



Institute for Strategy and Business Economics
University of Zurich

Working Paper Series
ISSN 1660-1157

Working Paper No. 99

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February 2009

Published as: "The Performance of German Research Training Groups in Different Disciplinary Fields: An Empirical Assessment." *Governance and Performance in the German Public Research Sector; Disciplinary Differences*, Volume 32 (2009), Ed. Dorothea Jansen. Dordrecht: Springer, 93-106. By Birgit Unger, Kerstin Pull and Uschi Backes-Gellner.

Available at: http://dx.doi.org/10.1007/978-90-481-9139-0_5

The Performance of German Research Training Groups in Different Disciplinary Fields: An Empirical Assessment*

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Abstract

In the early 90s, the German Research Foundation (Deutsche Forschungsgemeinschaft, abbr. DFG) established a new form of graduate education: the so-called Research Training Groups (RTGs). Comparable to PhD programs in the US, RTGs offer a structured course program and a framework for collaborative research for young researchers. As a result, the completion rate of doctoral degrees and the scientific visibility of doctoral and postdoctoral research were held to increase. However, the performance of German RTGs has not been evaluated as yet. In this paper, we undertake a first step in that direction and assess the performance of German RTGs in two different disciplinary fields (humanities & social sciences vs. natural & life sciences). We do so in two important respects by assessing (1) the doctoral completion rate as an immediate outcome of the graduate teaching undertaken and (2) the scientific visibility of doctoral and postdoctoral students as measured by their publication and presentation output. In our analysis of 86 German RTGs we are able to show that the performance of German RTGs varies considerably in and between the different disciplinary fields. An additionally performed Data Envelopment Analysis (DEA) hints at a considerable potential for a performance improvement.

Keywords:

Research Training Group, publications, presentations, doctoral completion rate, performance

This working paper is published in: Jansen, Dorothea (Ed.): Governance and Performance in the German Public Research Sector: Disciplinary Differences. Springer: Dordrecht. 2009.

The original publication is available at www.springerlink.com

* Financial support by the German Research Foundation as well as support concerning the collection of the data is gratefully acknowledged.

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1 German Research Training Groups: Profile and Goals

In an attempt to offer an alternative to the traditional student-teacher relationship in doctoral studies, in the early 90s the German Research Foundation (*Deutsche Forschungsgemeinschaft*, *abbr.* DFG) established so-called Research Training Groups (*Graduiertenkollegs*) offering a new form of structured doctoral education. A Research Training Group (RTG) constitutes a temporary program focusing on a special research topic that covers a set of doctoral projects and is supported by a study program at a single German university, at a small group of German universities, or at a German university cooperating with foreign partners. It is run by a group of cooperating researchers who apply for the funding at the DFG. The study program is compulsory for the doctoral and postdoctoral students and is held to provide the RTG students with well-founded methodological skills as well as with specialized knowledge in the particular field of research. Furthermore, an early integration of the RTG students in the research activities of a collaborative research environment is appreciated as well as an international and interdisciplinary orientation. The DFG grants fellowships to doctoral and postdoctoral students as well as funds for travel expenses and equipment for a maximum funding period of nine years for an RTG. Until March 2003, a grant consisted of an initial funding for a period of three years that – in case of a successful reapplication – could be renewed twice; since April 2003, however, a grant has consisted of a funding for 4.5 years that can only be renewed once. At present, about 240 Research Training Groups are funded by the DFG (see DFG 2008).

In this paper, we study the performance of German Research Training Groups funded by the DFG by assessing their performance in two important respects: (1) the completion of *doctoral degrees* and (2) the *scientific visibility* of RTG students. As a measure of scientific visibility besides publications, we also include presentations at conferences and workshops. As FABEL/LEHMANN/WARNING (2003) argue, presentations (at least those at refereed conferences) represent an “intermediate” indicator of research performance as they usually lead to publications at a later point in time. Hence, it would seem only fair to complement the data on publication output by the data on presentations – especially as we assess the performance of very young researchers at a very early point of time in their academic careers. However, as information on the latter is only available for a share of RTGs in our sample, we will not use the corresponding data in the Data Envelopment Analysis (DEA) performed in the last step of our analysis.

2 Data and Measures

Our empirical analysis is based on a data set of 86 RTGs funded by the DFG. It comprises *all* Research Training Groups belonging to the humanities, the social sciences, the natural & life sciences who are in their second funding period *and* who submitted an application for a third funding period to the DFG between October 2004 and October 2006.¹

The data on performance measures were extracted from the detailed reports of the Research Training Groups that are part of the application for a third funding period. The RTGs in our sample hence had a strong incentive to fully document their output in order to succeed in their application. On the one hand, the reports for the second funding period are especially suitable for our analysis, because at the time of submission, the RTGs already existed long enough to be able to report output of RTG students. The reports for the first funding period, on the other hand, contain only information on the years 1-2 (with hardly any performance data to be reported yet) and the ones on the third funding period presumably will only contain incomplete data as there is no incentive for fully reporting when the RTGs cannot be renewed again. The inclusion of these reports in the data set would hence not seem appropriate.

