Soc. Geogr. Discuss., 3, 121–157, 2007
www.soc-geogr-discuss.net/3/121/2007/
© Author(s) 2007. This work is licensed
under a Creative Commons License.

Social Geography Discussions

Social Geography Discussions is the access reviewed discussion forum of *Social Geography*

International collaboration, mobility and team diversity in the life sciences: impact on research performance

F. Barjak[1] and S. Robinson[2]

[1]School of Business, University of Applied Sciences, Olten, Switzerland
[2]empirica, Gesellschaft für Kommunikations- und Technologieforschung mbH, Bonn, Germany

Received: 1 December 2006 – Accepted: 4 February 2007 – Published: 16 February 2007

Correspondence to: F. Barjak (franz.barjak@fhnw.ch)

Abstract

The combination of knowledge and skills from different backgrounds or research cultures is often considered good for science. This paper describes the extent to which academic research teams in the life sciences draw on knowledge from different research cultures and how this is related to their research performance. We distinguish between international collaboration between research teams and international mobility leading to team diversity, where scientists with a background in another country work as members of a team over time. Our results show that the most successful teams both have a moderate level of team diversity and engage in collaboration activities resulting in joint publications with scientists in other countries. These results have implications for research team management and for research policy, in particular in relation to the mobility of scientists.

1 Introduction

Research has long been at the forefront of globalization: many research problems and their solutions are of global relevance and in no way constrained within country borders, particularly in basic research. At the same time, scientific excellence is spread all over the world, and leading scientists are used to communicating with their peers however distant. Globalisation of research continues to grow in intensity: the level of international cooperation and communication has been shown to have increased significantly over the past twenty to thirty years (European Commission, 2003; Narin et al., 1991; National Science Board, 2002, 2004).

Though the practice of global research is evident, it is more difficult to pin down the impact of research globalisation. It seems reasonable to speculate that scientists draw some benefit from working and speaking with their colleagues from other countries, based perhaps on some kind of global "matching" of scientific excellence. Scientists with specific capabilities and experience not finding the ideal complementary expertise

SGD

3, 121–157, 2007

F. Barjak and S. Robinson

Copernicus

in their country may enter a division of labour with peers abroad in addressing their research problems. Moreover countries are endowed with specific natural resources from which the objects of research can be taken. When human and physical resources from several countries are combined a richer mixture of research inputs is generated. Presumably, scientific knowledge is advanced more rapidly and scientific excellence benefits from this international combination and cross-fertilization of expertise. The conviction that trans-border interaction is beneficial for research is prevalent among policy-makers. The European Commission states in its Communication on the Mobility Strategy:

"[Mobility] permits the creation and operation of multi-national teams and networks of researchers, which enhance Europe's competitiveness and prospective exploitation of results." (European Commission, 2001:4)

Indeed, increasing the mobility of researchers has become a prominent goal in European research policy (European Commission, 2000, 2001, 2005). In support of this policy, it is pointed out how geographical mobility is assumed to lead to productive combination of localised knowledge, to fertilise intellectual exchange (Jöns, 2003, 2006), to foster international research collaboration and disseminate research excellence (European Commission, 2005).

Despite the extent of policy measures to promote the mobility of researchers, few studies have investigated the impact of mobility in science on research performance and output.

This study aims to reduce this gap. International researcher mobility, with the diversity of teams by origin it causes, is addressed in the study as one of two principal modes by which pools of knowledge and scientific expertise merge across national boundaries. The second mode is international collaboration among research teams, where scientists join forces across borders in their work but remain located with their teams in different countries[1]. The study sets out to explore the effect of the diversity

[1] 1 These two modes are a useful simplification of all possible interaction types along the dimensions of duration, distance and interaction intensity (see Fiol and O'Connor, 2005).

of teams caused by the international mobility of researchers and the international collaboration between researchers on the performance of research teams in a large and growing scientific domain: the life sciences.

2 Pooling knowledge for research

2.1 Evidence of the impact of diversity of geographic origin

Empirical studies of the influence of diversity of geographical origin on research team performance are scarce but provide some support to the idea that the mobility of scientists is good for research output. An investigation into the scientific success of the Rockefeller Institute showed a positive contribution of foreign permanent staff as well as of visiting scientists (Hollingsworth and Hollingsworth, 2000). However, the authors point out that the impact found may well have been due to the greater scientific eminence of the visitors rather than their geographic origins per se. It has been shown for the USA that foreign-born and foreign-educated scientists make more exceptional contributions to scientific output than would be expected from their proportion of the scientific workforce (Stephan and Levin, 2001).

When more general findings relating to the impact of group diversity on performance are applied to the possible impact of diversity of geographic origins on research team performance, such positive conclusions are opened to question. Research on groups in various settings has shown that diversity may have negative as well as positive effects on group processes and performance (Williams and O'Reilly, 1998). Positive effects are attributed to a broader range of knowledge, skills and contacts in the group, whereas negative effects arise from reduced and less efficient communication, less cooperation and more conflict (Bunderson and Sutcliffe, 2002; Williams and O'Reilly, 1998). In the area of science, Jöns agrees that impact is ambivalent, arguing that cross-border interactions might lead to inspiration and cooperation but also irritation and confrontation, depending on the degree of heterogeneity between the parties involved (Jöns, 2003).

The introduction of the term "faultline" by Lau and Murnighan (1998) to refer to "hypothetical dividing lines that may split a group into subgroups based on one or more attributes" has generated a spate of research (e.g. Earley and Mosakowski, 2000; Li and Hambrick, 2005; Thatcher et al., 2003), driven by the plausible argument that large subgroups within a team, homogeneous on some key characteristic such as country of origin, will have the effect that individuals within the subgroup will identify with the subgroup and interact more strongly with its members than with others in the team, reducing communication and raising the potential for conflict across the subgroup boundary.

Whether positive or negative effects prevail has been related to the origin, degree and type of diversity within a group or team. In terms of degree of diversity, Williams and O'Reilly suggest that positive effects may prevail at low levels of diversity, but that at higher levels, group cohesion may reduce to an extent which negates the positive effect (Williams and O'Reilly, 1998:90). Jehn et al. found that whereas differences in knowledge have a positive impact on performance, the impact of a diversity of values is negative (Jehn et al., 1999).

2.2 Evidence of the impact of international collaboration

Internal diversity of origin is only one possible channel for a team to combine knowledge and technical skills from different national backgrounds. Another channel is the acquisition of knowledge through research collaboration. Katz and Martin (1997) conclude that the empirical evidence supports the idea of a positive relationship between collaboration and research productivity.

In principle, the benefits quoted for international research collaborations are of the same nature as those listed for collaboration in general, see e.g. the benefits listed by Georghiou (1998); but international collaboration clearly gives rise to additional costs, for instance due to the necessity of bridging linguistic and cultural differences or finding suitable contractual arrangements. However, it is clear that international collaboration must bring additional benefits which outweigh higher transaction costs; otherwise it would be hard to explain its impressive growth rate (see European Commission, 2003; Narin et al., 1991; National Science Board, 2002, 2004). Such benefits might be access to equipment, local resources, data or other objects of study, or to eminent scientists and groups (Georghiou, 1998; Thorsteinsdóttir, 2000; Wagner, 2005).

Empirical evidence of the impact of international research collaborations on research productivity is mainly positive. Several studies have confirmed this for the life sciences. A study of Spanish biomedical research showed that international collaboration increased the productivity of team leaders and the impact of the published work (Bordons et al., 1996). Italian studies found a positive effect of the number of research collaborations with foreign non-profit institutions on the productivity of molecular biology and genetics research groups (Arora et al., 1998; Cesaroni and Gambardella, 2003). According to Narin et al. (1991) their finding that biomedical papers with international co-authors have greater impact than single-author and nationally co-authored papers can be generalised to other disciplines. Other studies have shown that international collaboration generally has a more pronounced positive effect on citation impact than local or domestic collaboration (Adams et al., 2005; Persson et al., 2004).

