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**Composition and Performance of Research Training Groups**

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# Composition and Performance of Research Training Groups \*

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## *Abstract:*

This chapter analyzes how one particular governance mechanism affects the performance of research teams. We look at an external requirement for interdisciplinarity and internationality of Research Training Groups (RTGs) and study how their performance is affected. We expect to observe two countervailing effects with changes in interdisciplinarity and/or internationality: first, increased performance due to an increase in productive resources and a second, decreased performance due to increased team problems (communication, conflicts etc). Since both effects are expected to vary with the disciplinary field of research, we separate our analysis for the Humanities & Social Sciences in comparison to the Natural & Life Sciences and indeed find different effects in the different disciplinary fields. Furthermore, we separately analyze the effects of interdisciplinarity on the one hand and internationality on the other hand. We conclude that the effectiveness of a particular governance mechanism varies substantially between the disciplinary fields and for the type of heterogeneity under consideration. Therefore governance of research should be either precisely engineered to a particular disciplinary field and a given type of heterogeneity or it should offer a menu of options that allows research teams to choose from according to their specific needs.

## Keywords:

governance of Ph.D.-education, internationality, interdisciplinarity, performance, scientific visibility, doctoral completion rates, disciplinary fields

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## 1 Introduction

In the early 90s, a new form of governance for Ph.D-education in Germany was established: the so-called *Graduiertenkollegs* (Research Training Groups – RTGs). RTGs were introduced by the German Research Foundation (*Deutsche Forschungsgemeinschaft*) as a major intermediary in the governance of research in Germany. They are run by a group of cooperating researchers and include a study program covering a set of doctoral and post-doctoral projects. The study program is compulsory for the RTG students and is held to provide them with methodological skills and specialised knowledge in a particular field of research. The German Research Foundation grants fellowships to the RTG students as well as funds for travel expenses and equipment. Until March 2003, a grant consisted of an initial funding for a period of three years that could be renewed twice; since April 2003 a grant consists of a funding for 4.5 years that can only be renewed once. At present, about 240 Research Training Groups are funded by the German Research Foundation. (See DFG 2008; and UNGER/PULL/BACKES-GELLNER 2010).

Among the most prominent governance mechanisms used to steer the RTGs is the explicit call by the German Research Foundation for interdisciplinarity and internationality. However, surprisingly little is known about the potential effects of this kind of input oriented external governance: Will more interdisciplinarity and internationality among RTG students increase RTG performance or not? In what follows we will shortly review the literature and then present first empirical evidence on the question.

## 2 State of Research

The impact of RTG composition on RTG performance has not been analyzed as yet. Also for research teams in general, studies on the relationship between team composition and team performance are few and far between and, moreover, lead to contradictory results. E.g., PORAC et al. (2004) study research cooperations on the analysis of ecosystems on the one hand and cooperations in the field of astrophysics on the other. While for the former, they detect a positive effect of interdisciplinarity on research output, for the latter they identify a negative one. HOLLINGSWORTH (2002) presents empirical evidence for a hump-shaped relationship between interdisciplinarity and innovativeness. In light of the inconsistency of empirical findings, PORAC et al. (2004: 675) conclude that „much more research is necessary” concerning research cooperations and alliances in order to better understand the relationship

between research team configurations and performance (see BELL/KRAVITZ 2008: 301 for a similar claim). Furthermore, what is true for research teams in particular is also true for the general question of team composition on team performance – in spite of a vast and growing body of literature. Accordingly, HARRISON/KLEIN (2007: 1199) conclude their recent review on the subject stating that findings on the relationship between team composition and team performance have been “weak, inconsistent or both“.

From a theoretical perspective these mixed empirical findings may be the result of two countervailing effects: (i) On the one hand and highlighted by the so-called resource perspective (see e.g. GRUENFELD et al. 1996, HAMBRICK/MASON 1984, JACKSON 1992, THOMAS 1999), team heterogeneity may indeed have *positive* effects on team performance if team members possess distinct knowledge bases or abilities that are relevant for the production process. (ii) On the other hand, however, team heterogeneity may also *negatively* affect team performance because communication between team members is endangered, conflicts arise and group cohesion is reduced (so-called process perspective, see e.g. BYRNE 1971, MCPHERSON/SMITH-LOVIN/COOK 2001, PELLEDE/EISENHARDT/XIN 1999, TAJFEL 1974, 1981, TURNER 1975, 1987).

