4	12.7	2.2	15.1%	30.3%
Sachsen	81 M€ - 4 U	20.2	24.8	12.7	3.1	15.5	4.5	62.7%	7.2%
Sachsen-Anhalt	86 M€ - 2 U	14.4	7.8	2.5	2.3	10.5	5.5	24.6%	26.7%
Schleswig-Holstein	100 M€ - 2 U	19.0	11.5	2.5	2.4	14.4	0.0	76.5%	17.3%
Thüringen	111 M€ - 3 U	11.0	12.6	3.0	2.5	6.4	1.4	74.1%	10.2%

Analysing the regional data no obvious clues ocure regarding specific profiles of more efficient regions, especially not the regions in the south (Bavaria, Baden-Württemberg, Hessia), which have the highest industry and economic strength and per-capita income levels in Germany.

Obviously – which has been the result in many DEA studies for German and other higher education institutions – is the analyzing perspective of efficiency not connected or predetermined by any other characteristics as neither size nor region nor specific funding inputs (i.e. industry funding) do explain solely the differences in efficiency results for the HEI on average (e.g. between 45.1% for southern Bavaria and 62.7% for mid-eastern Saxony.

In order to make the results more obvious, a map of Germany is used in figure 3 in order to communicate the regional distribution of GDP on average (colors of the states with the highest per-head GDP on average in the three southern states of Bavaria, Baden-Württemberg and Hessia) and the average industry funding income per HEI in these states, the highest amount being present in Berlin (21.4 M€ annual average).

Though the three economically best situated regions in the south follow suit, the four states positioned behind that as e.g. Saxony with

15.5 M€ annual industry funding in 2009 per university is close behind. Especially Saxony and Schleswig-Holstein would not have been among the "usual suspects" for high industry funding levels as the average economic strength of the immediate region is not very high.

A similar picture can be recognized in the efficiency numbers in relation to the economic strength of individual regions (figure 4), e.g. with Hamburg (100%) and successful eastern as well as northern states besides the expected southern states as Bavaria (45.1%).

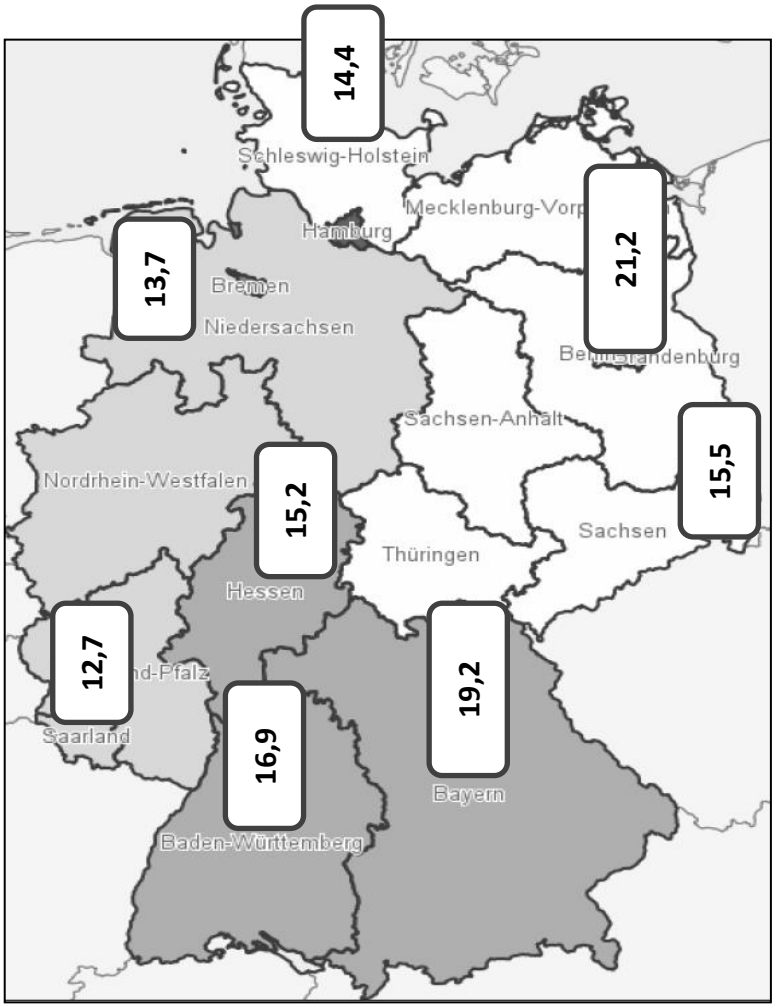

Figure 3. Average Industry Funding (Top 50%) and Economic (GDP) Levels (Colors from High GDP = Dark to Low GDP = White).