While doctoral degrees and publication data are an integral part of RTG reports (with the DFG explicitly asking for the respective data), this is not the case for our intermediate indicator of research performance, presentations at conferences, and workshops. Still and even though the DFG does not require the respective figures to be included in the reports, 75 out of 86 RTGs report on this category. As a consequence, we present the descriptive data on this indicator in *section 3*, but we do not include it in the DEA performed in *section 4*.

28 of the 86 RTGs in our data set belong to the humanities & social sciences, 58 RTGs belong to the natural & life sciences. In order to account for the different research technologies in the different disciplines (see for example LAUDEL 1999, SNOW 1967), we distinguish between the disciplinary field of *humanities & social sciences* on the one hand and the disciplinary field of *natural & life sciences* on the other hand.

¹ As the RTGs reported on varying time spans (partly as a result of the varying length of funding periods), we normalized all measures on a year basis.

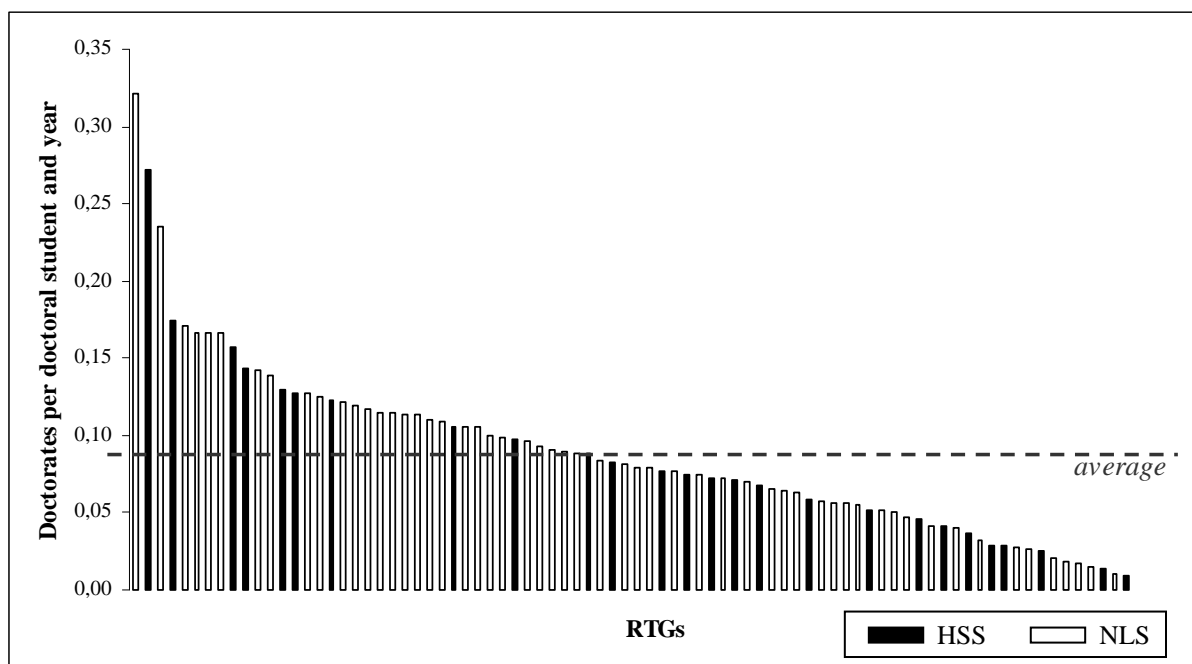
3 Descriptives

In the following, we present the descriptive data on the measures we use to assess the performance of the German RTGs: (1) doctoral degrees and (2) scientific visibility.²

(1) Doctoral Degrees

Our first performance measure is rather obvious from the key goal of an RTG: It is the number of successfully completed doctoral degrees. It is measured as the share of completed doctorates per doctoral student and year. According to our data, a little less than one of ten doctoral students (8.49%) on average receives his or her doctoral degree per year. While in the most active RTG almost one third of doctoral students per year completes the degree, there are also four RTGs that do not report the completion of one single doctoral degree (see figure 1).³

Figure 1. Share of completed doctorates per doctoral student and year in the different RTGs



Legend: HSS = humanities & social sciences, NLS = natural & life sciences

Source: own data

² Besides doctorates and scientific visibility, another possible measure to assess the performance of RTGs would be the placement rate of RTG students. As we do not have any information about the career paths of former RTG students, we refer to the contribution of SCHNEIDER/THALLER/SADOWSKI in this monograph who investigate the placement rate of selected economics departments in an international comparison.

³ While one of these RTGs reports on a time span as short as 5 months (which may well result in an underrepresentation of its performance), this is not true for the other RTGs with a doctoral completion rate of 0 who report on time spans in the range of comparable RTGs with significant doctoral degree completion rates.