While the net effect of team composition on team performance hence remains unclear from a theory as well as from an empirical perspective, we hypothesize that the it will (a) depend on the type of team heterogeneity (interdisciplinarity, internationality) and (b) on the disciplinary field (Humanities & Social Sciences vs. Natural & Life Sciences). While the latter hypothesis is motivated by our earlier study on RTG performance in these two different disciplinary fields (see UNGER/PULL/BACKES-GELLNER 2010), the former is based on an extensive body of literature concerning the potentially differing effects of functional as opposed to demographic heterogeneity: While demographic heterogeneity is regularly argued to have a negative impact on team performance resulting from enhanced communication problems, potential for conflicts and reduced group cohesion (see e.g. JEHN/NORTHCRAFT/NEALE 1999; PELLEDE/EISENHARDT/XIN 1999; SMITH et al. 1994), so-called functional heterogeneity is typically regarded as being performance enhancing as it is related to the team task. Moreover, functional heterogeneity is less linked to identity than demographic characteristics are and consequently causes less social categorization (see e.g. ANCONA/CALDWELL 1992; JEHN/NORTHCRAFT/NEALE 1999; PELLEDE/EISENHARDT/XIN 1999). Both theoretical claims, the potentially performance-enhancing effect of functional heterogeneity as well as the potentially performance-reducing effect of demographic heterogeneity are mirrored well in

empirical studies (see e.g. HAGEDOORN/LINK/VONORTAS 2000 and CANNELLA/PARK/LEE 2008 for the former and THOMAS/RAVLIN/WALLACE 1996 for the latter).

### 3 Data and Measures

Our empirical analysis is based on a data set of 86 RTGs funded by the German Research Foundation DFG. It comprises *all* Research Training Groups from the Humanities & Social Sciences and the Natural & Life Sciences who are in their second funding period *and* who submitted an application for a third funding period to the German Research Foundation between October 2004 and October 2006 (see UNGER/PULL/BACKES-GELLNER 2010 for the details). 28 of the 86 RTGs in our data set belong to the Humanities & Social Sciences, 58 RTGs belong to the Natural & Life Sciences.

#### *(a) Dependent variables: RTG performance*

The performance of the research training groups is measured by its *scientific visibility* (number of publications) and by the *doctoral completion rate*. Both are measured per funding year in order to control for varying RTG size and for varying degrees of student fluctuation among RTGs. While the doctoral completion rate is an obvious measure of RTG performance, a measure of scientific visibility is added in order to account for the fact that RTG students were established to train the next generation of researchers who should hence be introduced to the process of scholarly publication. When collecting the data, we counted all kinds of publications of RTG students: monographs, editorships, journal articles, book sections in edited books, conference proceedings, discussion papers, published abstracts, and reviews. We adjusted the publications 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).<sup>1</sup> We decided to use all publications instead of just counting journal articles as an indicator for research performance for the following reasons: *Firstly*, the indicator “total publications” proves to be a good predictor of the German Research Foundation’s decision to approve the application for a third funding period. As the decision to either approve or reject an RTG’s application is based on the well-founded judgement of experts in the respective field, we are confident that the indicator “total publication” measures RTG performance. *Secondly*, by not only including journal articles we account for differing modes of publication (in the Natural &

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<sup>1</sup> 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.

Life Sciences, journals are the predominantly used publication outlet whereas in the Humanities & Social Sciences, book sections represent the dominant mode of publication; see UNGER/PULL/BACKES-GELLNER 2010). *Finally*, as we do not dispose of a comprehensive journal ranking including all the different journals from all the different subjects and sub-disciplines covered in our data set, the main advantage of using an indicator of scientific visibility based on (appropriately weighted) journal articles only, was not an option.