The conclusion which might be drawn, that positive impacts are due to a positive effect of flows of knowledge between peers of different intellectual backgrounds, has been questioned. From a methodological point of view, the same effects may be the result of self selection – only the best scientists collaborate at international level (Bordons and Gomez, 2000) – or of increased self-citation (Herbertz, 1995). Also, the positive pattern is not universal across countries and disciplines. Though generally confirming the findings of Narin et al. (1991), Glänzel (2001) discovered a number of "cool links" - country pairs for which co-authored papers attract fewer citations than expected on the basis of the corresponding domestic reference standards (Glänzel and Schubert, 2001). Though in biomedical research the citation impact of co-authored papers is generally found to be higher than the domestic impact of at least one of the involved authors, the impact of joint papers in chemistry and mathematics in some pairs of countries was found to be consistently lower than domestic impact.

To add to the mixed picture, Adams et al. (2005) report a trade-off between quantity

SGD
3, 121–157, 2007

Title Page
Abstract | Introduction
Conclusions | References
Tables | Figures
◀◀ | ▶▶
◀ | ▶
Back | Close
Full Screen / Esc
Printer-friendly Version
Interactive Discussion

Copernicus

and quality such that international collaboration has a negative effect on the number of publications but a positive effect on citations. Contrary to their own expectations, Carayol and Matt (Carayol and Matt, 2004) found that the proportion of internationally co-authored publications and research productivity are not correlated.

From previous work, the impact of international mobility and the consequential diversity of geographic origin on science performance is unclear in direction and strength. The empirical evidence to date on international research collaboration, the other mode by which knowledge pools merge, also shows a mixture of positive and negative impacts. It seems that international research collaboration leading to co-authorship is not automatically beneficial for all concerned, and that apparent positive impacts may be due to mechanisms other than an improved international flow of scientific ideas or weakened by the costs of collaboration (see Katz and Martin, 1997).

3 Concepts and methods

3.1 The research team as the unit of analysis

The main unit of analysis in this study is the research team or group recognisable from outside the university as a distinct entity and understood as a group of people, scientists and non-scientists, some or all of whom are employed by a university, who work at the same location for a significant period of time to produce new scientific knowledge. Our definition is a blend of an institutional approach, which relies on organisational affiliation (Cohen, 1981; Hagstrom, 1965) and a functional approach, based on the specification of joint research activities (Andrews, 1979).

Limiting team membership to those who work at the same location allows us to address the impact on research performance of collaborative work spanning multiple locations. “Virtual teams”, whose emergence is facilitated by the internet and other networks, are thus analysed not as a type of team but as collaborative activity between teams. For similar reasons, visiting scientists and research workers are not regarded as members of a team unless they stay collocated longer than a minimum period of six months.

Our definition sets few limits on employment patterns or role in the team, allowing us to include Europe's diverse research structures in the analysis. In France, for instance, scientists with different organisational affiliations, usually universities and non-university research organisations, join forces in "mixed" research teams.

As we were able to elicit information directly from teams, it was not necessary to find definitions of team boundaries based on co-authorship (e.g. Adams et al., 2005; Bordons and Zulueta, 1997; Seglen and Aksnes, 2000). This allows us to address adequately the relationship between group size and research productivity without missing the impact of young researchers - many with no publications to their name (Stankiewicz, 1979).

3.2 Survey sampling and response

Webometric techniques were used to build a representative sample of 1773 university-affiliated research teams in the life sciences across 10 European countries: Through internet research a population of 7732 teams was identified (see Table 1) working in the life sciences, defined as ISCED 1997 category 42, and teams were drawn from this population by stratified random sampling. The stratification variable was the number of hyperlinks pointing to the team's internet homepage (inlinks), which is a readily available proxy for the research performance of the team. Previous research has shown that for academic organisations, the number of hyperlinks is related to research performance (see Thelwall, 2003). For the sample teams we identified the names and email addresses of the team leaders via the internet; for the majority of the teams we were also able to obtain some staff information about the total scientific and non-scientific staff (77.5% of the teams), the PhD students (53.8%) and the post-docs (39.3%).

Questionnaires were provided to team leaders electronically - online and via email. The questionnaire was opened by 811 respondents leading to 468 usable questionnaires (26.4% of the sample, see Table 1). A comparison of number of inlinks, team size and gender of the team leader between responding and non-responding teams revealed little bias in response. The Italian teams that responded tended to have somewhat fewer hyperlinks than those which did not respond. Teams with female team leaders were slightly overrepresented in Germany and underrepresented in Spain.

Using the information obtained from the internet and the survey it was possible to retrieve bibliographic data for the responding teams from the Thomson ISI Web of Science. Publication data was collected for the year 2001 and citation data for the years 2001–2003.

3.3 Metrics for key variables

3.3.1 Research performance

Team research performance was operationalised in three variables built from bibliographic data extracted from the Science Citation Index Expanded (SCIE) provided by Thomson ISI:

- TOTPAP (output volume): TOTPAP is the total number of papers recorded in the 2001 SCIE volume as article, letter, note, or review authored or co-authored by a member of the team;
- ZTOTPAP (team productivity): This variable is TOTPAP divided by team size;
- TOTMOCR (output quality): The number of citations received up to 2003 for a team's 2001 papers is divided by TOTPAP to obtain the Mean Observed Citation Rate per publication for that team.

These indicators and the SCIE database itself have several well documented weaknesses, for instance, not all co-authors of publications really contribute intellectually, the bias towards English language publications might inflate values for native speakers of that language, self-citation inflates citation scores, citations are sometimes created for other reasons than the quality of a paper, etc. (Borgman and Furner, 2002; Cronin, 1984; Herbertz, 1995; Leeuwen et al., 2001; Raan, 2003). Notwithstanding these weaknesses, publications and citations are viewed as good measures for comparing and analysing research performance.

3.3.2 Origin diversity

In previous work we had not examined team diversity as such. The mix of origins in teams was seen as the result of decisions by research managers whether or not to recruit more young researchers and whether to increase or decrease the quota of researchers from abroad. Correspondingly, the variables used in modelling were the proportions of PhD students and post docs from domestic, other EU or more distant origins.

Here, using an approach similar to Carayol and Nguyen Thi (2004) a Shannon Diversity Index of country of origin was calculated for each group of young researchers in a team with the formula below. Two indices were calculated per team: one for PhD students (ODIVPHD) and one for post-docs (ODIVPDOC). Country of origin was the country in which they obtained their most recent degrees. These indices represent in one value the degree to which different national pools of knowledge are present in the team. The larger the index, the larger the variety of countries in which the PhD students (post-docs) obtained their last degree.

$$\text{ODIVPHD} = -\sum_{i=1}^{C} (p_i * \ln p_i)$$

with

ODIVPHD	Origin diversity index of PhD students
C	Total number of different countries i where the PhD students of a team obtained their last degrees
p_i	Proportion of C made up of the ith country

SGD
3, 121–157, 2007

Copernicus

3.3.3 Collaboration

International collaboration was measured in this analysis by using data retrieved from the Thomson ISI database. Three binary indicators were built on co-author fields:

- ICPAP01 takes the value of one if the team has published one or more papers with co-authors from any foreign country, otherwise it is zero.
- EUCPAP01 takes the value of one if the team has published one or more papers with co-authors from another EU member state, otherwise it is zero.
- USCPAP01 takes the value of one if the team has published one or more papers with co-authors affiliated to organisations in the USA, otherwise it is zero.

A word of caution is necessary regarding the last two publication-based indicators. It is known that co-authorship often reflects an intense research interaction between the authors (Harsanyi, 1993; Laudel, 2001), and this is appropriate in indicators which are to represent the degree to which a team accesses pools of knowledge outside its country of location: However, there is at least anecdotal evidence that co-authors might be included in a publication for other reasons, e.g. because they secured the resources for a project. Nevertheless, it is difficult to conceive of a reason for co-authorship which does not indicate some degree of collaboration, so that we do not expect other reasons to introduce significant bias.