Concerning disciplinary differences, RTGs in the natural & life sciences are quite similar to those in the humanities & social sciences as far as the completion of doctoral degrees is concerned (see table 1): 7.87% of doctoral students receive their doctoral degrees in any given year in an RTG belonging to the humanities & social sciences, while the corresponding figure for the natural & life sciences is 8.78%. In absolute figures, these are on average 2.8 doctorates per year in an RTG belonging to the natural & life sciences and 2 doctoral degrees per year in an RTG belonging to the humanities & social sciences.

Table 1. Completed doctoral degrees per doctoral student and year on an RTG basis

	Min	Max	Mean		
			Total	Humanities & social sciences	Natural & life sciences
Completed doctoral degrees (in %)	0	32.14	8.49	7.87	8.78

Source: own data

(2) Scientific Visibility

As RTGs were also established in order to qualify the coming generation of researchers, we complement the indicator of doctoral degrees by indicators of the scientific visibility of the doctoral and postdoctoral students in an RTG. In order to educate a new generation of researchers, doctoral and postdoctoral students in the RTGs should be introduced to the process of scholarly publication, and they should produce a visible research output. The publication output of RTG members would then mirror the success of the RTGs in qualifying young researchers and in introducing them to scientific research; conference presentations would represent an early indicator of that same activity. When collecting the data, we distinguished between different kinds of publications and conference presentations. Then we adjusted the publication and presentation output according to the number of authors and allocated a fraction of $1/n$ to each author (see e.g. EGGHE/ROUSSEAU/VAN HOOYDONK 2000: 146).⁴

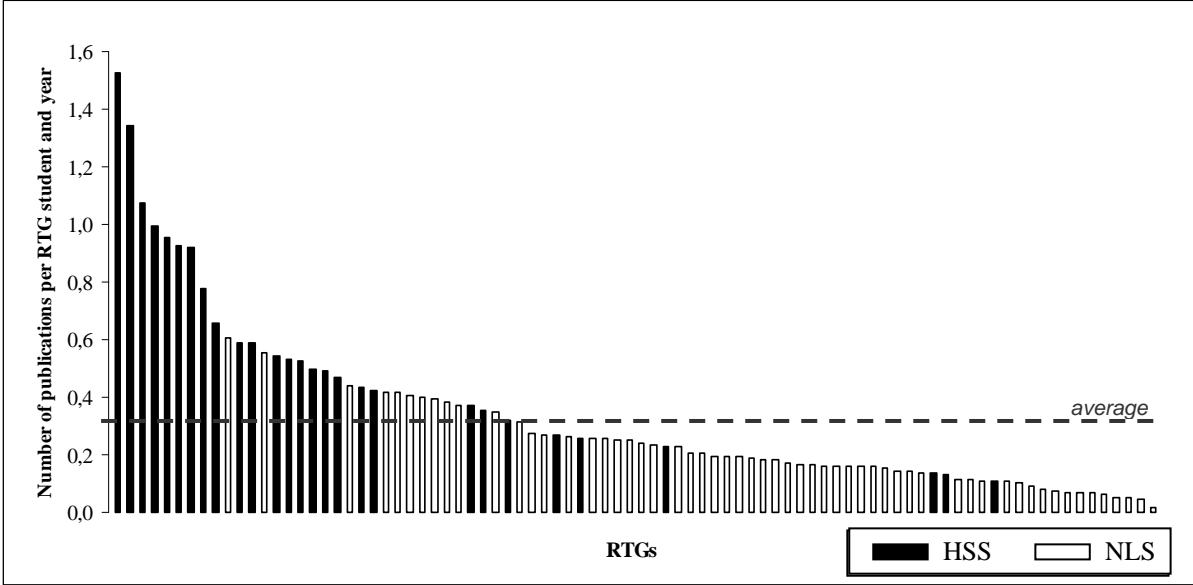
(a) Publications

Regarding the total publication output, the most active RTG reports 1.52 publications per RTG student and year while the least active RTG only reports 0.02 publications per RTG

⁴ Whenever the number of co-authors was not specified in the research reports but the expression “et al.” hinted at a joint production of publication outputs, we supplemented our data from the RTG research reports by information gathered from the internet.

student and year (see figure 2). On average, an RTG student (doctoral and postdoctoral students) produces 0.33 publications per year: RTG students in an RTG belonging to the humanities & social sciences produce on average 0.59 publications per year and RTG students in an RTG belonging to the natural & life sciences produce on average 0.21 publications per year (see figure 2 and table 2).

Figure 2. Average number of publications per RTG student and year in the different RTGs



Legend: HSS = humanities & social sciences, NLS = natural & life sciences

Source: own data

While the reported publication figures may seem quite low at first sight, one has to bear in mind that we are regarding very young researchers here. Most of them are doctoral students who come into contact with scientific research for the first time of their academic career. As postdoctoral students could be expected to show more active publication patterns and as their shares vary related to their RTGs, it would be interesting to regard only the publication output of doctoral students when comparing the scientific visibility of RTGs. This information, however, is not easily available. In the DEA performed in section 4, however, we are able to account for differing shares of postdoctoral students by regarding the different production inputs of doctoral and postdoctoral students.

