Transnational mobility and the spaces of knowledge production: a comparison of different academic fields

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Abstract

Transnational movements of academics shape the production and dissemination of knowledge and thus the geographies of contemporary knowledge economies. In this paper, I investigate the complex relationship between knowledge, mobility and space by examining three key aspects of academic mobility to Germany in the period 1981 to 2000: first, global patterns of interaction, second, motivations to work in Germany for a limited period of time and, third, resulting publications and collaborations. The study is based on two sets of statistical data and a postal survey involving about 1200 respondents from 90 countries. I argue that transnational academic mobility and collaboration is not only shaped by political, socio-economic, cultural, intellectual and individual circumstances but also by varying geographies of different research practices that help to explain field-specific cultures of academic mobility and collaboration. Drawing upon an actor-network based understanding of both the natural and technical sciences and the arts and humanities, a three-dimensional matrix is developed that conceptualises varying spatial relations of scientific practice and interaction in different fields and at different stages of knowledge production.

1 Introduction

At a time when the “knowledge economy” is growing in international importance, the global circulation of scientists and scholars is crucial to the competitiveness of modern nation states and individual academic institutions. Academic mobility, comprising of mostly circular geographical movements such as research stays abroad, guest professorships and conference travel, does not only seem to play a key role in the internationalisation of higher education and in maintaining a strong research capacity but also in the long-term development of transnational networks within and beyond the academy (Altbach, 1989; Blumenthal et al., 1996; OECD, 1996, 2004; Ackers, 2005). While research on the nature and outcome of academic mobility has important impli-
cations for science and higher education policies, it also provides vital insights into the geographies of contemporary knowledge economies and related spaces of knowledge production (Jöns, 2003a).

In this paper, I explore the complex relationship between knowledge, mobility and space by looking at the ways in which geographical patterns, motivations for and outcomes of transnational academic mobility vary among researchers working in different countries and in different academic fields. I argue that transnational academic mobility and collaboration is not only shaped by political, socio-economic, cultural, intellectual and individual circumstances but also by varying geographies of different research practices that help to explain field-specific cultures of academic mobility and collaboration. In order to develop this argument, I examine three key aspects of academic mobility to Germany in the period 1981 to 2000: first, global patterns of interaction, second, motivations to work in Germany for a limited period of time and, third, resulting publications and collaborations.

The study is based on three data sets about the largest sponsorship programme for visiting academics in Germany run by the Alexander von Humboldt Foundation (Bonn, Germany). The first set contains data on all granted Humboldt research fellowships in the period 1981 to 2000. The second includes data on all applications for Humboldt research fellowships in the period 1996 to 2000. The third draws on a postal sample survey of visiting researchers to Germany in the period 1954 to 2001. This survey, conducted at the University of Heidelberg in the year 2003, resulted in 1893 responses from former Humboldt research fellows\(^1\). In the following, I focus on the last two decades of the 20th century by examining the experiences of 1131 Humboldt

\(^1\)In the period 1954 to 2001, the Humboldt Fellowship Programme sponsored research stays of 17,216 visiting academics in Germany; in 2002, about 90% of these Humboldt fellows were still in contact with the foundation. Every fourth of them received a questionnaire. This resulted in a random sample of 3718 Humboldt research fellows, i.e. every fifth of all Humboldt research fellows in the period 1954 to 2001. After sending one reminder, the response rate amounted to 51%, or 1893 questionnaires.
research fellows from 90 countries. This equals roughly every eighth of all academics, who spent their first Humboldt research stay in Germany in the period 1981 to 2000. Methodically, the survey benefited from a previous study on German-American academic relations, which was based on a complete survey of the Humboldt award winner programme (1972–1996) and on more than 60 semi-structured interviews with US senior scientists (Jöns, 2003a). The detailed categories of the new questionnaire, constructed out of the rich qualitative data, and the large number of responses to the world-wide survey both provide a unique opportunity for analyzing the complexity and dynamics of academic mobility in different fields and types of research work.

Drawing upon recent work in science studies and geography, the conceptual considerations derived from the empirical findings in the final part of this paper build upon an actor-network based understanding of scientific work and interaction, which regards scientific work as a network-building process between heterogeneous human and non-human elements or “actants” (Bingham and Thrift, 2000; Latour, 1996, 2005; Law and Hassard, 1999). By proposing a three-dimensional conceptual matrix that accounts for varying degrees of materiality, standardisation and abstraction of these constituents of different research practices, the paper has a twofold aim: first, to explain cultures of academic mobility and collaboration in different disciplines and types of research work and second, to contribute to recent theoretical debates on the relationship between knowledge and space (Meusburger, 2000; Harvey, 2005).

2 Academic mobility and the geographies of science

Recent work in science studies and geography has focused on historical and geographical variations in the production and dissemination of scientific knowledge (Ophir and Shapin, 1991; Shapin, 1995; Smith and Agar, 1998; Livingstone, 1995, 2000, 2002a, 2003; Naylor, 2005). The basic idea of this work can be traced back to Thomas Kuhn’s (1962) seminal book, in which he pointed out that scientific methods, concepts, problems and problem solutions are not universally true but always related to shared
paradigms that vary over time. More than twenty years later, Bruno Latour (1987) and Donna Haraway (1988) argued for the spatially situated character of scientific practice by rejecting the idea of a universal scientific objectivity existing independently of local circumstances. According to Latour (1987:247–250), the existence of scientific facts and artefacts in time and space requires the extension of those networks that originally gave birth to them. Wissenschaft thus resembles a network of interconnected nodes in which disproportional amounts of heterogeneous resources are concentrated, transformed and transferred back and forth (Latour, 1987:179–180).

