Flying the nest: How the home department shapes researchers' career paths

Hanna Hottenrott and Cornelia Lawson*

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Abstract

This paper studies the importance of the socialization environment – nest – for the career destinations of early career researchers. In a sample of research groups in the fields of science and engineering at universities in Germany, we identify research orientation, output, funding as well as openness to industry and commercialization as relevant components. Nests that attract more public funding and are led by professors with high research performance are more likely to produce researchers that take jobs in public research, while links to industry predict jobs in the private sector. In a more nuanced analysis that differs by type of industry employment we find that larger firms also recruit from groups with higher scientific performance, while SMEs recruit from nests with a higher patent productivity. A focus on experimental development instead is associated with academic start-ups, and an applied focus with employment in consulting. Recommendations for research training are discussed.

Keywords: Researcher Mobility, Research Groups, Research Funding, Science-Industry Technology Transfer, Academic Careers

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* Hanna Hottenrott (corresponding author): Düsseldorf Institute for Competition Economics (DICE), University of Düsseldorf & Centre for European Economic Research (ZEW). Address: Düsseldorf Institute for Competition Economics (DICE), Heinrich Heine University Düsseldorf, Universitätsstrasse 1, 40225 Düsseldorf, Germany; Tel: +49 211 81-10266, Fax: + 49 211 81-15499; Email: hottenrott@dice.hhu.de

Cornelia Lawson: Centre for Business Research, University of Cambridge & BRICK, Collegio Carlo Alberto & Department of Sociology and Social Policy, University of Nottingham. Address: Centre for Business Research, Cambridge Judge Business School, University of Cambridge, Trumpington Street, Cambridge, CB2 1AG, UK; Tel: 01223 765340; Fax: 01223 765338; Email: c.lawson@cbr.cam.ac.uk

1. Introduction

Socialization in science is often viewed as a process shaped by institutions such as the department or research laboratory (Tierney 1997; Weidman et al. 2001; Antony 2002; Weidman and Stein 2003; Golde 2005; Gardner 2007). Socialization processes affect research performance (Hall et al., 2007), scientists' attitudes towards knowledge transfer (Bercovitz and Feldman 2008), teaching (McDaniels 2010) as well as careers (Austin and McDaniels 2006; Weidman et al. 2001; Fuhrmann et al. 2011).

The framework proposed by Weidman et al. (2001) describes socialization as a process through which researchers acquire the skills and knowledge to lead a later professional life and stresses the importance of socialization at the professional preparation stage (i.e. during graduate education). The research group head has been identified as having a particularly formative influence on the values and perceived opportunities of their research staff and graduate students (Mangematin 2000).

The outcomes of this socialization should become particularly visible in situations where individuals leave these formative environments – their nests. The first important mobility decision, and the one most often considered in academic literature, is the completion of doctoral education that prompts researchers to embark on their future career paths. Researchers may leave their home institution but remain in academic research by taking jobs at public research institutions or other universities. Alternatively, researchers - especially those in science and engineering - may leave academia and move to a career in industry.[1] For instance, in the US about 34% of physicists and 46% of chemists were employed by private sector firms five to six years after obtaining their PhD (Stephan 2012). These numbers are comparable to those of European countries like Germany (50% of physicists and 45% of chemists), the UK (50% in physical sciences and engineering) and the Netherlands, Belgium and Denmark (33-37% of all PhD holders).[2]

[1] Researchers in the private sector earn higher wages and are more likely to be employed in a permanent contract compared to those that stay in academia (OECD, 2013), making industry a very attractive destination for PhD holders.

[2] See KBWN (2013) for the numbers for Germany, Vitae (2010) for the UK and Auriol et al. (2013) for Belgium, Denmark and the Netherlands. Destinations for German PhDs were measured 1.5 years after graduation, UK three years after graduation and others measured employment status in 2010, regardless of year of graduation. These numbers are also comparable to Japan where about 44% of PhDs in the physical sciences for whom destinations are known moved out of academia following graduation (NISTEP 2009). In contrast, in countries with lower R&D intensity, for example in eastern and southern Europe, government represents the second most important destination sector after higher education (Auriol et al. 2013).

Despite these numbers, few papers have investigated the role played by the research group environment in determining the job destinations of departing researchers. Early studies by Crane (1965, 1970), Long (1978) and Long and McGinnis (1985) stressed the influence of department reputational effects on the first academic job, whereas more recent studies focus on sector preferences of PhD students between industry and academia (Roach and Sauermann, 2010; Gemme and Gingras, 2012; Agarwal and Ohyama, 2013; Balsmeier and Pellens, 2014; Lam and de Campos, 2014).