*(b) Explanatory variables: RTG composition*

To capture heterogeneity we calculate the widely used BLAU-Index of heterogeneity (BLAU 1977). It is defined as

$$H = 1 - \sum_{i=1}^n s_i^2$$

with  $n$  representing the total number of categories of a variable, and  $s_i$  the fraction of team members falling into category  $i$ . We calculate the BLAU-Index concerning (i) the field of study and (ii) the nationality of the doctoral and postdoctoral students in an RTG. As fields of study we distinguish 22 different fields according to the ISCED classification; concerning the nationality of RTG students we distinguish nine cultural regions according to the classification by HUNTINGTON (1996). Afterwards the figures are normalized on the interval [0,1] (see ALEXANDER et al. 1995: 1466).

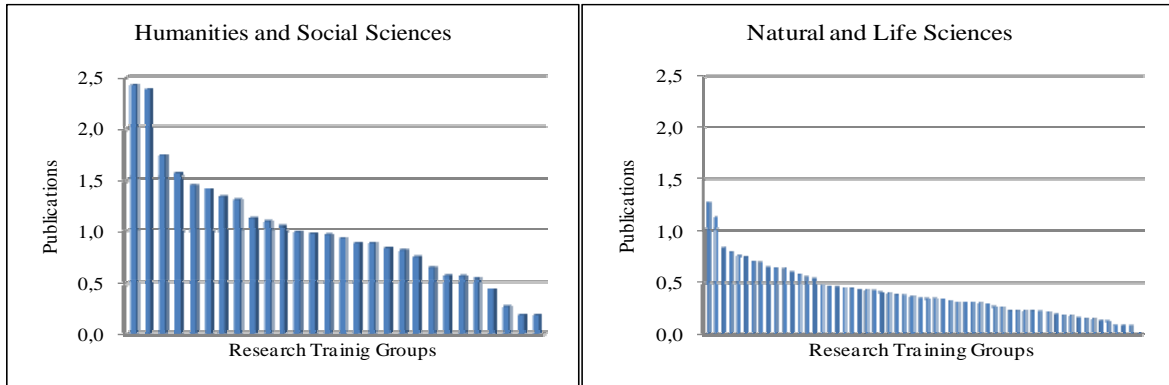
## 4 Descriptives

As the descriptive statistics reveal, performance as well as heterogeneity vary considerably between the disciplinary fields and also between individual RTGs within one disciplinary field.

### 4.1 RTG performance

*Number of publications:* Figure 1 first displays the number of publications per funding year, both for the Humanities & Social Sciences (left panel) and for the Natural & Life Sciences (right panel). As can be clearly seen, in the RTGs from the Humanities & Social Sciences the number of publications per funding year is on average considerably higher than in the RTGs from the Natural & Life Sciences. This result is mainly explained by differences in co-authorships and the 1/n-count which reduces the publication count particularly for Natural & Life Sciences with their traditionally long lists of co-authors.

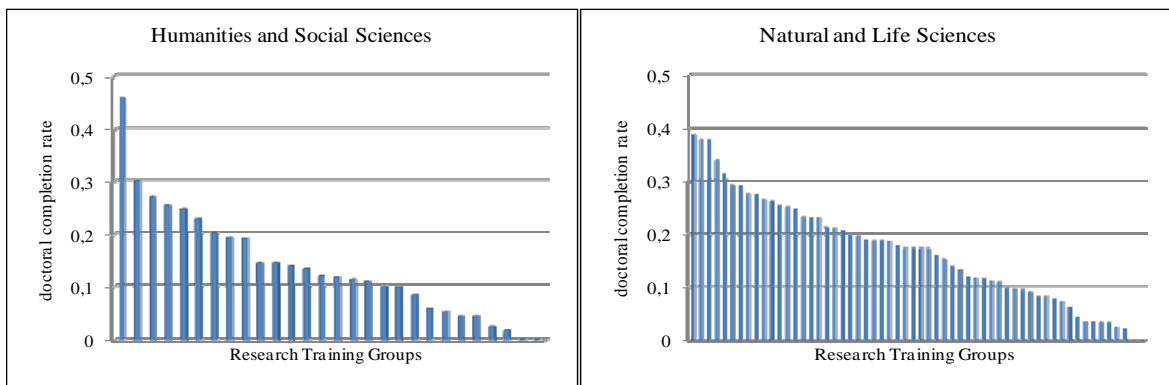
Figure 1: Number of Publications per funding year



Source: Own data.