Stimulated by these ideas and by an interest in the history of geography itself, David Livingstone (1995, 2000, 2002a, 2003) outlined the foundations and aims of what might be called a “geography of science”. He suggested that “a spatial taxonomy of scientific knowledge” could be centred around three main lines of inquiry, namely the analysis of (1) spaces and places of knowledge production, (2) spaces and places of knowledge dissemination and consumption, and (3) lived geographical biography (Livingstone, 2002b:12ff.). By providing ample historical evidence for the fact that “[t]he growth of scientific knowledge has been intimately bound up with geographical movement”, Livingstone (2003:177) in particular reinforces the idea that “the connection between cultures of travel and spatial formations of knowledge is an ancient [and intimate] one” (Gregory, 2000:317). But how do these “spaces-in-motion” (Gregory 2000:317) unfold in the context of contemporary research practice? Or, posed in more pragmatic terms, in which ways do the (macro) geographies of academic mobility and collaboration differ over time and between different fields and types of research work? Is it possible that, if the connection is indeed an intimate one, the (micro) geographies of scientific practice and interaction may explain typical patterns of academic mobility and collaboration in the natural and technical sciences as well as in the arts and humanities?

Despite the importance of academic mobility for a better understanding of science and society, surprising little is known about global patterns of interaction, motivations for and outcomes of transnational academic mobility (Findlay, 1996; Goodwin, 1996; Teichler, 1996; Windham, 1996; Koser and Salt, 1997; Salt, 1997; Iredale and Apple-
Mainly a question of data availability, most studies on the wider topic concentrate on student rather than staff mobility (Barnett and Wu, 1995; Jallade, 1996; Li et al., 1996; Teichler 2002; Budke, 2003; King and Ruiz-Gelices, 2003; Baláz and Williams, 2004). Only very few studies examine academic mobility of scientists and scholars (Heffernan, 1994; Jöns, 2003a; Jöns and Meusburger, 2005; Van de Sande et al., 2005) and related networks of communication and collaboration (Button et al., 1993; Ekman and Quandt, 1999). In the context of highly skilled scientific migration, research has focused on questions of “brain drain” and “brain gain”, even if “brain circulation” begins to receive more attention (for recent reviews, see Ackers, 2005; Jalowiecki and Gorzelak, 2004; Pethe 2006). Along these lines, King (2002:89–90) argues that geographical movements of the highly skilled are characterised by “new space-time flexibilities” that complicate the “never straightforward boundary between migration and mobility”. A growing number of studies apply a comparative approach by examining cultures of academic work, international contacts and scientific career trajectories in different geographical and disciplinary contexts, although the arts and humanities are rarely included (Becher, 1989; Crawford et al., 1993; Wagner, 2005; Ackers and Gill, 2005; Laudel, 2005; Morano-Foadi, 2005). Based on a comparative approach, the main challenge thus seems to lie in linking three research traditions: first, empirical work on academic mobility that needs a better “theoretical basis of analysis” (Teichler, 1996:339; see also Iredale 2001:7); second, historical studies on the meaning of geography in the making of science (Livingstone, 2003); and, third, conceptual accounts of academic travel and scientific work, which require more detailed empirical case studies (Latour, 1999:viii; Jöns 2003a:16f.; Barnett and Phipps, 2005:3f.).

Striving for the establishment of such a linkage, the focus of this paper is on transnational mobility of academics, who went to Germany in the period 1981 to 2000 in order to pursue a specific research project at one or more host institutions for about a year. Since 80% of the visiting researchers returned to their country of origin (10% moved on to another country and 8% stayed in Germany; 2% no answer), the Humboldt fel-
lowship programme typically sponsors circular transnational mobility. The questions raised by these movements are as follows: Where did visiting researchers to Germany come from during the last two decades of the 20th century? Why did they choose to spend their research stay in Germany? Could they have done their research project also at home or in any other country? To what extent did the visiting researchers write joint publications with colleagues in Germany, and how many returned for a further academic visit or longer stay? Above all, I am interested in the ways in which global patterns of interaction, motivations and outcomes varied according to different fields of knowledge production. Based on rich quantitative data, the paper presents empirical insights into the nature of academic mobility and collaboration in the late 20th century and offers a conceptual explanation of typical mobility and collaborative cultures in different disciplines and types of research work.

3 Global patterns

Germany’s post-war history of international academic relations has been shaped by the Humboldt fellowship programme, which was established by the Alexander von Humboldt Foundation in 1953 (Jansen, 2004). Humboldt research fellowships allow highly-qualified foreign scholars with a doctoral degree and below 40 years of age to carry out a research project in the Federal Republic. With more than 50,000 applicants and 20,000 research fellows from more than 130 countries in the first five decades of its existence, the Humboldt fellowship programme has been the largest sponsorship programme for long-term research stays at German institutions of higher education and research (Jöns, 2002). Academics from all countries and disciplines are encouraged to apply for Humboldt research fellowships. Thus, each application can be interpreted as a result of professional and personal interests mediated by the opportunities and restrictions of a specific place of work at a certain time. The selection of Humboldt research fellows, resulting in an average success rate of 34%, is based on the candidate’s academic qualification, which is assessed in the context of the general research situa-
tion in the applicant’s country of origin. There are no pre-determined quotas or priorities with regard to nationality or discipline, which allows for a comparison of transnational mobility and collaboration in different countries and academic fields².