3.4 Modelling approach

The analytical approach is a combination of bivariate analysis – the "initial view" reported below – and multivariate modelling using linear regression techniques[2]. In the latter we provide first a baseline model. This incorporates factors apart from

[2]The work reported here extends linear modelling of the impact of team structure on research performance (Robinson, S., Mentrup, A., Barjak, F., Thelwall, M., Li, X., and Glänzel, W.: The Role of Networking in Research Activities. NetReAct D4.1 – final. Report to the

knowledge-pooling mechanisms which impact on research productivity such as country of location or simply team size. The impact on research productivity of international collaboration and origin diversity is then examined in an extension of the baseline model.

Independent variables of theoretical relevance and expected to improve the explanatory power of the model were included in baseline models. One set consist of team characteristics found to be influential in previous work such as country of team location, principal research discipline, age (time since foundation, also interpreted as team "maturity") and team size. Characteristics of team leaders which might affect research performance were also included, in particular the experience (number of years leading a research team) and recognition (specific acts of professional recognition received since 2000)[3].

The properties of the dependent variables for team productivity (ZTOTPAP) and output quality (TOTMORC) – non-negative metrics – allow use of ordinary least squares (OLS) estimation. Residuals were tested for heteroscedasticity on team size using the Goldfeld-Quandt test and adjusted using the White estimator or by including team size as weighting variable (Greene, 2000).

TOTPAP, the number of papers listed in the SCIE database in 2001, is a non-negative integer, for which a Poisson distribution is a better approximation than the Gaussian. Count data models are known to deal efficiently with such variables. If the dependent variable is subject to overdispersion – the variance exceeds the mean – the negative

Institute for Prospective Technological Studies, Commission of the European Communities, April 2006, http://www.netreact-eu.org/documents/NetReAct_D41.pdf, 2006.) by including additional co-determinants of research performance, using regression models appropriate to the statistical properties of discrete integer dependent variables and including explicit modelling of non-linear relationships.

[3]This was assessed through five related questions: "Since 2000, has your work been recognised in any of the following ways? Have you (a) won a scientific award, (b) been invited to serve on a major professional committee, (c) been invited to serve on the editorial board of a scientific journal, (d) organised an international conference, (e) been invited to serve on a national or international advisory committee."

binomial regression model (NEGBIN) is preferable to the Poisson model (Cameron and Trivedi, 1998). We tested for overdispersion as described in Cameron and Trivedi and include the alpha values from the NEGBIN estimation in the results tables – significant alphas indicate overdispersion. The difference between the Log-L and restricted Log-L (NEGBIN versus Poisson) was used as indicator of goodness of fit – as a substitute for the role of R^2 in OLS. Also, the Vuong statistic was used to test for "zero inflation" (Greene, 2000). The result was negative, indicating no need to use corrective techniques such as Zero Inflated models or Hurdle models.

4 An initial view

4.1 International origin diversity

Table 2 shows the country of last degree for doctoral students and post-docs broken down by country group. Last degrees are the master's degree or equivalent for PhD students and the PhD for post-docs. As we would expect, post-docs are more internationally mobile than PhD students. Whereas 80% of the students write their PhD in the country in which they graduated, only 60% of the post-docs continue to work in the country in which they obtained their PhD. The target of mobility is mainly Europe rather than countries outside Europe for both PhD students and post-docs.

Table 3 shows Shannon's Diversity Index for country of last degree of PhD students and post-docs in life sciences teams. Across all countries we obtain origin diversity indexes of 0.41 for PhD students and 0.38 for post-docs. Broken down by country, we see that in 7 out of 10 countries origin diversities for PhD students and for post-docs are more or less in line. Universities in the United Kingdom (UK) and Sweden (SE) have the most international research teams, in Spain (ES) and France (FR) diversity is close to the average, and in Czech Republic (CZ), Hungary (HU) and Italy (IT) the teams have only few PhD students and post-docs from other countries. German teams (DE) have a large diversity of PhD students but only average diversity of post-docs. Portuguese

SGD
3, 121–157, 2007
Int. collaboration, mobility and team diversity
F. Barjak and S. Robinson

Copernicus

teams (PT) are below the average diversity when it comes to PhD students and at the average for post-docs, for Norwegian teams it is the other way around.

We conclude that the differences between countries in regard to origin diversity are notable and that they depend to some extent on the staff group that is considered.

When we relate origin diversity of PhD students and post-docs to research performance, a complex pattern emerges. In the case of team productivity, the link between origin diversity and performance is similar for PhD students and post-docs; in both cases, teams with low diversity have the highest productivity (see Figs. 1 and 2).

For research quality, measured as the success of publications in attracting citations, results differ between PhD students and post-docs (see Fig. 3 and Fig. 4). Teams whose PhD students have a level of origin diversity close to average produce publications that are more often cited than those from teams with lower or higher levels of diversity. In the case of post-docs, the opposite is the case; teams with high or low origin diversity of post-docs attract more citations per publication than teams with average origin diversity of post-docs.

4.2 International collaboration

International collaboration is one of the two modes studied here for achieving international knowledge flows. Using the number of journal articles published jointly with scientists from other countries as an indicator of the degree of international collaboration, we obtain the breakdown by country shown in Table 4. The highest rates of international collaboration as a proportion of total collaboration are found in Norway, Portugal and Sweden, rates in Spain, France and the UK are below average – under 35% of total collaboration.

The pattern of collaboration within and with the EU is striking. The three countries that were not members of the EU in 2001, namely Norway, Czech Republic and Hungary, show some of the highest rates of joint publication with scientists from EU countries. With some exceptions, the rate of joint EU-publication of teams in EU member states is lower, particularly in the case of Germany and the UK. Collaboration with scientists from the United States, one of the leading countries for research in the life sciences, was found to be rather low. The maximum was found in Portugal, where nearly 15% of papers published by life sciences research teams are published jointly with scientists from the USA. In many countries such as France, the Czech Republic, Spain and Norway the rate of joint publication with the USA is well below 10%.

In Fig. 5 we contrast the performance – team productivity and output quality – of teams that had engaged in any collaboration, i.e. those which had published at least one research article jointly with a scientist from any other country, with the performance of teams not having exhibited any collaboration of this kind. Figure 6 presents the same contrast between collaborating and non-collaborating teams, but limiting collaboration to cases of collaboration with the USA.

We see in both cases that team productivity is higher for teams with collaboration compared to teams without. It also appears that teams collaborating internationally achieve a higher quality of publications, measured by MOCR, than teams with no international collaboration. However, only in the specific case of collaboration with the USA is the difference in research output quality statistically significant.

5 Modelling the performance of research teams

Tables 5 and 6 show some of the regression models we examined[4]. The first pair in Table 5 (Models 1 and 2) model factors affecting research output volume (TOTPAP - total number of publications in 2001) and the other models 3–6 productivity (ZTOTPAP - output volume per team member). The models in Table 6 show the results for output quality (using the MOCR indicator). Models 1, 3, 4 and 7–9 are baseline models to

[4]In addition to the variables shown the estimations included dummy variables for country, life sciences discipline and – only the full models – further variables on the team composition and collaboration activities by research field and by sector (industry collaboration). The results for these variables are not shown, but can be obtained from the authors upon request (see also Barjak, 2006).

SGD

3, 121–157, 2007

Copernicus

examine influences on team performance other than knowledge pooling such as team size or characteristics of the team leader. Models 2, 5, 6 and 10–12 are extended or full models including, where possible, variables for both modes of knowledge pooling – origin diversity (mobility) and international collaboration.