*Doctoral completion rate:* Concerning the doctoral completion rate per funding year (Figure 2), the picture is less clear: While the RTG with the highest doctoral completion rate per funding year belongs to the Humanities & Social Sciences, the overall performance is higher in the Natural & Life Sciences (with 20 out of 58 RTGs having a doctoral completion rate per funding year of at least 20 percent) and lower in the Humanities & Social Sciences (with only seven out of 28 having a completion rate of more than 20 percent).

Figure 2: Doctoral completion rate per funding year



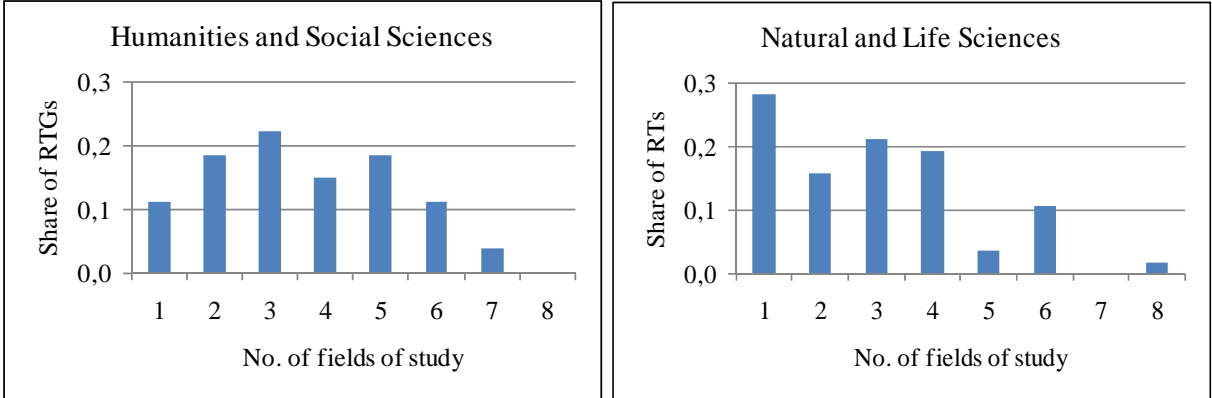
Source: Own data.

## 4.2 RTG composition

*Interdisciplinarity:* Our first dimension of heterogeneity concerns the question in how far an RTG is characterized by interdisciplinarity of its students. Figure 3a displays the shares of RTGs in the Humanities & Social Sciences (left panel) and in the Natural & Life Sciences (right panel) concerning the number of different subjects studied by their doctoral and post-doctoral members. The share of RTGs in the Humanities & Social Sciences characterized by all of its students coming from the same study field is 10 percent, while in about 28 percent of

RTGs in the Natural & Life Sciences all of its students come from the same study field. The majority of RTGs in both disciplines are comprised of students from three or more different study fields. In light of the fact that the ISCED study field classification already represents a rather aggregate classification only distinguishing 22 different fields of study, this is indeed a striking result.

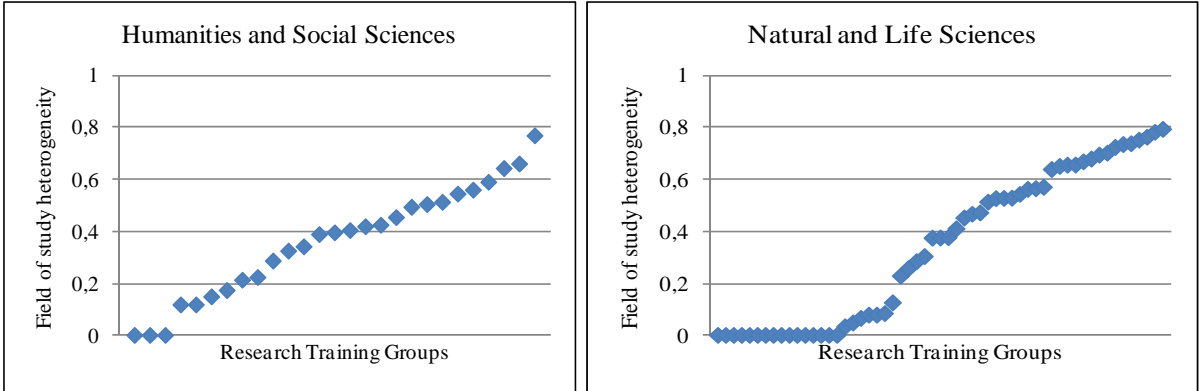
Figure 3a: Interdisciplinarity – no. of fields of study represented by the students in an RTG