A continuous growth in the number of applications, granted fellowships and countries of origin from 1954 to the early 1980s reflects a gradual reintegration of Germany into the international scientific community after World War Two. It also mirrors the expansion of the German tertiary educational system in the 1970s and a substantive increase in the quality of research and teaching in German higher education. Rising qualifications of Humboldt research fellows and a growing interest in the programme by applicants from the United States indicate that the process of reintegration had been successfully pursued in most disciplines by the late 1970s (Jöns, 2003b). The number of applications for Humboldt fellowships in 1980 (N=1481) was only surpassed in 1988 (N=1536), when the impending end of the Cold War led to enormous changes in the network of international academic relations. The number of applications from Poland had already doubled in the period 1980 to 1989, but the late 1980s and early 1990s saw a boom in applications from all successor states of the Soviet Union and the transformation states of central and south eastern Europe. Consequently, the number of applications for Humboldt research fellowships reached its maximum in 1990 to 1992, when the number of applications exceeded 1900 per year³.

During the 1990s, the total number of applications per year dropped to levels only slightly above those of the 1980s. In the year 2000, it even fell below 1200 applications,

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²Humboldt research fellows of the period 1981 to 2000 were on average 35.8 years old, only 12.6% were female. The length of their main Humboldt stay was 11 months on average. About 80% of them worked at universities. Other important host institutions included Max Planck Institutes and major state-subsidised research institutions (e.g., DESY, GSI).

which is the result of a complex bundle of developments in Germany and abroad. There
was an exceptionally strong interest in Germany during the unique historical situation
of unification, while international scientific contacts diversified after the fall of the Iron
Curtain (Wagner and Leydesdorff, 2005a). This went hand in hand with a growing in-
ternational competition for highly qualified visiting researchers and a considerable rise
in the range of fellowships on offer world-wide. The consequences of the drop in the
birth-rate in highly-developed industrialised nations meant that there were fewer young
academics available, while in many countries graduates preferred financially more at-
tractive jobs in industry to those in academia. In the United States, the competition
among post-docs for jobs in academia became so high that many of them had to be
present in the job market for interviews and could not afford to leave the country for
one to two years\(^4\). In Poland and Hungary, the increasing predominance of Anglo-
American scientific discourses led to a re-orientation from an initial focus on Germany
to a growing interest in the UK and the USA. Since cultural and biographical bonds
to the host country are important for the decision to spend a long-term research stay
abroad, diminishing biographical connections to Germany and central Europe have
been responsible for a further decrease in the number of visiting researchers (Jönß,
2003a:193–198, 2005:12–14). Finally, investment in large research facilities, charac-
terising German science in the 1980s, stagnated in the first half of the 1990s when
restructuring efforts of higher education and research in the new Länder became a

In the 1980s, the focal point of sponsorship lay on the USA, Poland and Japan with
more than 400 research fellows from each country (34% of all Humboldt research fel-
lows). The 1990s, however, saw a huge increase in applications and fellowships from
China and Russia, the USA being the third country with more than 400 research fellows
(32% of all Humboldt research fellows). The considerable interest of qualified visiting

\(^4\)This situation is reinforced by the fact that the symbolic meaning of post-doctoral positions
in the United States, specifically at the large research universities, is still valued much higher
than work experience in most groups in Europe.
researchers from Asia and the USA as well as from western and eastern Europe underlines Germany’s mediating position in the highest levels of a worldwide hierarchy of national research contexts (Fig. 1). The geographical pattern of applications for Humboldt research fellowships in the period 1996 to 2000 underlines a strong interest in German higher education and research from China, India and Russia. It also reveals distinct transnational spaces of knowledge production in the natural sciences, the engineering sciences, and the arts and humanities (Fig. 2). The interest in the natural sciences was widespread, though 54% of all applications came from six countries (India: 17.3%, China: 16.5%, Russia: 8%, Japan, France and USA: 4% each). In engineering, 68% of all applications were concentrated in only seven countries (China: 31%, India: 18%, Russia: 7%, USA, Japan, Turkey and Ukraine: 3% each). The interest in the arts and humanities was least concentrated in individual countries; 42% of all applications came from six countries (USA: 14%, Russia: 9%, Italy: 7%, Poland: 5%, Japan and Great Britain: 4% each). While transnational mobility to Germany in the natural and technical sciences was thus dominated by scientists from Asia, interest in Germany from the arts and humanities was largest from the USA and also much stronger from within Europe. These asymmetrical global patterns of academic exchange in different fields are the result of variations in international politics, socio-economic development, historical and cultural relations, national research traditions and political priorities as well as technological and intellectual standards and prestige. They also imply field-specific cultures of academic mobility and collaboration, which will be further examined in the course of this paper.

During the post-war period, the disciplinary profile of visiting researchers to Germany

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The latter are expressed in different success rates by country of origin. Among the 20 countries with most applications, the success rates ranged from more than every second in the case of applications from Canada (55%), Australia (52%) and Great Britain (51%) to less than one third (China: 33%, Nigeria: 32%, Bulgaria: 31%, Ukraine: 28%, Turkey: 28%, India: 21%, Egypt: 16%). The success rate was highest in the arts and humanities (35%), followed by the natural sciences (31%) and engineering (28%).
has significantly shifted towards the natural and technical sciences. This process has been based on a growing economic importance and a targeted development of scientific and engineering research at German institutions of higher education and research since the late 1960s. It shows how the establishment of new research infrastructure in the physical, biological and technical sciences, which often operate on the basis of a relatively standardized communication, can massively raise scientific interest in Germany. The mobilisation of new visiting researchers in the arts and humanities, however, remains difficult because language skills and cultural knowledge are often necessary for conducting research projects in these fields and the number of foreign scholars with German language skills is not only restricted but, as indicated above, declining for historical reasons. Therefore, the shift in subject emphasis among Humboldt research fellows cannot be simply attributed to the international attractiveness of different national academic communities. It rather indicates that the “expectation of mobility” varies in different fields of academic work (Ackers, 2005:104) and that different research practices require different spatial contexts (Fig. 3).