Model 1 in Table 5 (a negative binomial model for count data) shows the results of the baseline estimation for research output. Significant positive relationships can be confirmed between output and the size of the research team (TEAMSIZE) and the recognition of the team leader (RECOG). As with team size, the experience of the team leaders – measured as the number of years since attaining leadership of a team for the first time – has a non-linear but positive effect on the team's publication output: the more experienced the team leader, the higher the output. Only for higher values of experience – team leaders with many years of leadership and probably close to the end of their careers, expressed in the squared experience variable (EXPRNCE2) – does the curve slope downward again, i.e. the publication output is smaller. In the first estimations we also included a control variable for the gender of the team leader that was generally not significant, neither for TOTPAP nor the other dependent variables. Moreover, all models included controls for countries and life sciences sub-disciplines (also not shown).

In model 2 we added to the baseline model a set of variables reflecting the different dimensions of internal structures at international level. The variables for research collaborations with foreign partners – at global level, from the EU or from the US – had to be excluded due to estimation problems. We obtain a curvilinear relationship for the origin diversity of the PhD students in the teams (ODIVPHD). The magnitude of the coefficients for the upward and downward slopes (squared variable ODIVPHD2) is similar. Hence, we can conclude that the optimum level of origin diversity for maximised output is rather low.

Models 3–6 used a different dependent variable, namely the number of papers published in 2001 and listed in the Thomson ISI database divided by the number of staff in the team (ZTOTPAP). The normalised publication output is a continuous variable and we therefore changed the estimation method to OLS regressions. The results consequently differ somewhat to those using models 1 and 2. Still, model 3 – without the variables on team diversity and collaboration – is similar to model 1 when it comes to the direction of the relationship (the signs of the coefficients) except for the two team size variables. Their effect is exactly the opposite of that found with models 1 and 2: the larger the team, the smaller the number of published articles per team member. The squared variable (TEAMSIZE2) points to a curvilinear effect. Goldfeld-Quandt and Breusch-Pagan Tests point to heteroscedasticity of the residuals caused by the TEAMSIZE variable. Therefore we also estimated a weighted model. In this model 4 the coefficients for the recognition and experience variables are not significant.

If we add the variables on international orientation and further control variables, the quality of the model improves considerably: the adjusted R-squared increases to 0.35 (unweighted model 5) and 0.36 (weighted model 6). We also see that the effect of collaboration with scientists from both other EU countries (EUCPAP01) and the US (USCPAP01) is positive and highly significant (Models 5 and 6). As for the non-normalised total number of papers, the relationship between normalised output and the origin diversity of PhD students is curvilinear with a low level optimum (ODIVPHD and ODIVPHD2 are of similar magnitude). This indicates that low origin diversity of PhD students is conducive to research output.

The models shown in Table 6 use the Mean Observed Citation Rate MOCR as the explained variable. The MOCR can be considered as an indicator of the quality of publications. Again the tests point to heteroscedasticity of the residuals and we show the results of weighted estimations (Models 8, 9, 11, 12) in addition to the standard OLS models. The estimation with the restricted variable set (Models 7–9) show a negative effect of the team size; in this case it is linear, as the comparison between models 7/8 and 9 reveals. Papers of large teams are less often cited than papers of smaller teams. A slight positive effect of the team leader's experience can also be shown, but only if the squared variable that intends to measure non-linear effects is excluded (Model 9). In the full models (Models 10–12), we obtain positive coefficients for the variables assessing international collaborations (EUCPAP01 and USCPAP01). The results for the diversity indexes are not consistent in the models of Table 6.

The estimated models provide a variety of results which corroborate some of the previous findings in the bivariate analyses and specify others:

- We find that only the origin diversity of PhD students exhibits a quantifiable relationship to the number of publications. The relationship is curvilinear as already shown in Fig. 1: with other factors kept constant, the publication output is highest for teams with moderate PhD student origin diversity and lower for teams with high, low or zero diversity.

- As with previous studies (Arora et al., 1998; Bordons et al., 1996; Cesaroni and Gambardella, 2003), we find a positive relationship between international collaborations and research productivity. We also confirmed other work in regard to the positive effect of international collaborations on the impact of research papers (Adams et al., 2005; Glänzel, 2001; Narin et al., 1991; Persson et al., 2004).

A further remark on team size is appropriate: this was included as a control variable and has been discussed controversially in previous research (see the reviews in (Bonaccorsi and Daraio, 2005; von Tunzelmann et al., 2003). We found an inverse relationship between size and performance and an optimum team size of only a few team members (the maximum average publication per capita is reached for teams with 7 members). This contradicts the expectation voiced by Bonaccorsi and Daraio (2005) that increasing returns of size might apply at the team level, as they themselves could not find them at the level of institutes.

6 Summary and conclusions

We have provided evidence of a positive relationship between international collaboration and research productivity and in this way confirm previous studies (Arora et al.,

SGD
3, 121–157, 2007

F. Barjak and
S. Robinson

Copernicus

1998; Bordons, et al., 1996; Cesaroni and Gambardella, 2003). We have also confirmed the positive effect of international collaboration on the citation impact of research papers (Adams et al., 2005; Glänzel, 2001; Narin et al., 1991; Persson et al., 2004). Our results are in line with findings from group diversity research such that maximising diversity does not necessarily maximise performance; we have shown that in today's science settings the best mix and structure are not extremes.

Those life sciences teams appear to be most successful which have a strong domestic base but collaborate actively enough outside the country to ensure a moderate amount of external involvement in the team. Extreme management or policy strategies which result in teams which are all domestic or mostly from non-domestic origins are clearly at a disadvantage compared to those leading to an appropriate mix. Non-zero but small proportions of students from domestic origins, from the EU and from further abroad are linked to the highest rates of publication.

The message to research managers and team leaders is that team composition matters, and that it is indeed beneficial to integrate researchers from another country. A well-balanced team is characterised by some heterogeneity, but this should not be excessive. Diversity provides a team with different skills, experience and cognitive frameworks which is believed to underlie the enhanced productivity we have found. At the same time diversity gives rise to additional costs, as people from different cultural backgrounds may speak different languages, attach different significance to concepts and research questions, and have been taught different norms for research procedures etc., placing burdens on communication and consensus formation.

Our results suggest that finding the right mix in recruiting researchers from at home and abroad might raise research output and productivity of many research teams. Picking the right mix is made more complex if, as seems likely, the best composition for research output volume and productivity differs from the best for research output quality.

Negative impacts are visible today in the performance of over-diverse teams, but these effects might be counteracted by improvements in research management. The integration of scientists from abroad could be improved, e.g. by reinforcing mentoring schemes and allocating specific responsibility for integration of new team members.

A message to research policy-makers is that further increases in the mobility of scientists between countries are not necessarily beneficial to research performance, unless flanked by other measures. The requirement to improve integration is already well recognised, for instance, the EC Mobility Strategy specifies as an objective "to encourage host organisations to take more responsibility for their foreign staff and visiting researchers." (European Commission, 2001:11). However, if appropriate improvements in diversity accommodation cannot be made, it seems that financial support to mobility of scientists should be limited to a certain proportion per team of guest scientists, PhD students or post-docs, or otherwise spread as widely as possible over recipient teams.

Some words of caution are appropriate here in respect of specific recommendations. Our analysis uses publications and citations as metrics for the performance of research teams. However, scientific work has a number of other valuable outputs, such as new methods and tools, well-trained graduates, and knowledge or other products of use to private enterprise, the public sector and the general public (Larédo and Mustar, 2000). There may well be a trade-off between optimising levels of publication-based research output and achieving other valuable results. Clearly, our analysis of the link between diversity in a research team and publication-based research output is only valid for the output we have chosen to study.

Our recommendations also assume that some mechanism of pooling knowledge and expertise across countries underlies the relationship found here between the presence of researchers of different geographical origin in a research team and research output. However, what these underlying mechanisms are is not yet entirely clear. Education systems in different countries may give rise to ideas and perceptions, behaviours and practices etc. which are complementary in some general way. In addition, the fact that research programmes tend to be relatively homogeneous within countries may mean that mixing research staff exposed to different programmes might be a route to improving research productivity. Methods learned elsewhere for other problems may be found to be useful in the research task at hand.