Concerning the different publication outlets, these, too, differ significantly between the disciplines. Therefore, the RTG students of an RTG belonging to the natural & life sciences publish articles particularly in scientific journals with 0.11 articles per RTG student and year, whereas RTG students in an RTG belonging to the humanities & social sciences mostly

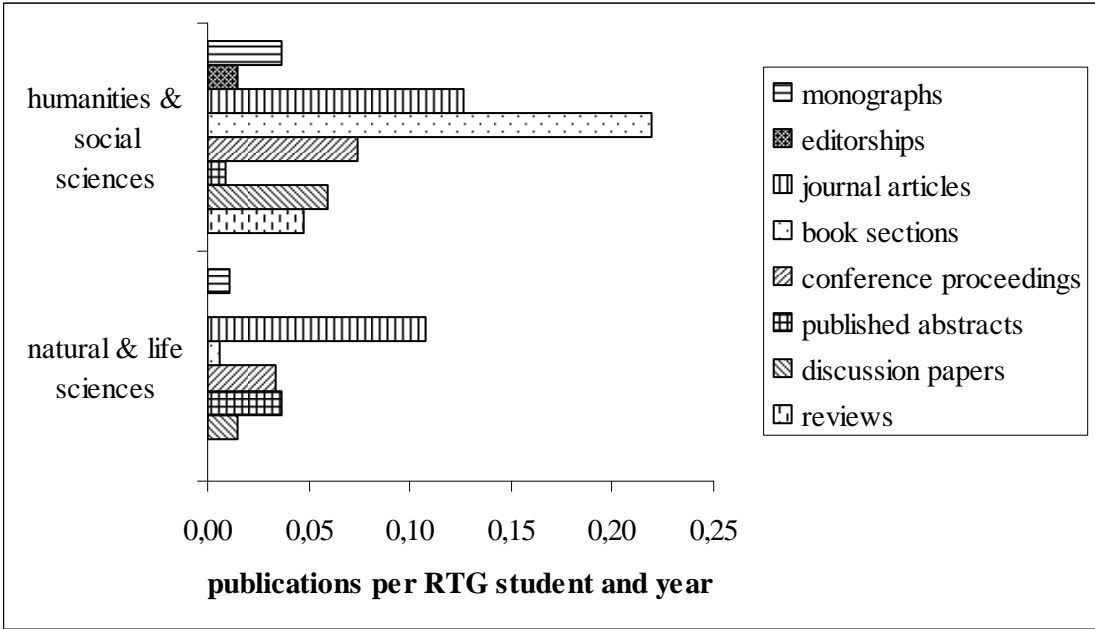
publish book sections with 0.22 book sections per RTG student and year. Table 2 shows the different kinds of publications that can be distinguished in the data and those publications' use by RTG students. Figure 3 shows the publication patterns for the RTGs belonging to the humanities & social sciences and to the natural & life sciences respectively.

Table 2. Publications per RTG student and year on an RTG basis

	Min	Max	Mean		
			Total	Humanities & social sciences	Natural & life sciences
Publications (in total)	0.02	1.52	0.33	0.59	0.21
Thereof: Monographs	0	0.14	0.02	0.04	0.01
Editorships	0	0.11	0.01	0.01	0.00
Journal articles	0	0.40	0.11	0.13	0.11
Book sections	0	0.79	0.08	0.22	0.01
Conference proceedings	0	0.59	0.05	0.07	0.03
Discussion papers	0	0.42	0.03	0.06	0.02
Published abstracts	0	0.30	0.03	0.01	0.04
Reviews	0	0.28	0.02	0.05	0.00

Source: own data

Figure 3. Publication patterns by disciplines



Source: own data

The average RTG student in an RTG belonging to the humanities & social sciences produces 0.22 book sections, 0.13 journal articles, 0.07 conference proceedings, 0.06 discussion papers,

0.05 reviews, 0.04 monographs, 0.01 editorships and 0.01 published abstracts in the course of one year. Except for the published abstracts, the average publication numbers in an RTG belonging to the natural & life sciences are *below* the average publication numbers in an RTG belonging to the humanities & social sciences. Even the average number of journal articles per RTG student in an RTG belonging to the natural & life sciences is – even though the journal is the most widely used publication outlet – lower than the corresponding number of articles displayed by an RTG student in an RTG belonging to the humanities & social sciences. This finding is, however, – at least in parts – owed to the fact that publication output was adjusted for the number of authors and that papers in the natural & life sciences typically have considerably more authors (with more than 500 authors of one single article as an extreme case in our data set). When the number of authors is ignored and each publication is fully counted for each co-author, the finding is reverse: An RTG student in the natural & life sciences on average participates in the production of 0.47 journal articles per year while his colleague in the humanities & social sciences only participates in 0.19 journal articles. Furthermore, it has to be kept in mind that in our data set we are not able to adjust for a possibly differing quality of journals (or even articles) as there is no comprehensive journal ranking for all the different study fields under consideration. If the RTG students in the natural & life sciences systematically aimed at more reputable journals, this then would also be able to explain the observed differences in publication output.