4 Motivations

The motivations for spending a year of research in Germany represent a complex bundle of influencing factors. These differ only slightly from motivations for scientific migration in terms of less emphasis on economic issues and more emphasis on new scientific and cultural experiences and contacts (Department of Trade and Industry, 2002; Martin-Rovet, 2003). The fifteen most frequent motivations include general reasons for a sabbatical abroad such as the search for new experiences and ideas (75.4%), time to do research and to publish academic work (66.8%), establishment and fostering of contacts with foreign researchers (55.1%), improvement in career opportunities (49.3%) and gathering of foreign experience (47.6%)\(^6\). Motivations related to Germany more

\(^6\)The questionnaire contained 36 possible responses divided into three sections: 1) Research in Germany and the host institution (15 items), 2) Biographical and cultural relations (9
specifically are the prestige of the Humboldt Foundation (67%), a particular subject or project of research (62.1%), the scientific reputation of the host institution (56.2%) and the financial attractiveness of the Humboldt fellowship (42.6%). Every second former Humboldt fellow in the period 1981 to 2000 stated that a cultural and historical interest in Germany influenced his or her decision to apply for a Humboldt research fellowship (55.5%). About two fifth of the visiting researchers wanted to improve their German language ability (39.5%) and regarded good contacts with their academic host as a motivating factor (38%). About one third was attracted by specific research infrastructure (34.9%), by the fact that the host team was interested in their academic work (33.8%) and by their good experience with previous stays (30.5%).

The responses of researchers from different countries expose some of the ways in which national research contexts provide different preconditions for academic work and mobility on a global scale (Table 1). They reveal that cultural and geographical distances still shape the international academic community and enable the identification of different academic cultures around the globe. Particular research projects in Germany were an important motivation for Humboldt fellows from the global centres of scientific learning in the USA, Canada and Australia. Every second American and Canadian researcher and thus also more than in any other region maintained good contacts with his or her academic host, wanted to improve his or her German language ability and had a cultural and historical interest in Germany. This might be influenced by the strong representation of the arts and humanities among American and Canadian Humboldt fellows. Also, most Humboldt fellows who had friends, relatives or family roots in Germany and biographical connections to Central Europe came from the USA and Canada, which underlines close historical and cultural transatlantic relations. The prestige of the Humboldt Foundation was particularly high among visiting researchers from South Asia, South East Europe and Central and South America. Among Humboldt fellows from South Asia and South Eastern Europe this was related to the frequent motivation of achieving better career opportunities. The interest in the German language
was also particularly high among Humboldt fellows from South Eastern and East Central Europe, while the access of specific research infrastructure was mentioned most often by Humboldt fellows from the former Soviet Union, from South Eastern Europe, East Central Europe and Africa. In support of other studies, an important motivating factor among Humboldt fellows from the European Union was a “lack of employment opportunities in the home country” (Morano-Foadi, 2005:148). The number of Humboldt fellows from the European Union (EU-15), who mentioned this aspect (22.7%), was even higher than among Humboldt fellows from the former Soviet Union and its successor states (16.9%). For almost every second visiting researcher from the former Soviet Union and its successor states, however, the decision to apply for a Humboldt research fellowship was influenced by a lack of research funds (46.2%; all regions: 16.5%). Accordingly, every second Russian Humboldt fellow was interested in specific research infrastructure and appreciated the financial attractiveness of the fellowship.

Variations in motivations between different fields of knowledge production point to the existence of field-specific cultures of academic work and underline the observation that different research practices both require and produce specific spatial contexts, which is closely linked to a different emphasis on international mobility (Table 2). The data also reveals a great difference between strongly contextualised practices in history, philosophy, language and cultural studies and lowly contextualised practices in physics and chemistry. Every second to more than two thirds of Humboldt fellows working in the strongly contextualised disciplines considered specific research infrastructure, a cultural and historical interest in Germany and good experiences with previous stays as motivating factors; more than three quarters of them enjoyed the time to do research and publish academic work. While all of these figures are far above the average, the number of physicists and chemists regarding these aspects as influencing factors on their decision to apply for a Humboldt fellowship is far below the average. In chemistry, however, most Humboldt fellows, despite their few previous experiences with Germany, were motivated by the possibility of better career opportunities after the Humboldt stay. On the one hand, this points to a high convertibility of chemical knowledge (Ackers,
2005:102); on the other hand, it illustrates the high reputation of chemical research in Germany.

For almost every second Humboldt fellow (46.4%), the contact to his or her academic host developed through their own international academic mobility (26.8%), or those of their academic host (21%), their supervisor (7.3%) or other people (6.8%). Further 11.6% met their academic host at international conferences or similar events. Personal contact through different forms of academic mobility thus remains pivotal for the generation, maintenance and expansion of international academic relations. This personal contact, the high reputation of the Humboldt Foundation, the financial attractiveness of the Humboldt fellowship and a high quality of research in Germany contributed to attracting a large number of visiting researchers, who could also have done their project at home or in other countries (69.8%). Analysing the context-dependency of Humboldt research projects, i.e. the extent to which they were bound to a particular setting in Germany, reveals striking differences between different fields and types of work (Fig. 4). Research projects in the arts and humanities, and particularly those that involved empirical work, were most frequently tied to the German context and less frequently also possible in other countries than Germany. They were followed by experimental and theoretical projects in engineering and in the natural sciences. The reasons for this ranking and for the fact that theory in the natural sciences appears to be the most “ubiquitous” subject will be discussed after more characteristics of field-specific cultures of academic mobility and collaboration have been explored in the next section.