SGD
3, 121–157, 2007

Copernicus

Pooling knowledge is not the only imaginable link between team diversity and performance. Diversity may instead improve job satisfaction and promote stability in team composition (Williams and O'Reilly, 1998). It is also possible that mechanisms work in the reverse direction, for instance, high research productivity and visible success might well attract researchers from other countries into a team. Though these alternative hypotheses are plausible, it is difficult to imagine that they are responsible for the magnitude of the effects found.

The possible underlying mechanisms for the impact of knowledge-pooling appear plausible and we therefore believe we have provided substantial evidence of the impact of pooling knowledge internationally on research performance. However, until the underlying mechanisms are better understood, there remains some uncertainty attached to specific recommendations to research and policy decision-makers on the optimal levels of team origin diversity and international collaboration they should strive for.

Acknowledgements. This paper builds on data gathered and analytical approaches developed in the "Study on the role of networking in research activities" (NetReAct) for the Institute for Prospective Technological Studies of the European Commission under contract 22540-2004-12 F1ED SEV DE. W. Glänzel, X. Li, M. Thelwall, A. Mentrup and G. Wiegand are thanked for their contributions to NetReAct, without which this work would not have been possible.

References

Adams, J. D., Black, G. C., Clemmons, J. R., and Stephan, E.: Scientific teams and institutional collaborations: evidence from U.S. universities, 1981–1999, Research Policy, 34, 3, 259–285, 2005.

Andrews, F. M. (Ed.): Scientific productivity, the effectiveness of research groups in six countries, Cambridge University Press, Cambridge, 1979.

Arora, A., David, A., and Gambardella, A.: Reputation and competence in publicly funded science: estimating the effects on research group productivity, Annales d'Economie et de Statistique, 49/50, 163–198, 1998.

Barjak, F.: Team diversity and research collaboration in life sciences teams: does a combination of research cultures pay off? University of Applied Sciences Northwestern Switzerland, Olten, 2006.
Bonaccorsi, A. and Daraio, C.: Exploring size and agglomeration effects on public research productivity, Scientometrics, 63, 1, 87–120, 2005.
Bordons, M. and Gomez, I.: Collaboration networks in science, in: The web of knowledge: a Festschrift in honor of Eugene Garfield, edited by: Cronin, B. and Atkins, H. B., Information Today, Inc., Medford, NJ, USA, pp. 197–213, 2000.
Bordons, M., Gomez, I., Fernandez, M., Zulueta, M. A., and Mendez, A.: Local, domestic and international scientific collaboration in biomedical research, Scientometrics, 37, 2, 279–295, 1996.
Bordons, M. and Zulueta, M. A.: Comparison of research team activity in two biomedical fields, Scientometrics, 40, 3, 423–436, 1997.
Borgman, C. and Furner, J.: Scholarly communication and bibliometrics, Annual Review of Information Science and Technology, 36, 3–72, 2002.
Bunderson, J. S., and Sutcliffe, K. M.: Comparing alternative conceptualizations of functional diversity in management teams: Process and performance effects, Academy of Management Journal, 45, 5, 875–893, 2002.
Cameron, A. C. and Trivedi: K.: Regression analysis of count data, Cambridge University Press, Cambridge, 1998.
Carayol, N. and Matt, M.: Does research organization influence academic production? Laboratory level evidence from a large European university, Research Policy, 33, 8, 1081–1102, 2004.
Carayol, N. and Nguyen Thi, T. U.: Why do Academic Scientists Engage in Interdisciplinary Research?, http://cournot2.u-strasbg.fr/users/beta/publications/2004/2004-17.pdf (download 07-06-2005), 2004.
Cesaroni, F. and Gambardella, A.: Research productivity and the allocation of resources in publicly funded research programmes, in: Science and innovation rethinking the rationales for funding and governance, edited by: Geuna, A., Salter, A., and Steinmueller, W. E., Edward Elgar, Cheltenham, UK and Northampton, MA, USA, pp. 202–232, 2003.
Cohen, J. E.: Publication rate as a function of laboratory size in 3 biomedical-research institutions, Scientometrics, 3, 6, 467–487, 1981.
Cronin, B.: The citation process. The role and significance of citations in scientific communica-

tion, Taylor Graham, London, 1984.
Earley, C. and Mosakowski, E.: Creating hybrid team cultures: An empirical test of transnational team functioning, Academy of Management Journal, 43, 1, 26–49, 2000.
European Commission: Towards a European research area. COM(2000) 6, http://europa.eu/eur-lex/en/com/cnc/2000/com2000_0006en01.pdf (download 30-11-2006), 2000.
European Commission: A mobility strategy for the European Research Area. COM(2001) 331 final, http://ec.europa.eu/eracareers/docs/Com_2001_331_en.pdf (download 30-11-2006), 2001.
European Commission: Third European Report on Science and Technology Indicators 2003 – Towards a knowledge-based economy, European Commission, Brussels, 2003.
European Commission: Commission Recommendation of 11 March 2005 on the European Charter for Researchers and on a Code of Conduct for the Recruitment of Researchers, http://ec.europa.eu/eracareers/pdf/am509774CEE_EN_E4.pdf (download 25-03-2006), 2005.
Fiol, C. M. and O'Connor, E. J.: Identification in Face-to-Face, Hybrid, and Pure Virtual Teams: Untangling the Contradictions, Organization Science, 16, 1, 19–32, 2005.
Georghiou, L.: Global cooperation in research, Research Policy, 27, 6, 611–626, 1998.
Glänzel, W.: National Characteristics in International Scientific Co-authorship Relations, Scientometrics, 51, 1, 69–115, 2001.
Glänzel, W. and Schubert, A.: Double Effort = Double Impact? A Critical View at International Co-authorship in Chemistry, Scientometrics, 50, 2, 199–214, 2001.
Greene, W. H.: Econometric Analysis, Prentice Hall, Upper Saddle River, NJ, [1993]2000.
Hagstrom, W.: The scientific community, Basic books, New York, 1965.
Harsanyi, M. A.: Multiple authors, multiple problems – bibliometrics and the study of scholarly collaboration: a literature review, Library and Information Science Research, 15, 325–354, 1993.
Herbertz, H.: Does it pay to collaborate? A bibliometric case study in molecular biology, Scientometrics, 33, 1, 117–122, 1995.
Hollingsworth, J. R. and Hollingsworth, E.: Major Discoveries and Biomedical Research Organizations: Perspectives on Interdisciplinarity, Nurturing Leadership, and Integrated Structure and Cultures, http://www.umu.se/inforsk/universitetsligan/hollingsworth.html (08-03-2005), 2000.
Jehn, K. A., Northcraft, G. B., and Neale, M. A.: Why differences make a difference: A field study of diversity, conflict, and performance in workgroups, Administrative Science Quarterly,