This study adds to previous research by studying the outflow of researchers from 676 science and engineering research groups at 46 universities in Germany. We consider movements within academe, but also transitions to the private sector including the founding of new companies, since socialization has also been identified as playing a crucial role for entrepreneurial orientation (see Nabi et al. 2006 for a review). We further distinguish between research and non-research careers in industry as well in public institutions. This thus represents the first study to investigate multiple types of sector and work content destinations in one setting. It also is the first study to investigate various socialization factors simultaneously, including performance, orientation, inter-organizational networks, and funding of nests. Our results show that nest characteristics can explain much of the variation in departing researchers' job destinations.

2. The nest and its impact on follow-on jobs

An academic career has traditionally been the preferred career path for PhD graduates and postdoctoral researchers, but most will move to other sectors as more researchers aspire to academia than positions are available (Fox and Stephan 2001; Stephan 2012). Previous studies have shown that many early career researchers are aware that they are not training for one career path exclusively, and indeed a significant proportion of those in science and engineering express a preference for a career in industry or government (Roach and Sauermann 2010; Gemme and Gingras 2012) or a career outside research (Fuhrmann et al. 2011). These preferences can shift over time (Fuhrmann et al. 2011; Gemme and Gingras 2012) and prior literature suggests that preferences may be shaped by group leaders who act as role models and shape a group's research ambitions and its profile. Researchers trained as PhDs or postdocs by highly reputed mentors will have a publication and reputation advantage and may value academic career paths more than researchers from other groups (Long and McGinnis 1987; Petersen et al. 2014). Sauermann and Roach (2014), for example, find that those from highly ranked PhD programs give higher importance to publishing. This may result in a higher preference to remain in academia or at least a preference for a research job over consulting or non-research jobs. Moreover, employers typically consider reputation when recruiting new researchers, and highly ranked universities and firms with large R&D departments actively recruit from prestigious research groups.

The destination of departing researchers may also be affected by the research orientation of the group as some research lines and practices may be better suited to meet the needs of prospective employers. For example, Murray and Hsi (as cited in Hilton 2008) reported that the ability to work in a team, to design experiments and to solve specific research problems is highly valued by R&D firms. Research units that pursue a higher share of applied research or experimental development may therefore be more likely to train researchers for industry than departments that focus on basic research lines.

Socialization also plays a crucial role in determining the entrepreneurial orientations of researchers (Nabi et al. 2006). Indeed, several papers have shown that academics in departments with high levels of commercial activity are more likely to be entrepreneurial themselves (Bercovitz and Feldman 2008; Aschhoff and Grimpe 2014; Lam and de Campos 2014). Kyvik and Olsen (2012) also report that PhD holders in Norway working outside academia and in non-research jobs would have preferred a stronger emphasis on commercialization than those that remained in academia. A stronger focus on commercialization may therefore be reflected in a higher propensity for firm foundation, employment at smaller and younger firms or in non-research jobs.

In addition to the research and training content, the group's network ties may be crucial for the careers of its members. Burris (2004), for instance, describes elite networks that have developed between top universities and determine hiring practices. In Europe, too, the importance of social ties for appointment and promotion within academia is very high and may impact on mobility decisions (Cruz and Sanz 2010; Pezzoni et al. 2012). Links with firms also affect socialization and early career researchers may be trained into a role that supports academic as well as industry goals (see Thune 2009 for a review). Mangematin (2000) finds, for instance, that collaboration with a private-sector partner during the PhD-phase increases the probability of French PhD graduates obtaining a position in industry.

All the socialization factors described above, research agendas, group performance and network ties, are affected by research funding and its sources (Hottenrott and Lawson 2014).

As a consequence funding may also impact on the profiles and careers of research group members and a largely publicly funded group may produce more science-oriented researchers. It may also build a higher reputation and pass on skills (e.g., those required for grant capture) which encourage researchers to stay in academia. On the contrary, Gemme and Gingras (2012) show that the preference for a position outside academia is higher for Quebec PhD students training in groups receiving third-party funding. Industry ties are also largely influenced by the head of the research group, who shapes a group's collaboration patterns, and research funding from industry may constitute a channel through which these ties are maintained (see for example Lam 2007).

In summary, the socialization of early career researchers and therefore their career destinations are influenced by nest characteristics including research performance, research orientation, inter-organizational networks, and funding. In the empirical section of these papers we estimate how these nest characteristics work together to shape career destinations of early career researchers.