5 Publications and collaborations

The analysis so far has shown that international academic mobility is structured by a great variety of contextual and individual circumstances. Once the researchers are in Germany, however, their professional interaction and the immediate scientific results of their stays vary considerably according to field-specific scientific practices and col-
laborative cultures. This can be illustrated by a comparison of the visiting researchers’ collaborations in Germany before and after their Humboldt stay. Joint publications are a particular frequent example of collaborations between visiting researchers and their colleagues (Jöns, 2003a:354, 351–418). Prior to their first Humboldt research stay in Germany, every fifth visiting researcher had published joint work with colleagues in Germany (22.4%). Variations between researchers from different countries mirror still existing but diminishing differences in geographical, political and cultural proximity, which created more opportunities for researchers from European countries to publish with colleagues in Germany than for those in south and east Asia (Fig. 5a-A). The share of visiting Humboldt fellows from Australia, for example, who had published with colleagues in Germany prior to their research stay, amounted to 3.7% in the period 1961 to 1980 (USA and Canada: 13.5%; all countries: 15.9%) and rose to 24.4% in the period 1981 to 2000 (USA and Canada: 24.8%; all countries: 22.4%). This underlines the decreasing importance of distance for international collaborations and the growing importance of collaborative projects in the natural and technical sciences (Wagner, 2005; Wagner and Leydesdorff, 2005b). Particular high shares of previous joint publications by future Humboldt visiting researchers from south west Asia, south east Asia and Africa can be explained by the fact that many of them did their PhD or spent a previous research in Germany. Previous academic stays abroad seem both to help and to motivate researchers from less developed countries to further participate in international scientific discourses.

As a result of the Humboldt research stay, more than two thirds of all visiting researchers in the period 1981 to 2000 wrote joint publications with their colleagues in Germany (70.7%). This share varied less between researchers from different countries than between researchers working in different fields and with different methods (Fig. 5a-B and 5b-B). Joint publications were most frequently written in physics (92.3%), chemistry (89.8%), medicine (87.8%), engineering (87.2%) and the biological sciences (87.1%), while research in mathematics and in the earth sciences was characterised by a greater individuality (65.4% each). The latter characterises the arts
and humanities with significant variations between different branches. The spectrum ranges from every second economist and social scientist (50.0%), who wrote joint publications with colleagues in Germany, to roughly one third in language and cultural studies (32.2%) and in history (31.1%), every fifth in law (21.1%) and only every sixth in philosophy (15.7%).

Significant differences in collaborative cultures can also be observed for different types of research work. The frequency of joint publications with German colleagues ranges from a quarter of Humboldt fellows conducting argumentative and interpretative work in the arts and humanities (25.3%) to almost all Humboldt fellows working in experimental engineering (97.3%; Fig. 5b-B). These collaborative cultures in different fields and types of work are so important that they explain variations in resulting joint publications among researchers from different countries of origin (Fig. 5a-B). While two fifth of Humboldt fellows from the USA and Canada worked in the arts and humanities (39.4%), more than 90% of Humboldt fellows from South Asia were natural scientists and engineers (93.7%). Accordingly, a considerably lower number of researchers from the USA and Canada had published joint publications with colleagues in Germany as a result of their Humboldt stay (59.2%) than researchers from South Asia (93.5%). The often larger degree of site-specific contextuality in the arts and humanities also leads to the apparently contradictory finding that previous to their Humboldt research stay in Germany, more researchers working in these fields had published with colleagues in Germany than among their colleagues in the natural and technical sciences (Fig. 5b-A). Scholars in the arts and humanities often require learning the language of their area of specialisation and thus mostly look back on a history of research stays abroad starting with their PhD if not earlier. Prior to their Humboldt research stay in Germany, more than 80% of those working on empirical (95.1%), argumentative-interpretative (83.8%) and theoretical (87.2%) projects in the arts and humanities had been to Germany, while this were less than 70% in the theoretical natural sciences (65.5%) and less than 60% in the experimental natural (54.9%), the experimental technical (51.4%) and the theoretical technical sciences (35.9%).
Due to the greater individuality and different kind of context-dependency of research work in the arts and humanities, more Humboldt scholars working in these fields returned to Germany for another research stay of over one month (50.2%) than in the natural or engineering sciences (41.6% and 42.4%; all fields: 44.0%). The same is true for short-term return visits to Germany of up to one month, which were only slightly more frequent (arts and humanities: 51.8%; natural sciences: 44.2%; engineering sciences: 48%; all fields: 46.5%). Return visits of the Humboldt fellows themselves, however, represent only one type of subsequent mobility in a complex web of flows involving many more students, post-docs and professors (Jöns, 2003a:377–396, 2005:19–21). Therefore, much more complex relationships led to country-specific differences in return visits and also influenced follow-up contacts in different fields and types of research work (Fig. 6). These include financial, geographical, organisational and intellectual aspects and the fact that in the case of those fellows, who spent their first Humboldt stay in the decade 1991 to 2000, the time period between the end of their Humboldt stay and the survey was not very long for evaluating long-term consequences.