44, 4, 741–763, 1999.
Jöns, H.: Grenzüberschreitende Mobilität und Kooperation in den Wissenschaften: Deutschlandaufenthalte US-amerikanischer Humboldt-Forschungspreisträger aus einer erweiterten Akteursnetzwerkperspektive, Department of Geography, Heidelberg, 2003.
Jöns, H.: Internationale Mobilität von Wissen und Wissensproduzenten, in: GrenzWerte. Tagungsbericht und wissenschaftliche Abhandlungen. 55. Deutscher Geographentag Trier 2005, edited by: Kulke, E., Monheim, H. and Wittmann, P., DGFG, Berlin, Leipzig, Trier, pp. 151–160, 2006.
Katz, J. S. and Martin, B. R.: What is research collaboration?, Research Policy, 26, 1, 1–18, 1997.
Larédo, P. and Mustar, P.: Laboratory Activity Profiles: An Exploratory Approach, Scientometrics, 47, 3, 515–539, 2000.
Lau, D. C. and Murnighan, J. K.: Demographic diversity and faultlines: The compositional dynamics of organizational groups, Academy of Management Review, 23, 2, 325–340, 1998.
Laudel, G.: Collaboration, creativity and rewards: why and how scientists collaborate, International Journal of Technology Management, 22, 7/8, 762–781, 2001.
Li, J. and Hambrick, D.: Factional groups: A new vantage on demographic faultlines, conflict, and disintegration in work teams, Academy of Management Journal, 48, 794–813, 2005.
Leeuwen, T. N. v., Moed, H. F., Tijssen, R. J. W., Visser, M. S., and Raan, A. F. J. v.: Language biases in the coverage of the Science Citation Index and its consequences for international comparisons of national research performance, Scientometrics, 51, 1, 335–346, 2001.
Narin, F., Stevens, K., and Whitlow, E. S.: Scientific collaboration in Europe and the citation of multinationally authored papers, Scientometrics, 21, 313–323, 1991.
National Science Board: Science and Engineering Indicators 2002, National Science Foundation, Arlington, VA, 2002.
National Science Board: Science and Engineering Indicators 2004, National Science Foundation, Arlington, VA, 2004.
Persson, O., Glänzel, W., and Dannell, R.: A relational charting approach to the world of basic research in twelve science fields at the end of the second millennium, Scientometrics, 55, 3, 335–348, 2004.
Raan, A. v.: The use of bibliometric analysis in research performance assessment and monitoring of interdisciplinary scientific developments, Technikfolgenabschätzung – Theorie und Praxis, 12, 1, 20–29, 2003.

Seglen: O. and Aksnes, D. W.: Scientific Productivity and Group Size: A Bibliometric Analysis of Norwegian Microbiological Research, Scientometrics, 49, 1, 125–143, 2000.
Stankiewicz, R.: The size and age of Swedish academic research groups and their scientific performance, in: Scientific productivity: the effectiveness of research groups in six countries, edited by: Andrews, F. M., Cambridge University Press and UNESCO, Cambridge and Paris, pp. 191–222, 1979.
Stephan: E. and Levin, S. G.: Exceptional contributions to US science by the foreign-born and foreign-educated, Population Research and Policy Review, 20, 1, 59–79, 2001.
Thatcher, S. M. B., Jehn, K. A., and Zanutto, E.: Cracks in diversity research: The effects of diversity faultlines on conflict and performance, Group Decision and Negotiation, 12, 3, 217–241, 2003.
Thelwall, M.: Web use and peer interconnectivity metrics for academic web sites, Journal of Information Science, 29, 1, 1–10, 2003.
Thorsteinsdóttir, O. H.: External Research Collaboration in Two Small Science Systems, Scientometrics, 49, 1, 145–160, 2000.
von Tunzelmann, N., Ranga, M., Martin, B., and Geuna, A.: The Effects of Size on Research Performance: A SPRU Review, SPRU, Brighton, 2003.
Wagner, C. S.: Six case studies of international collaboration in science, Scientometrics, 62, 1, 3–26, 2005.
Williams, K. Y. and O'Reilly, C. A.: Demography and diversity in organizations: A review of 40 years of research, Research in Organizational Behaviour, 20, 77–140, 1998.

Table 1. Dataset of life sciences research teams by country (source: authors).

Country	Research population	Sample	Usable questionnaires				
			Number	In % of sample	Mean no. of inlinks	Mean team size	% of female heads
CZ	173	119	30	25.2	1.6	12.8	23.3
DE	1,447	271	60	22.1	9.5	16.6	20.0
ES	896	164	37	22.6	1.9	14.8	8.1
FR	1,384	225	56	24.9	4.4	16.8	12.5
HU	214	108	34	31.5	5.8	22.3	17.6
IT	952	186	52	28.0	1.5	8.8	21.2
NO	199	122	37	30.3	7.8	11.0	18.9
PT	229	123	44	35.8	11.4	12.6	50.0
SE	650	148	41	27.7	7.3	12.3	26.8
UK	1,588	307	77	25.1	8.7	13.1	13.0
Total	7,732	1,773	468	26.4	6.4	14.3	20.5

SGD
3, 121–157, 2007

Title Page
Abstract Introduction
Conclusions References
Tables Figures
◀| |▶
◀ ▶
Back Close
Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Copernicus

SGD

3, 121–157, 2007

Int. collaboration, mobility and team diversity

F. Barjak and S. Robinson

Table 2. PhD students and post-docs in life sciences teams by country of last degree (source: authors).

Country of last degree	PhD students	Post-docs
Own country	79.7	59.3
Other EU country	8.2	19.5
Other European country outside EU	1.9	5.7
USA or Canada	1.8	3.9
Other country	8.4	11.6
Total	100	100
N	1676	880

Copernicus

Table 3. Shannon's Diversity Index for country of last degree (Note: Shannon's Diversity Index in brackets [PhD students/post-docs]. The classification as above or below average is based on the 95% confidence intervals of the mean indexes per country).

		Origin diversity of PhD students		
		Above average	Average (Ø=0.41)	Below average
Origin diversity of post-docs	Above average	SE (0.65/0.64) UK (0.70/0.55)		
	Average(Ø=0.38)	DE (0.60/0.37)	ES (0.35/0.28) FR (0.33/0.43)	PT (0.14/0.50)
	Below average		NO (0.33/0.20)	CZ (0.19/0.06) HU (0.22/0.07) IT (0.16/0.18)

SGD

3, 121–157, 2007

Title Page
Abstract Introduction
Conclusions References
Tables Figures
◀◀ ▶▶
◀ ▶
Back Close
Full Screen / Esc
Printer-friendly Version
Interactive Discussion

Copernicus

Table 4. International collaboration of research teams in the life sciences (no. of co-authored ISI journal articles and share of total no. of published articles in 2001; source: Glänzel, W. Co-authorship links of life sciences institutes. Bibliometric measures of networking activities and of their impact [NetReAct Deliverable 2.2]. Report to the Institute for Prospective Technological Studies, Commission of the European Communities, January 2006, pp. 97–98, http://www.netreact-eu.org/documents/NetreactDeliverable2.2.pdf).

	International collaboration		Collaboration with partners from EU15		Collaboration with partners from the USA	
Country	N	Share (%)	N	Share (%)	N	Share
CZ	48	39.7	35	28.9	7	5.8%
DE	168	39.2	64	14.9	45	10.5%
ES	54	30.5	34	19.2	12	6.8%
FR	103	33.3	57	18.5	18	5.8%
HU	78	40.4	44	22.8	22	11.4%
IT	58	39.2	33	22.3	18	12.2%
NO	45	47.4	39	41.1	7	7.4%
PT	87	47.0	56	30.3	27	14.6%
SE	68	44.7	37	24.3	16	10.5%
UK	110	34.6	50	15.7	33	10.4%

SGD
3, 121–157, 2007

Copernicus

Table 5. Regression models of research output and productivity on international collaboration and origin diversity with other team characteristics (Note a: The Goldfeld-Quandt test returns a test value of 1.682 significant at $p<0.01$, indicating heteroscedasticity due to the team size variable. A weighted regression may control for this. Note b: estimated coefficient; t-ratio: quotient of estimated coefficients and standard errors; Significance levels **<0.01, *<0.05, +<0.1).