Source: Own data.

Figure 3b displays the BLAU-Index of heterogeneity according to the field of study of RTG students. As can be seen, no RTG achieves a degree of heterogeneity of 1.0. In both disciplinary fields, the maximum level of heterogeneity concerning the field of study is around 0.8.

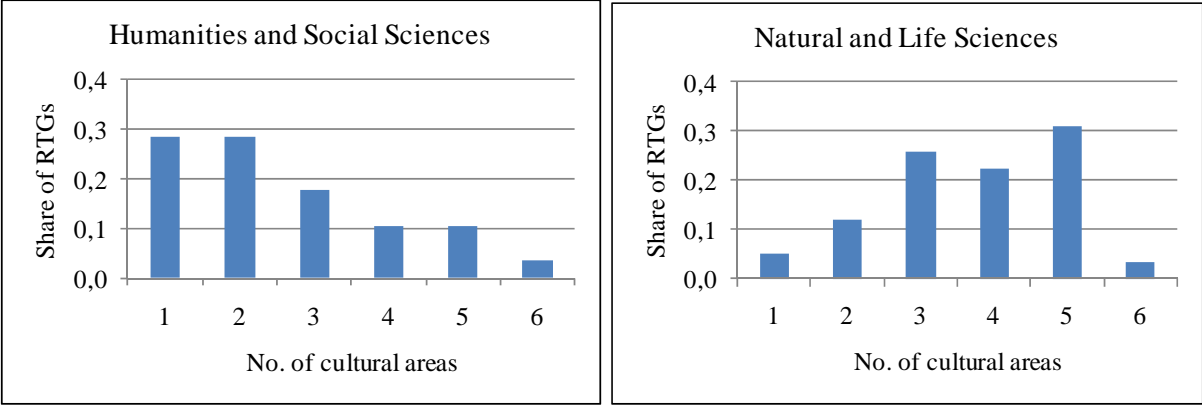
Figure 3b: Interdisciplinarity – BLAU-Index concerning field of study





post-doctoral members. As can be seen, RTGs in the Humanities & Social Sciences are on average less characterized by internationality than those from the Natural & Life Sciences: In the latter, the majority of RTGs is comprised of students from more than three different cultural areas whereas in the former, the majority of RTGs is comprised of students from at most two different cultural areas.

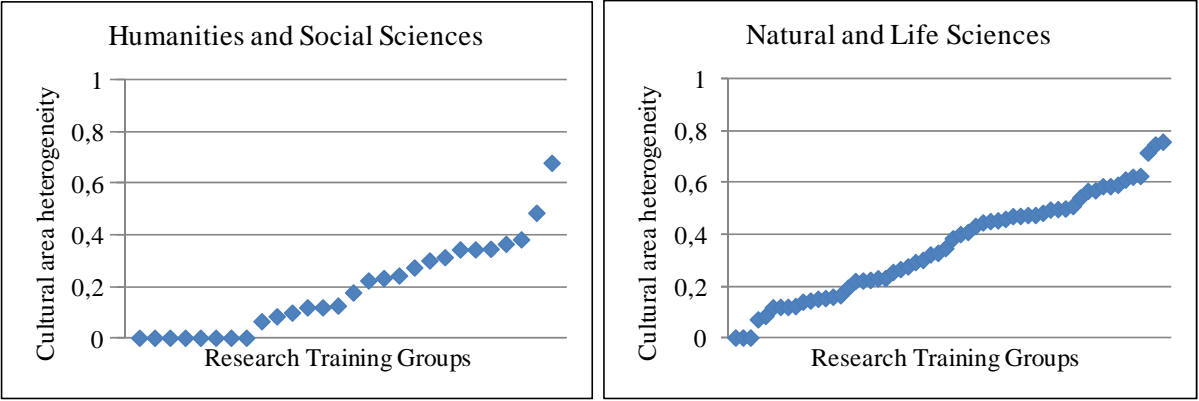
Figure 4a: Internationality – no. of cultural areas represented by students in an RTG



Source: Own data.