6 Conceptual spaces of knowledge production

What conclusions can be drawn from these empirical findings on academic mobility and collaboration for conceptual ideas about the spaces of knowledge production? In terms of actor-network theory, scientific practice can be understood as a network-building process between human and nonhuman entities. Both are regarded as outcomes and mediators of network-building and thus, by extending human agency to things, are called “actants” (Latour, 1999:180). According to Latour, scientific network-building is characterised by a systematic mobilisation of heterogeneous actants in a few “centres of calculation” that can afford the expensive “proof race” of the sciences (Latour, 1987:179). Inside these centres the accumulated resources are transformed, tied together and re-represented in order to build a strong web of associations that makes up a new scientific claim when all the assembled human and nonhuman allies
successfully control one another and thus act as “black box”, a unified whole (Latour, 1987:130–131). By claiming that nonhumans can incorporate both material and social characteristics, actor-network theory applies a concept of hybridity that facilitates to acknowledge the hybrid ontological status of sociomaterial entities. Through the various processes of network formation such as mobilization, translation and transformation, material entities get socialized and become sociomaterial hybrids with their own (hybrid) historicity (Latour, 1999:212–214). In this respect actor-network theory “makes apparent the impossibility of having an artifact that does not incorporate social relations as well as the impossibility of defining social structures without accounting for the large role played in them by nonhumans” (Latour, 1999:212).

From this point of view, the ontological status of the constituents of scientific practice is altered within the process of network-building. (Material) artefacts and (immaterial) facts can be regarded as (temporarily) stabilized results of scientific work (Latour, 1992:285–286). They might still be ontologically hybrid in the sense that (immaterial) ideas and knowledge claims are always embodied in some kind of physical vehicle, while (material) artifacts and machines always incorporate some kind of information (Jöns, 2006:573). Based on the empirical findings, however, I argue that different degrees of materiality and immateriality in scientific practice and interaction imply varying spatial relations, which help to explain the wide range of field- and method-specific cultures of academic mobility and collaboration. In this understanding, each material, sociomaterial, mental or human element that constitutes a scientists’ web of (well proven) allies and (new) resources is more or less strongly localised in a particular physical and social context (Ophir and Shapin, 1991:9). This influences a researcher’s needs and opportunities to reach out from a place of knowledge production in order to communicate and to interact, to work and to mobilize new resources in other places. As the analysis of motivations for academic mobility showed, there are of course very complex relations at work when it comes to the question of whether a researcher becomes internationally mobile, including political systems, economic resources, laws, funds, scholarships, past achievements, language skills, academic functions, personal
contacts, academic socialisation, cultural affinities and biographical backgrounds, family situation, stage of the career, scientific cultures and symbolic hierarchies of centres of calculation (Jöns, 2003a:435–450). Depending on the researcher’s individual position in such networks of heterogeneous resources, his or her behaviour may evade typical patterns in his or her field and type of work. The empirical findings, however, suggest that despite the “double embeddedness” of academic mobility in the societies involved and in the migrant’s life course (King, 2002:101), the varying spatial relations of the constitutive elements of academic work are so important that they lead to typical patterns in regard to the context-dependency and individuality of knowledge production. In order to account for these patterns, I propose to differentiate three dimensions along which the spatial relations of scientific practice and interaction may vary.

First, I suggest that the great variety of research practices in the natural sciences, the engineering sciences and the arts and humanities is constituted by elements of knowledge production that differ in their degree of materiality and immateriality, or symbolical content. Due to the corporeality of human beings or other “dynamic hybrids”, all research practices are to some extent physically embedded and localized (Jöns 2006). However, the more a researcher deals with physically embedded material research objects, such as archival material, field sites, landscapes, technical equipment, groups of people and events, the stronger he or she is dependent on one particular site or local research context and the less he or she can do at least certain parts of the work elsewhere. Those scientists and scholars, who primarily deal with theories and thoughts, are in turn as mobile as the embodiment of these immaterialities allows them to be. This embodiment includes at least themselves, but it may also comprise of other researchers, computers and books, thus blurring any sharp boundaries in regard to higher and lower degrees in the (im)materiality of research work. The first dimension of the proposed three-dimensional conceptual matrix thus positions a great variety of research practices between the two extremes of strongly and lowly context-dependent or site-specific types of academic work resulting from their different degrees of materiality and immateriality.
Second, I propose that the constitutive entities of scientific work vary according to their degree of standardisation. Standardisation results from the work previously invested in things, ideas, and people. A new field site would initially show no signs of standardisation, while laboratory equipment had been manufactured on the basis of previous—and then standardized—considerations and practices. The field site may be unique, the laboratory equipment may be found at several sites to which the networks of science had previously been extended (Latour, 1987:249). Therefore, empirical studies, which examine authentic life worlds, or pedological field studies may at least at some point be dependent on one particular site, while experimental studies in the highly standardised laboratory context of the physical and biological sciences may be conducted in several places offering the necessary equipment. To be sure, all of these practices involve various types of materialities, but these are characterised by very different degrees of standardisation and thus by varying amounts of previous research-related input of money, ideas, work and material resources that could enable their multiplication in time and space. A similar differentiation could be made in the realm of theoretical and argumentative work involving mainly ideas and arguments. This is because the varying spatial relations of their embodiment and the connectivity of the ideas involved (in relation to existing knowledge and ideas of other people) cause enormous differences in the context-dependency and collaborative cultures of research practices characterised to a larger degree by immaterial elements. (Rarely standardised) philosophical bodies of work may be so dependent on the language skills, views and reading experiences of an individual that it is difficult to find another individual to work with (among philosophers), while (highly standardised) mathematical discourses may show less signs of individuality and thus a greater connectivity (among mathematicians). Empirically, this was observed in the difference between argumentative-interpretative and theoretical work regarding the extent to which the research projects of visiting Humboldt fellows were bound to Germany and the frequency to which these projects resulted in joint publications (Figs. 3 and 5). More than 80% of those scientists working in the theoretical natural sciences stated that they could have done their
Humboldt research project outside Germany as well (82.3%), while this was only true for 50% of scholars working in both the argumentative-interpretative and the theoretical arts and humanities. The second dimension of the proposed three-dimensional conceptual matrix thus differentiates between the two extremes of strongly and lowly context-dependent or site-specific types of academic work resulting from their degrees of standardisation, whether this is in the realms of larger degrees of materiality or immateriality.