(b) Presentations

Presentations at conferences and workshops are an indicator that is only available for 75 out of the 86 RTGs. This indicator has to be interpreted with caution as the corresponding information is *not* an integral part of the reports as demanded by the DFG. RTG students from an RTG belonging to the humanities & social sciences are also more active when they are about to present their research findings (table 3): They give on average 0.90 presentations per year while their colleagues from an RTG in the natural & social sciences on average give only 0.41 presentations per year. Across all 75 RTGs that report on that category the mean is 0.57 presentations per RTG student and year with the most active RTG reporting 1.82 presentations per RTG student and year, whereas the least active one reports only 0.02 presentations per RTG student and year.

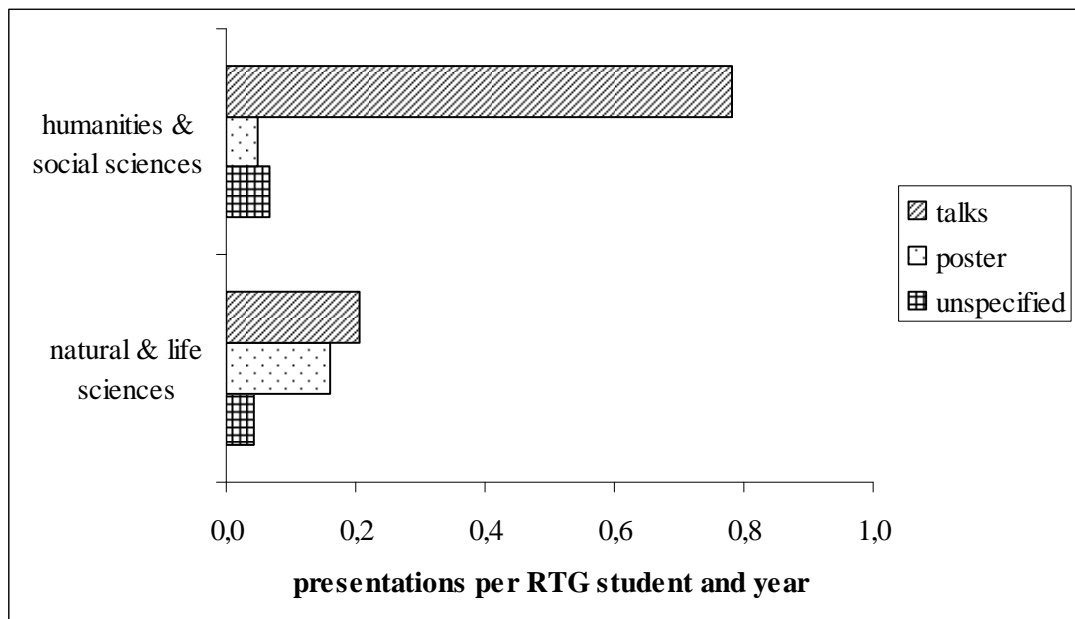
Table 3. Presentations per RTG student and year on an RTG basis

	Min	Max	Mean		
			Total	Humanities & social sciences	Natural & life sciences
Presentations (in total)	0.02	1.82	0.57	0.90	0.41
Thereof: Talks	0	1.82	0.40	0.78	0.21
Posters	0	0.98	0.12	0.05	0.16

Source: own data

Regarding different types of presentations, we distinguish between talks and poster presentations. The presentations we were not able to assign to one of the two categories were allocated to the category “unspecified” (see figure 4).

Figure 4. Presentation patterns by discipline



Source: own data

With regard to the different types of presentations, it can be seen that, on the one hand, an RTG student in an RTG belonging to the humanities & social sciences gives on average 0.78 talks per year, whereas a doctoral student in an RTG belonging to the natural & life sciences gives only 0.21 talks per year. On the other hand, an RTG student from an RTG belonging to the natural & life sciences gives on average three times as many poster presentations per year (0.16) as an RTG student from an RTG belonging to the humanities & social sciences (0.05). It is evident that the choice of the presentation type largely depends on the discipline: While

talks are by far the most common kind of presenting research results in the humanities & social sciences, researchers in the natural & life sciences introduce their research findings to a wider public either in the form of poster presentations or in the form of conference talks.

(c) Summary

To sum up, the descriptive analysis reveals considerable disciplinary differences between the field of humanities & social sciences and the field of natural & life sciences (see table 4): While the average doctoral completion rate in RTGs belonging to the humanities & social sciences is almost as high as the one in RTGs belonging to the natural & life sciences, the average publication and presentation outputs both are considerably higher in RTGs belonging to the humanities & social sciences. In light of the existing literature hinting at differences in the scientific production process between the disciplinary fields (see e.g. LAUDEL 1999, SNOW 1967), these findings make us analyze the efficiency for the two disciplinary fields separately in *section 4*.