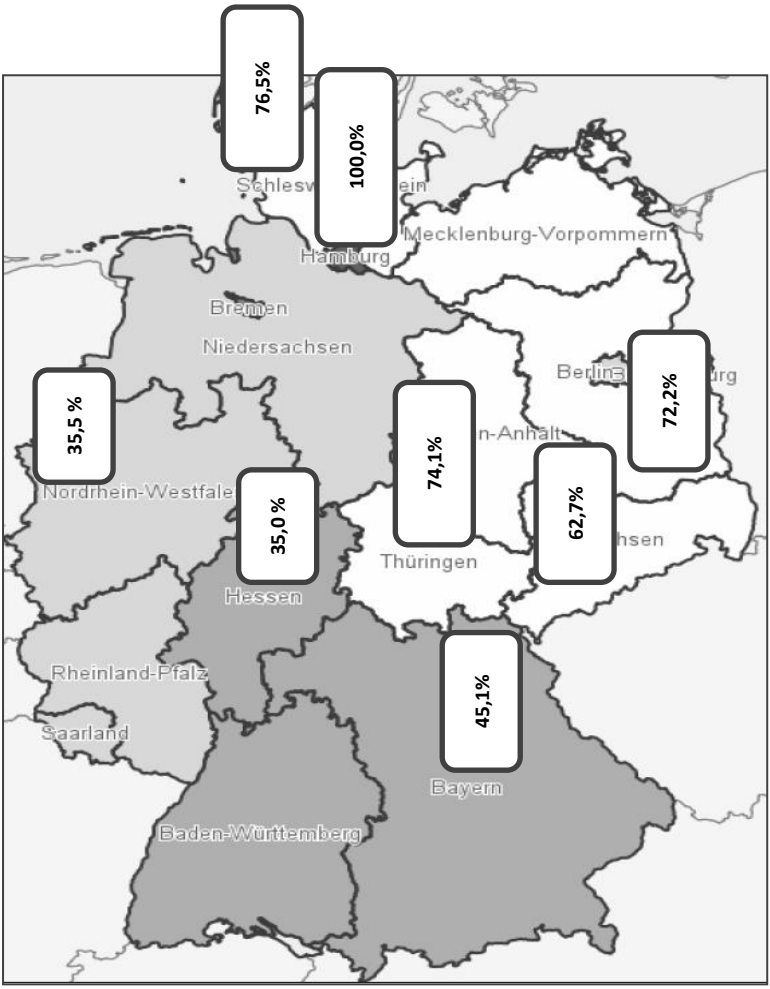

Figure 4. Average Efficiency (A) Values (Top 50%) for all HEI of one Region (State).

5 Discussion

As described in the results section, the assumption or hypothesis of major importance of large industry funding volumes from regional sources for individual universities or regions has not been corroborated. As suggested for example by other authors like Azagra-Caro (2007), other factors besides the simple location of universities play a role in industry and other competitive research funding sources for universities (i.e. scientific quality and reputation).

Further implications of the results may include:

- Institutional processes and performance seems to be much more important than regional location („high“ and „low“ performers in every region / state)
- Further research (institutional research) and management focus needed for supporting and motivation research funding acquisition (e.g. Science Support Centre UDE)
- Diseconomies of scale should be a major concern for system funding
- Diversity of funding schemes is a strategic „value“ and has to be enhanced not diminished
- Economic background & supra-regional attraction important
- In-depth research for the economies / diseconomies of scale question in higher education
- International comparison of results on regional funding
- An analysis including state base grants
- Integration of regional funding discourse in general research budget acquisition and directions of competitive funding

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