In the resulting two-dimensional matrix on the spatial ontologies of webs of research, we can locate the empirically observed differences of both the context-dependency or site-specificity of Humboldt research projects and the resulting joint publications with colleagues in Germany (Fig. 7). Empirical work, showing a high degree of materiality and a low degree of standardisation, is most often dependent on one particular site, followed by argumentative-interpretative work, which is characterised by a similar low degree of standardisation but a higher degree of immateriality. Experimental (laboratory) work, showing a high degree of both materiality and standardisation, can often be conducted in several (laboratory) sites, while theoretical work in the natural sciences, involving both a high degree of immateriality and standardisation is most rarely tied to one particular site. A senior professor of mechanical engineering at the University of California, Berkeley, put it this way: “In theoretical research you have the advantage that you can make assumptions; in real life nature constrains you. You can make assumptions but you won’t get anywhere. In theory you can say, well, if this is true then that is true, ok, but in the laboratory this is true [and] you can’t say that is true” [personal interview conducted in 1999; first Humboldt stay in 1983].

Collectivity, defined here as an opportunity for collaboration, increases with both growing materiality and standardisation. From the perspective of the researcher, a growing external (material) context and a high standardisation offer the most opportunities for collaboration. On the one hand, it is easier to create a common understanding on the basis of visible research contexts, standardised equipment and methods, and a common technical English language. On the other hand, the complexity of the equip-
ment and task may require a division of labour, which can more or less be easily arranged on these grounds. While Humboldt fellows in the arts and humanities had often visited Germany before their Humboldt stay, previous visits were much less frequent in the experimental sciences. They were not necessary because the highly standardised laboratory sciences offer a larger connectivity of arguments, ideas and practices, which is much more independent of a specific German (language) context. The least collaboration took place in argumentative-interpretative work, where a large internal (immaterial) context and a multiplicity of arguments from different authors in possibly different languages complicate collaboration on a specific topic. To be sure, both internal and external contexts are part of the same actor-networks and thus not possible to separate, but the different degrees of (im)materiality suggest that it makes sense to introduce these categories temporarily for the purpose of understanding differences between research practices.

Third, I propose that the spatial relations of scientific practice vary along the lines of different stages of knowledge production. This argument builds upon Latour’s claim that in the course of scientific practice multiplicity gets transformed into uniformity in order to be able to speak about much more complex phenomena in a structured way (Latour, 1999:70–73). In this understanding, researchers perform consequential mediations from matter to form involving a trade-off between the loss of multiplicity, materiality and locality and the gain of standardisation, immateriality and relative universality (Latour, 1999:71; Jöns, 2006:571). This means that independent of the ontology of the constituting elements, scientific and scholarly research resembles work of abstraction that proceeds from strongly to less spatially embedded practices. Latour (1999) developed his concepts of “chains of transformation” and “circulating reference” between the world (the field site) and words about this world (the resulting paper) by following earth scientists into the field. However, the concept seems also to be true for theoretical work, because thoughts and theories can as much be superimposed, combined and transformed into new forms as (socio)materialities can be (Latour, 1987:243–247). When mathematicians work on a particular problem, they start with a lot of ideas and
possible linkages between a great variety of forms and often end up with a specific set of equations in which only a few elements and well defined linkages are left. While the experimental physicist successively transforms matter (e.g., particle beam collisions) to form (e.g., claims about the properties of the state of matter resulting from these collisions; see Jöns, 2006:570–571), the mathematician’s chain involves several transformations from form to form as the multiplicity of ideas gets replaced by a set of well structured ideas. The third dimension of the proposed three-dimensional conceptual matrix thus describes strongly to lowly context-dependent or site-specific practices at different stages of scientific network-building, which result from different degrees of abstraction.

The spatialities of knowledge production may thus be described by a three-dimensional conceptual matrix (Fig. 8). This conceptual space of knowledge production allows for ample trajectories in a vast universe of research practices and helps to explain typical patterns, or cultures, of academic mobility and collaboration in different fields and at different stages of research work.

### Conclusions

Academic mobility to Germany is part of a complex set of transnational flows and collaborations that get extended and intensified through face-to-face communication. E-mail and the Internet may have revolutionised transnational academic contacts in all fields (Ekmann and Quandt, 1999) but personal interaction remains pivotal for experiencing different research contexts, for mobilizing new and unexpected scientific resources and for building up trust for successful collaborations and informal networks across the globe. The opportunities for international academic mobility, however, vary considerably over time and space. The analysis has shown that the geographies of

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7 For a theoretical foundation of the differentiation of materialities, hybridities and immaterialities along an axis of different degrees of (im)materiality, see Jöns (2006).
academic mobility to Germany in the 1980s and 1990s had been structured by political, socio-economic, cultural and intellectual relations, including the end of the Cold War, the division between a rich global North (and West) and a poor global South (and East), diminishing biographical connections to Central Europe, and the different prestige of national and institutional research contexts.