	Model 1 TOTPAP		Model 2 TOTPAP		Model 3 ZTOTPAP		Model 4 ZTOTPAP[a]		Model 5 ZTOTPAP		Model 6 ZTOTPAP	
Variable	*b*	*t*-ratio	*b*	*t*-ratio	*b*	*t*-ratio	*b*	*t*-ratio	*b*	*t*-ratio	*b*	*t*-ratio
Constant	0.862	3.936**	0.895	3.186**	0.514	4.211**	0.529	5.301**	0.364	2.844**	0.400	2.995**
TEAMAGE	0.005	0.822	0.011	1.484	0.002	0.540	0.003	1.676+	−0.29E-03	−0.077	0.002	0.803
TEAMSIZE	0.023	3.469**	0.019	2.419*	−0.019	−4.874**	−0.012	−5.749**	−0.019	−5.175**	−0.013	−5.127**
TEAMSIZE2	−0.11E-03	−1.983*	−8.4E-05	−1.404	0.11E-03	3.269**	6.1E-05	4.932**	0.10E-0.3	3.542**	6.1E-05	4.478**
RECOG	0.106	3.256**	0.137	3.403**	0.044	2.254*	0.024	1.504	0.029	1.468	0.015	0.839
EXPRNCE	0.038	2.318*	0.014	0.699	0.016	1.694+	0.005	0.746	0.010	1.050	−4.9E-04	−0.071
EXPRNCE2	−0.001	−2.771**	−0.001	−1.238	−0.001	−1.961+	−2.7E-04	−1.529	−0.41E-03	−1.419	−1.0E-04	−0.491
EUCPAP01	–	–	–	–	–	–	–	–	0.331	6.312**	0.230	7.028**
USCPAP01	–	–	–	–	–	–	–	–	0.206	3.684**	0.190	3.768**
CDIVPHD	–	–	0.674	1.930+	–	–	–	–	0.314	1.896+	0.378	2.633**
CDIVPHD2	–	–	-0.581	-2.002*	–	–	–	–	−0.267	−1.935+	−0.307	−2.444*
CDIVPDOC	–	–	0.122	0.362	–	–	–	–	0.043	0.257	0.106	0.664
CDIVPDOC2	–	–	−0.127	−0.486	–	–	–	–	−0.053	−0.413	−0.123	−1.118
Model type		NEGBIN		NEGBIN		OLS		OLS, weighted by teamsize		OLS		OLS, weighted by teamsize
Alpha	0.534	7.571**	0.461	4.560**		–		–		–		–
Log-L		−1037.516		−770.4513		–		–		–		–
Rest. Log-L		−1334.189		−939.0459		–		–		–		–
F		–		–		2.62**		4.11**		6.08**		6.40**
Adjusted R2		–		–		0.076		0.136		0.348		0.362
Cases		395		296		395		395		296		296

SGD

3, 121–157, 2007

Copernicus

SGD
3, 121–157, 2007

Int. collaboration, mobility and team diversity

F. Barjak and
S. Robinson

Table 6. Regression models of research quality (TOTMOCR) on international collaboration and origin diversity with other team characteristics (Note a: The Goldfeld-Quandt test returns a test value of 2.755 significant at $p<0.01$, indicating heteroscedasticity due to the team size variable. A weighted regression may control for this. Note: b: estimated coefficient; *t*-ratio: quotient of estimated coefficients and standard errors; Significance levels **<0.01, *<0.05, +<0.1).

	Model 7, OLS unweighted[a]		Model 8, OLS weight=teamsize		Model 9, OLS weight=teamsize		Model 10, OLS unweighted[a]		Model 11, OLS weight=teamsize		Model 12, OLS weight=teamsize	
Variable	*b*	*t*-ratio	*b*	*t*-ratio	*b*	*t*-ratio	*b*	*t*-ratio	*b*	*t*-ratio	*b*	*t*-ratio
Constant	5.953	3.345**	5.516	3.489**	5.647	3.904**	7.382	3.364**	6.372	2.696**	5.789	2.920**
TEAMAGE	0.013	0.230	−0.012	−0.370	−0.015	−0.531	0.023	0.350	−0.001	−0.035	−0.007	−0.201
TEAMSIZE	0.007	0.134	−0.031	−0.928	−0.022	−2.815**	0.014	0.219	−0.022	−0.555	−0.012	−1.233
TEAMSIZE2	−1.88E-04	−0.405	0.61E-05	0.306	–	–	−1.36E-04	−0.273	−1.21E-04	0.488	–	–
RECOG	0.172	0.604	0.336	1.207	0.326	1.178	−0.287	−0.855	−0.029	−0.084	0.052	0.153
EXPRNCE	0.135	0.970	0.119	1.137	0.082	1.737+	0.101	0.613	0.172	1.262	0.074	1.259
EXPRNCE2	−0.004	−0.838	−0.001	−0.339	–	–	−0.003	−0.558	−0.003	−0.707	–	–
EUCPAP01	–	–	–	–	–	–	1.377	1.533	1.323	1.802+	1.395	1.868+
USCPAP01	–	–	–	–	–	–	2.477	2.584*	1.807	1.713+	1.684	1.672+
CDIVPHD	–	–	–	–	–	–	−2.990	−1.056	−3.938	−1.693+	−1.181	−1.299
CDIVPHD2	–	–	–	–	–	–	1.710	0.724	2.563	1.283	–	–
CDIVPDOC	–	–	–	–	–	–	−2.716	−0.958	−1.978	−0.626	1.596	1.726+
CDIVPDOC2	–	–	–	–	–	–	3.602	1.629	2.728	1.012	–	–
F		2.01**		3.58**		3.99**		2.00**		3.28**		3.65**
Adjusted R2		0.054		0.128		0.133		0.096		0.193		0.189
Cases		353		353		353		296		296		296

Copernicus

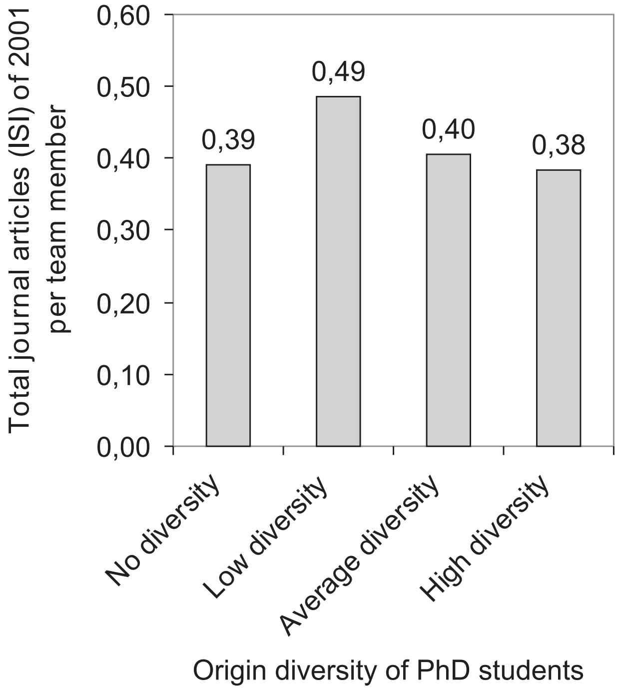

Fig. 1. Total journal articles by origin diversity (OD) of PhD students (ANOVA: F=0.83, p=0.48. Note: "No diversity" means that all PhD students/post-docs of a team obtained their last degree in the same country; "Low diversity" 1 [out of 3, 4, or 5] PhD students/post-docs obtained their degree abroad; "Average diversity" 2 obtained their last degree abroad; "High diversity" 3 obtained their degree abroad).