Figure 4b displays the BLAU-Index of heterogeneity according to the cultural area an RTG student comes from. Again, no RTG achieves a degree of heterogeneity of 1.0. In both disciplines, the maximum level of heterogeneity is below 0.8.

Figure 4b: Internationality – BLAU-Index of heterogeneity concerning cultural areas



Source: Own data.

### 5 Results

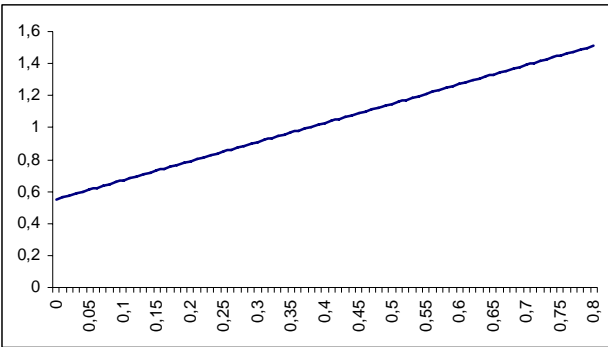
In order to analyze the effect of RTG composition on RTG performance as measured by scientific visibility and the doctoral completion rate we employed Seemingly Unrelated Regressions (SUR). Seemingly Unrelated Regressions are an extension of the linear regression

model and are used for analyzing a system of multiple regressions with correlated error terms. As our estimations for scientific visibility and the doctoral completion rate use the same data set, the errors might well be correlated across the equations rendering the use of SUR adequate. In light of our small data set we ran separate regressions to test for the potential effects of interdisciplinarity and internationality and also had to abstain from using control variables. However, we estimated two different models in each case: one testing for a linear relationship between the respective measure of heterogeneity (interdisciplinarity, internationality) and performance and one allowing for a potentially non-linear relationship between the respective measure of heterogeneity and performance by adding a quadratic term of the respective heterogeneity measure.

### 5.1 RTGs in the Humanities & Social Sciences

*Interdisciplinarity:* For the Humanities & Social Sciences, heterogeneity concerning the field of study is positively related with RTG performance as far as scientific visibility, i.e. the publication output per funding year is concerned; there is no indication of the relationship being non-linear. Figure 5 visualizes the corresponding relationship. RTG performance with respect to the doctoral completion rate remains unaffected by study field heterogeneity. In other words, the interdisciplinarity of RTG students has on average positive effects on RTG performance in the Humanities & Social Sciences.

Figure 5: BLAU-Index concerning field of study (x-axis) and no. of publications per funding year (y-axis)

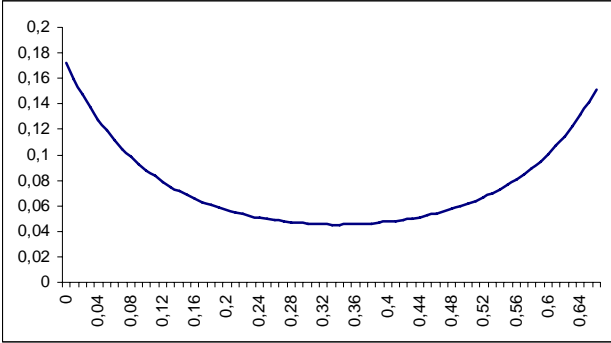


Source: Own data.