Table 4. RTG-performance in the two different disciplinary fields

	Min	Max	Mean	Standard deviation
Completed doctorates per doctoral student and year (in %)				
... in humanities & social sciences	0	27.16	7.87	6.08
... in natural & life sciences	0	32.14	8.78	5.70
Publications per RTG student and year (in absolute numbers)				
... in humanities & social sciences	0.11	1.52	0.59	0.36
... in natural & life sciences	0.02	0.61	0.21	0.13
Presentations per RTG student and year (in absolute numbers)				
... in humanities & social sciences	0.13	1.82	0.90	0.47
... in natural & life sciences	0.02	1.65	0.41	0.32

Source: own data

4 The Relative Efficiency of RTGs: The Results of a Data Envelopment Analysis

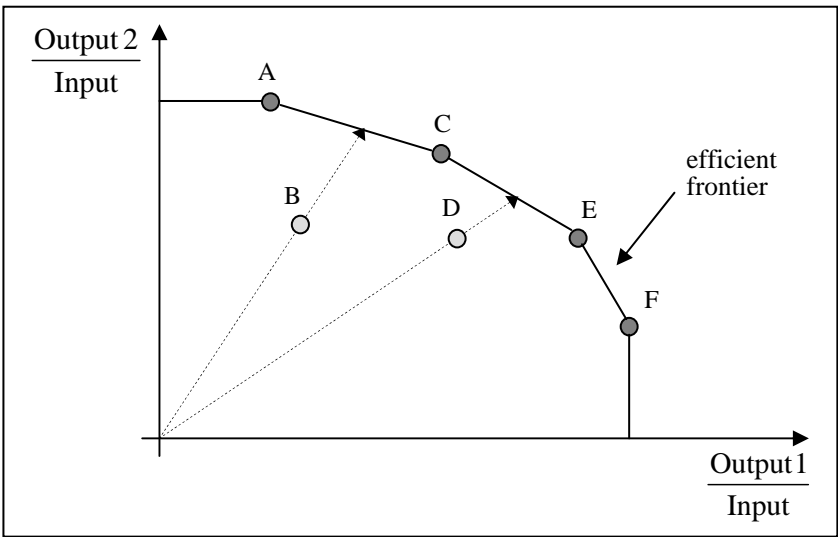
As RTGs have multiple inputs (doctoral students, postdoctoral students) and outputs (doctorates, publications, presentations) which do not only have different dimensions but may also be given different grades of importance by the individual RTGs, performing a Data Envelopment Analysis (DEA) is the measure at hand to analyze the efficiency of RTGs. As the DEA is especially useful when the lack of market prices for the outputs inhibits a coordination of supply and demand by the market mechanism, there exists a wide range of applications for a

DEA in the non-profit sector (for applications in academia see e.g. ABBOTT/DOUCOULIAGOS 2003, BACKES-GELLNER/ZANDERS 1989 or LEHMANN/WARNING 2004).

4.1 The DEA Model

The DEA is based on Charnes, Cooper and Rhodes (CHARNES/COOPER/RHODES 1978). It was the most suitable way for us to present the DEA intuition graphically: In the example presented in figure 5, there are six decision making units (i.e. in our case, 6 RTGs) to be evaluated. Let there be only one input (e.g. doctoral students) and two outputs (e.g. doctorates and publications). The input-output ratios are plotted for each decision making unit. The DEA uses all the other decision making units as reference points to identify the *relative* efficiency of a decision making unit. Connecting the decision making units A, C, E, and F, we can construct an efficient frontier. All units lying on this frontier line are efficient and have an efficiency index of 100% – although they display different output structures (e.g. unit A concentrates on output 2 while unit F concentrates on output 1). The units B and D, which are below the frontier, are inefficient. A linear projection of B and D to the efficient frontier shows that both units could realize higher output levels without using more of the input. In fact, unit B realizes only about 70% of its potential output, unit D only about 80%. This approach is called *output-oriented* because it emphasizes the maximization of the output that may be realized with a given amount of input. On the contrary, *input-oriented* DEA models emphasize the minimum input which is necessary to realize a given amount of output. (See SCHNEIDER 2007: 624f.; COOPER/SEIFORD/TONE 2006: 58.)

Figure 5. The DEA intuition



Source: in analogy to Cooper/Seiford/Tone (2006: 9)

Mathematically, the DEA solves the following problem (CHARNES/COOPER/RHODES 1978: 430):

$$\max h_0 = \frac{\sum_{r=1}^s u_r y_{r0}}{\sum_{i=1}^m v_i x_{i0}} \quad (1)$$

h_0 = efficiency index for unit 0
 y_r = amount of output r with $r = 1, \dots, s$
 x_i = amount of input i with $i = 1, \dots, m$
 u_r = weight for output r
 v_i = weight for input i

$$\text{s.t. } \frac{\sum_{r=1}^s u_r y_{rj}}{\sum_{i=1}^m v_i x_{ij}} \leq 1 \quad \text{for all } j = 1, \dots, n \quad (2)$$

$$u_r, v_i \geq 0 \quad (3)$$

When the index h for every decision making unit in the sample is maximized (equation 1), the DEA endogenously determines the optimal input and output weights from the perspective of the individual decision making unit. The optimal weights are subject to two conditions. Firstly, the weights that are determined for every decision making unit must not result in an efficiency index larger than 100%, neither for the decision making unit under consideration nor for any of the other units (equation 2). Secondly, all weights have to be non-negative (equation 3). With the help of these two conditions, the interval for the efficiency index is restricted to a scale of 0 to 100. An index of 100% stands for relative efficiency and an index of less than 100% for relative inefficiency (see SCHNEIDER 2007: 624).