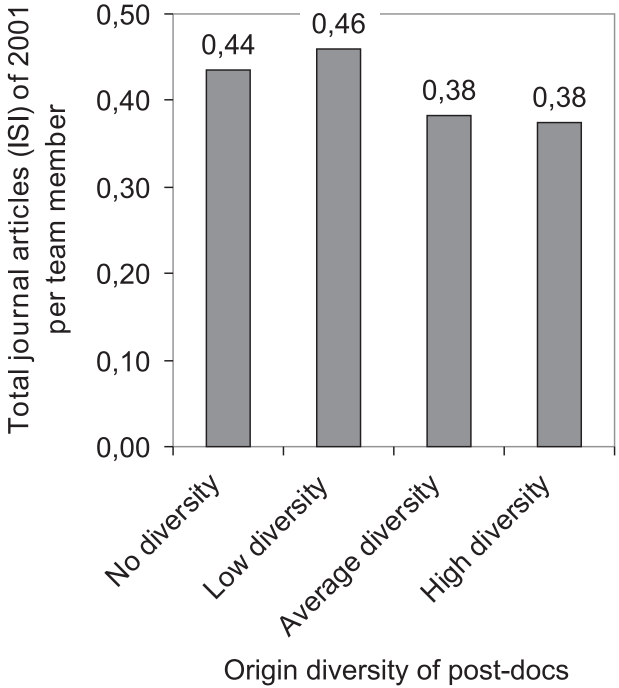

Fig. 2. Total journal articles by origin diversity (OD) of post-docs (ANOVA: F=0.26, p=0.85; see Fig. 1).

SGD
3, 121–157, 2007

Int. collaboration, mobility and team diversity

F. Barjak and
S. Robinson

Title Page
Abstract Introduction
Conclusions References
Tables Figures
◀I ▶I
◀ ▶
Back Close
Full Screen / Esc
Printer-friendly Version
Interactive Discussion

Copernicus

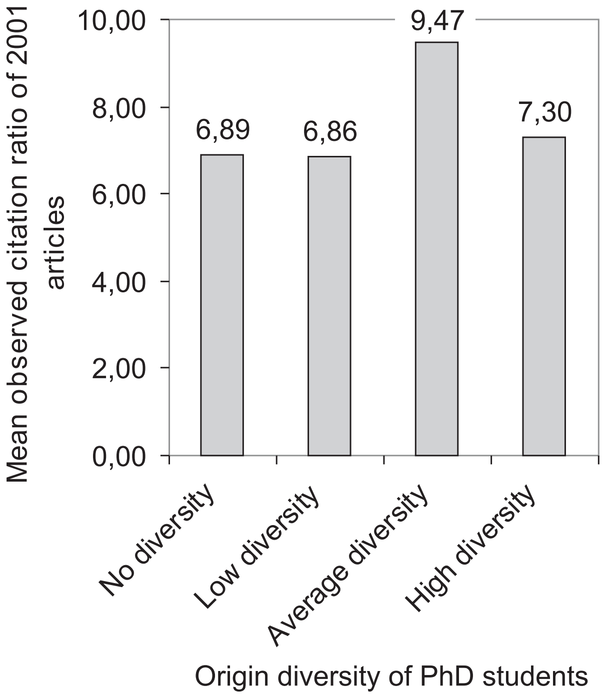

Fig. 3. Mean Observed Citation Ratio (MOCR) by origin diversity (OD) of PhD students (ANOVA: $F=1.04$, $p=0.37$; see Fig. 1).

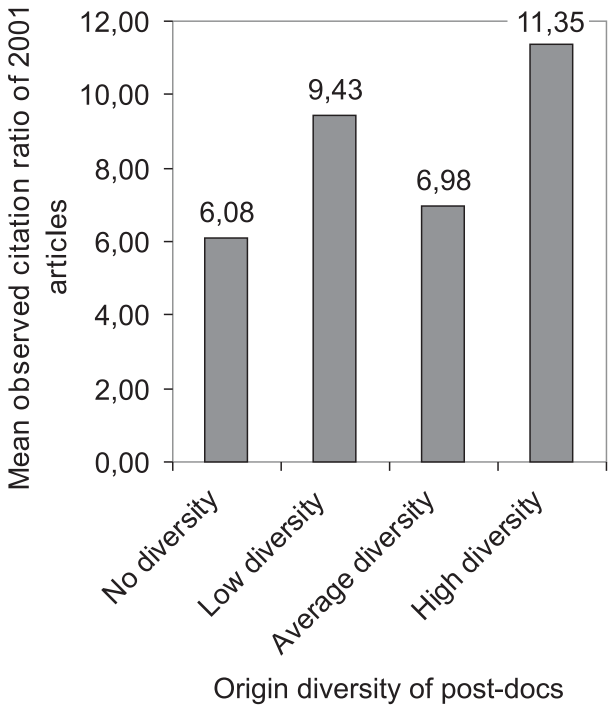

Fig. 4. Mean Observed Citation Ratio (MOCR) by origin diversity (OD) of post-docs (ANOVA: F=3.54, $p<0.05$; see Fig. 1).

SGD
3, 121–157, 2007

Int. collaboration, mobility and team diversity

F. Barjak and
S. Robinson

Copernicus

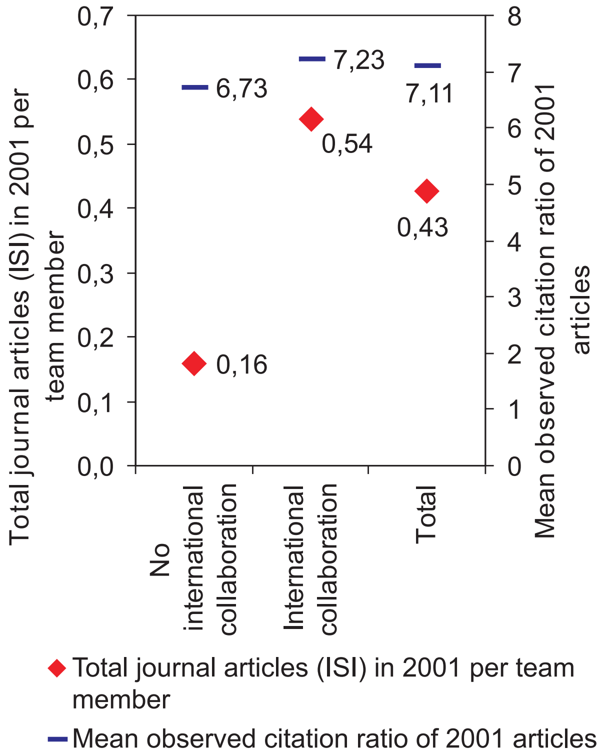

Fig. 5. Team productivity and output quality for teams with and without international collaboration: International collaboration partners (Note: ANOVA-results: Journal articles: F=42.54, $p<0.01$; MOCR: F=0.18, $p=0.67$).

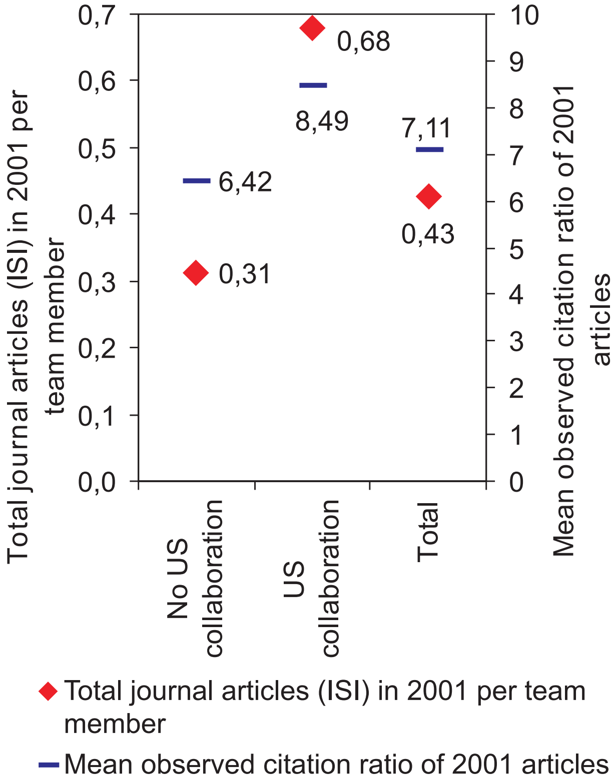

Fig. 6. Team productivity and output quality for teams with and without international collaboration: Collaboration partners from the US (Note: ANOVA-results: Journal articles: F=39.95, $p<0.01$; MOCR: F=3.80, $p=0.052$).

Copernicus