*Internationality:* Concerning cultural heterogeneity, the picture is quite different: While scientific visibility remains unaffected by student internationality, the doctoral completion rate is affected in the following way: an increasing degree of student internationality at first is associated with a lower doctoral completion rate. Once a certain level of cultural

heterogeneity is reached, a further increase in heterogeneity raises the doctoral completion rate (see figure 6). However, even at the highest level of national heterogeneity reached in the data set, the doctoral completion rate is below its value in a completely homogeneous RTG comprising only students from one cultural area. In other words, the internationality of RTG students seems to have on average negative effects on RTG performance in the Humanities & Social Sciences.

Figure 6: BLAU-Index concerning cultural area (x-axis) and doctoral completion rate (y-axis)

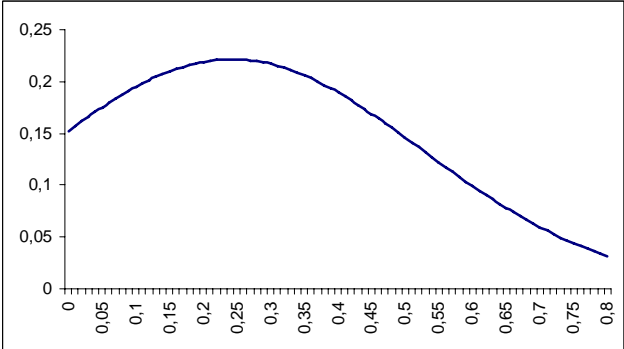


Source: Own data.

### 5.2 RTGs in the Natural & Life Sciences

*Interdisciplinarity:* Using again Seemingly Unrelated Regressions, we find for the Natural & Life Sciences that the relationship between study field heterogeneity and the doctoral completion rate is hump-shaped: The regression model including the quadratic term shows that an increase in student interdisciplinarity at very low levels first increases the doctoral completion rate, but then very soon decreases it. RTG performance with respect to *scientific visibility* seemingly remains unaffected by heterogeneity concerning the field of study.

Figure 7: BLAU-Index concerning field of study (x-axis) and doctoral completion rate (y-axis)



Source: Own data.

*Internationality*: Concerning heterogeneity with respect to student nationality, there is no indication of a linear or non-linear relationship between heterogeneity and performance.

## 6 Conclusion

In this chapter we analyze how one particular governance mechanism affects performance of research teams. The governance structure we look at is the requirement of interdisciplinarity and internationality of Research Training Groups (RTGs) uttered by the German Research Foundation. We study how the performance of RTGs is affected by the heterogeneity that is induced by an increasing number of study subjects and by an increasing number of cultural areas within a research group. From a theoretical perspective there may be two countervailing effects: according to the resource perspective, team performance should rise with increasing team heterogeneity because the team as a whole has access to a larger set of intellectual resources. However, from a socio-psychological process perspective, team performance might also be endangered by an increase in team heterogeneity because communication between team members may suffer due to different (study field and national) languages, increased conflicts and reduced group cohesion. We expect that the size of both effects depends on the type of research in an RTG and analyze how the overall effect is shaped in the Humanities & Social Sciences as compared to the Natural & Life Sciences.

Using Seemingly Unrelated Regressions, we find for the Humanities & Social Sciences that an increasing study field heterogeneity does have significant effects on research performance: it enhances scientific visibility as one research indicator and it follows an inversely hump-shaped relationship for the doctoral completion rate as another indicator for research performance. In contrast, for the Natural & Life Sciences, we only find a significant effect for the doctoral completion rate that exhibits a hump-shaped relationship with study field heterogeneity.

To summarize, we conclude that the effectiveness of a particular governance mechanism varies substantially from discipline to discipline and that governance of research therefore has to carefully take into consideration the different production functions across the different disciplinary fields. What may work well in one disciplinary field, may have just the opposite effect in the other. Increasing the degree of interdisciplinarity in the Humanities & Social Sciences positively affects research performance. At the same time, increasing the degree of interdisciplinarity in the Natural & Life Sciences positively affects research performance only up to a certain point, but not if it is driven to the extreme. Therefore, it seems reasonable to

conclude that in governing research groups, all kinds of external governance should be either precisely engineered to the disciplinary field and its specificities or a menu of options should be offered that allows research teams to choose a structure that is most effective given the specificities of its disciplinary field and the specific research requirements.

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