Apart from individual preferences, the extent to which researchers become internationally mobile and the question of where they go are also influenced by the field of knowledge production, leading to distinct global geographies of academic exchange in different disciplines. To be sure, all research practices produce situated knowledge and are thus shaped by what Derek Gregory identified as a “double geography”, namely “a hierarchy of spaces of knowledge production” in which some sites are valorized as more central than others” and “a hierarchy of sites of study” in which some places are valorized as canonical or exotic, as exemplary sites of consuming interest, whereas others are marginalized as merely other, less interesting or less instructive instances of more general conditions that are better exemplified elsewhere” (Gregory, 1998:57f.).

While this “double geography”, however, refers to the level of discourses and imaginaries circulating in the academic community (though being materialised in research infrastructure and research money), I argued in this paper that the spatial relations of knowledge producing practices vary in such a way that they help to explain field-specific cultures of academic mobility and collaboration.

Based on the questions whether the particular research project conducted in Germany could also have been carried out at home or in other countries and whether the visiting researchers wrote joint publications with colleagues in Germany as a result of their research stay, the empirical findings pointed to typical patterns in regard to the site-specific context-dependency and the collectivity/individuality of knowledge production in different academic fields: The more immaterial and standardised the research practice, the lower is the spatial embeddedness of one’s work and the easier it is to work elsewhere; the more material and standardised the research practice, the more likely is a collaboration with others. In addition to different degrees of (im)materiality
and standardisation, a third dimension of varying spatial relations unfolds along the degree of abstraction at different stages of knowledge production.

In the previous study on academic mobility of US senior scientists to Germany mentioned in the introduction, it was only possible to differentiate two dimensions of the conceptual matrix (degrees of (im)materiality and abstraction) because almost all interviewees worked in the natural and technical sciences (Jöns, 2003a:426). In the project discussed in this paper, the large number of respondents from across all fields and types of academic work, including the arts and humanities, helped to identify that the (micro) geographies of different research practices may vary along (at least) three dimensions. The proposed conceptual matrix on varying spatialities of scientific practice and interaction can be linked to other typologies of knowledge and space in geography and beyond. Peter Meusburger (2000), for example, argues that different types of knowledges imply different degrees in the spatial concentration of work places. Barnett and Phipps (2005) developed a threefold classification of academic travel that differentiates between the intersecting categories of geographical, epistemological and ontological travel. While these categories take account of different forms of (im)material travel, further analytical distinctions introduced by the authors elaborate on this distinction by differentiating physical and metaphorical travel, interior and exterior dimensions of academic travel and actual and virtual travel. The idea of a matrix of different spatialities has also been developed by Benno Werlen (1993, 2000:329) in the context of his social theory of action and by David Harvey (2005:105, 111) in the context of both a general and a Marxist understanding of society. All these attempts to offer an analytical overview on the meanings of knowledge and space, including my own, share a context-specific and relational understanding that escapes simple definitions and allows for contingency, complexity and multiplicity within a roughly sketched conceptual framework.

The explanation of field-specific cultures of academic mobility and collaboration through varying spatial relations of scientific practice and interaction helps to draw important conclusions for science policy and evaluation efforts that acknowledge field-
and method-specific differences and enable the identification of strong and weak ties in international academic exchange. In regard to the relations between knowledge and space, the findings of this paper raise the question in which ways the varying spatial relations of knowledge production shape patterns of interaction in different times and spaces and in other constitutive realms of what might be entitled an emerging “knowledge society”.

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### Table 1. Motivations for a Humboldt research stay in Germany by region of origin, 1981–2000 (in %; own survey, 2003, n=1131).

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<th>Item</th>
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<th>AFR</th>
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<th>SEE</th>
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<th>MEC</th>
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<th>SEA</th>
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<tr>
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<td>15.5</td>
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<td>Family roots in Germany</td>
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<tr>
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<tr>
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<td>Gathering of foreign experience</td>
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Number of respondents 1128 142 45 47 172 62 165 130 19 96 13 176 34

Abbreviations: Statistical SIGNificance; TOTal; USA und Kanada; Central and South America (incl. Mexico); AFRica; EU-15; South East Europe; East Central Europe; Former Soviet Union and successor states; Middle Eastern Countries; South ASia; South East Asia; East ASia; AUStalia and Oceania; the category “Other European countries” is not displayed.

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Abbreviations: Statistical SIGnificance; TOTal; PHYsics; CHEmistry; EARth Sciences; BIO Sciences; MEDicine; MAThematics & COMputer Sciences; ENGineering Sciences; ECOonomic & SOCial Sciences; LAW Studies; HISTorical Sciences; PHIlosophy; LANguage & CULTural Studies.
Fig. 1. Countries of origin of Humboldt research fellows in the 1980s and 1990s.
Fig. 2. Countries of origin of applications for Humboldt research fellowships, 1996–2000.
**Fig. 3.** Humboldt research fellows by academic field, 1980s and 1990s.

Data source: Humboldt Foundation.
Fig. 4. Possibility of doing the Humboldt research project in another country than Germany, 1981–2000.
Fig. 5. Joint publications of Humboldt fellows and colleagues in Germany, 1981–2000 (a) by country of origin (b) by type of work.
Fig. 6. Scientifically motivated return visits to Germany by Humboldt fellows from the period 1981 to 2000 (up to the year 2003).
Fig. 7. Theoretical interpretation of empirical results: a two-dimensional matrix on varying spatialities of research practices (for A see Fig. 4; for B see Fig. 5b-B).
**Fig. 8.** A three-dimensional conceptual matrix on varying spatialities of scientific practice and interaction.