4.2 The Input-Output Structure of the DEA Model

As *inputs*, we use (1) the number of fellowship months of doctoral students per year and (2) the number of fellowship months of postdoctoral students per year. Thus, we count how many months in total the DFG supported the doctoral students (“Fellowship months of doctoral students”) and, respectively, the postdoctoral students (“Fellowship months of postdoctoral students”) of a given RTG. Afterwards we normalize the figures on a year basis. We prefer the number of *fellowship months* as input variable to the number of RTG *students* in any given year because the former is not susceptible to a fluctuation bias. Table 5 presents information on the input variables.

Table 5. Input variables for the DEA: Descriptive statistics

	Min	Max	Mean		
			Total	Humanities & social sciences	Natural & life sciences
Fellowship months of doctoral students (per year)	73.09	395.27	178.40	172.63	181.19
Fellowship months of postdoctoral students (per year)	0	86.86	12.74	11.91	13.13

Source: own data

As *outputs*, we include (1) the share of completed doctorates per RTG and year and (2) the number of publications per RTG and year. We exclude presentations because we do not have the corresponding data for our whole set of RTGs. Furthermore, presentations correlate significantly positive with publications ($r=0.6$, 0.1%-level). As publication data is available for all RTGs in our sample, we include those instead of presentations in the DEA.

We use the DEA specification with the *constant-returns-to-scale technology* (see CHARNES/COOPER/RHODES 1978) because our data supports the assumption of constant returns to scale per fellowship month – at least for the case of doctoral students whose fellowship months on average account for more than 90 percent of the fellowship months in an RTG. We use an *output-oriented* DEA model, calculated separately for the two different disciplinary fields: humanities & social sciences on the one hand and natural & life sciences on the other hand.

4.3 DEA Results and Implications

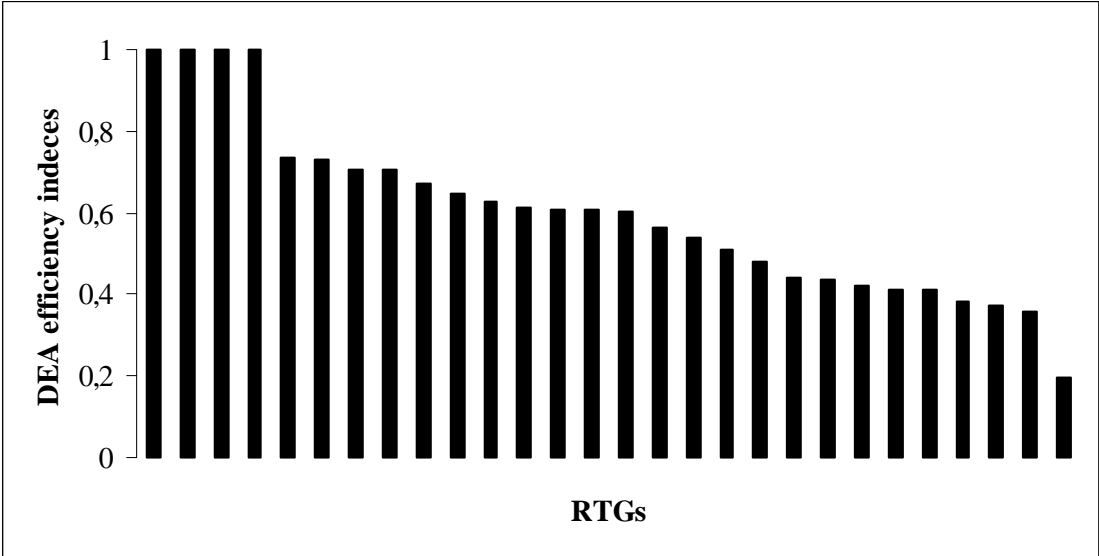
When interpreting the results, it is important to notice that we must not compare the efficiency indices of the two disciplines. The humanities & social sciences would be favored over the natural & life sciences because of their lower number of RTGs in the DEA leading to a generally larger share of efficient RTGs.

(a) Humanities & Social Sciences

Figure 6 presents the efficiency indices of the RTGs in the humanities & social sciences. Only four of the 28 RTGs in the humanities & social sciences, reach an efficiency index of 100%: While three of these score highly on publication output (with varying success in the completion of doctoral degrees), one clearly concentrates on the completion of doctoral degrees and is characterized by a comparatively lower publication output. Regarding the average efficiency score of 59.9% and the share of RTGs that operate at a relative inefficiency, the

efficiency can still be improved. However, it has to be kept in mind that maybe an RTG scores low on publication output because it concentrates on high-quality journal publications instead of going for a “mass production” in lower ranked publication outlets. However, according to our DEA, the lowest performing RTG (efficiency score of 19.8%) was in fact not renewed for a third funding period by the DFG (whose referees should be in a position to evaluate the quality of publications). This hints at the plausibility of our analysis. Furthermore, the average efficiency score of those RTGs in the humanities & social sciences that were not renewed by the DFG is about ten percentage points below the average efficiency score of all RTGs from the respective disciplinary field in the sample. In the humanities & social sciences, the RTGs with a below average efficiency score have a significantly lower chance of being renewed than those with an efficiency score above average.

Figure 6. Efficiency indices of the RTGs in the humanities & social sciences



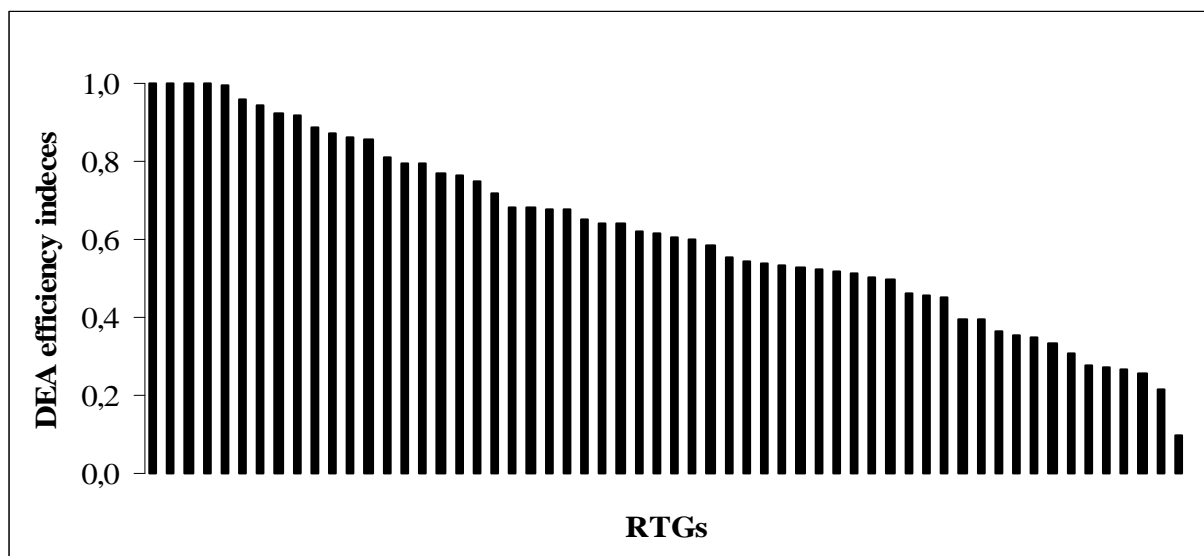
Source: own data

(b) Natural & Life Sciences

Figure 7 presents the efficiency indices of the RTGs in the natural & life sciences. Here again, only four of the 58 RTGs in the natural & life sciences reach an efficiency index of 100%: Two of these score comparatively highly on doctoral completion rates (with varying success in generating publication output), one is characterized by a comparatively low doctoral completion rate but generates a comparatively high publication output, one actually succeeds in both: doctoral completion and publication output. The small number of RTGs that operate at a relative efficiency and the average efficiency index of 61.7% both hint at considerable

room for efficiency improvement. However, the same caveat as above is still true: Without an adequate measure of publication quality an efficiency analysis of RTGs is generally incomplete and should only be interpreted with caution. However, according to our DEA again, the lowest performing RTG (with an efficiency score as low as 9.6%) was not renewed for a third funding period by the DFG, which hints at the plausibility of our analysis. As it was the case in the humanities & social sciences, the average efficiency score of those RTGs in the natural & life sciences that were not renewed by the DFG is below the average efficiency score of all RTGs from the respective disciplinary field in the sample; and RTGs with a below average efficiency score have a significantly lower chance of being renewed than those with an efficiency score above average.

Figure 7. Efficiency indices of the RTGs in the natural & life sciences



Source: own data

5 Conclusions

Even though Research Training Groups were already established in the early 90s, their performance has not been evaluated as yet. In this paper, we undertook a first step in that direction and assessed the performance of German RTGs in two different disciplinary fields: the humanities & social sciences on the one hand and the natural & life sciences on the other hand. We did so by assessing (1) the doctoral completion rate and (2) the scientific visibility of doctoral and postdoctoral students as measured by their publication and presentation output. We are able to show that the performance of German RTGs varies considerably in and between the different disciplinary fields: While the average doctoral completion rate of the

RTGs belonging to the humanities & social sciences was almost as high as the one of the RTGs belonging to the natural & life sciences, the average publication and presentation outputs both were considerably higher in the RTGs belonging to the humanities & social sciences. An additionally performed output-oriented constant returns-to-scale Data Envelopment Analysis (DEA) with doctoral degrees and publications as outputs and fellowship months of doctoral and postdoctoral RTG students as inputs reveals that there seems to be a remarkable potential for a performance improvement among RTGs in both disciplinary fields.

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