3. Empirical Analysis

3.1 Data

The empirical analysis is based on a survey of research groups at German higher education institutions in the fields of science and engineering. The Centre for European Economic Research (ZEW, Mannheim) conducted the survey of 3,507 research units at universities, technical universities and universities of applied sciences in 2000. The questionnaire addressed the head of a research group who is usually a full professor with budget and personnel responsibility. The overall response rate to the survey was 24.4%. The survey data were complemented with publication data from the ISI web of science at the level of the head of the research group for the period 1994-1999. Further, patent applications on which the head appeared as inventor have been gathered from German Patent Office data base for the same period. For both data sources, we also collected citations and chose a citation window ending in 2008. Publication and patent data were manually matched to survey respondents based on names and information collected from university websites and the researchers' CVs. We also collected information on the year of doctoral degree for each research group head to derive a measure for the academic age and experience of the professor. The final sample comprises 676 professor-research group observations from 46 higher education institutions of which 56% are Universities (Uni), 23% are Technical Universities (TUs) and 21% are Universities of Applied Sciences (UAS).

3.2 The setting: The institutional background in Germany

Germany's higher education system is characterized by a chair system in which the chair holder plays the central role in training PhD students and raising funding for group members (Enders 2001). In contrast to an Ivy-League system with few star universities, the university landscape has been shaped by an egalitarian approach leading to many equally ranked, publicly financed universities (Kehm 2006). Thus, undergraduate students usually choose a university based on proximity to their home, attractiveness of the city or town and attractiveness of the university in terms of course variety or size. The selection into graduate studies mostly happens based on personal relationships between students and professors developed during undergraduate studies and professors often encourage outstanding students to work with them. This implies that graduate students rarely move before starting their PhD education and factors like research performance of the chair do not play a crucial role when becoming a member of a research group. After PhD completion, however, like in the US system mobility is strongly encouraged. Young academics are usually expected (and have in the past even been required) to leave their home department following *habilitation*.

During post-graduate education and the post-doctoral phase, German universities primarily offer temporary positions (about 80% of non-professorial positions are fixed term, see Teichler et al. 2013) and academics therefore face mobility and career decision points regularly and still at a relatively late age. Consequently, the average mobility rate in Germany is high with more than 50% of PhD holders having moved at least once over a ten year period (Auriol et al. 2013).

These features have not fundamentally changed since the year of the survey. In particular, the share of early career (non-professorial) academics in fixed term contracts remained almost unchanged at about 80% (Teichler et al. 2013). The share of PhD holders in science and engineering as a percentage of the age cohort remained relatively constant and at internationally comparable levels (OECD 2003, 2011).[3] The number of fixed-term employed

[3] The graduation rate for science and engineering (S&E) at doctorate level in Germany was 0.9% in 2009 compared to approx. 0.8% in 2000. Similar shares and increases can be found in Finland, Austria, the UK and France. Only Switzerland and Sweden produce more S&E PhDs per capita. The average OECD graduate rate for S&E at doctorate level was 0.6% in 2009. In Germany, the UK and France the number of science PhDs far

researchers, however, doubled, while the number of professorial positions increased only marginally (EFI 2012). Fixed-term positions also increased in the US, the rest of Europe and Japan, stressing the relevance of this topic beyond Germany.

3.3 Nest Measures

The socialization framework proposed by Weidman et al. (2001) stressed the role of the institutional environment in the personal and professional socialization of researchers and the central role played by role models. The survey used for our study hence addressed the heads of research groups, and asked about personal characteristics, as well as the size, research orientation, inter-organizational networks, and funding of the group.

Table 1 summarizes the main characteristics of research groups and research group heads in the sample. The surveyed professors show an average of 22 years of experience since their doctoral degree, which can be considered representative of German academia (e.g. 22.5 years in Teichler et al. 2013), and only about three per cent were female.

To derive indicators for research orientation, research group heads were asked about the time the group usually spent on basic research, applied research and experimental development. On average, research groups spent about 42 per cent of their time on basic research, about 41 per cent on applied research and slightly less than 18 per cent on experimental development. By multiplying these time shares with the number of researchers in the group, we measure the relative work force attributed to each type of activity. The average size of research groups in our sample is 7.5 people (not including the head) and the mean share of technical staff over all employees is about 10 per cent.

To measure the importance of several mechanisms for groups' links with industry the research group leaders were asked to indicate the importance of their former jobs in industry, the relevance of contract research, and joint research outputs using a scale from zero to three (0 = not important to 3 = very important). Of these three categories the first two were of higher importance, on average, than the latter.

Above we argued that sources of research funding could affect the socialization of group members. The survey therefore also asked for information on the amount and composition of

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outnumbers that of engineering while the reverse is true for Finland, Sweden and also Korea and Japan (OECD 2011, 2003).

research grants that complemented a group's institutional core funding. A differentiation is made between grants from public sources, e.g. the German Research Foundation (DFG) and the federal state governments, and income generated from industry sources. 61% of surveyed professors stated that their group had received funding from industry and 78% had acquired public research grants in addition to their core institutional funding. On average about 28% of a group's team members were financed through 'third-party funding'. The amount of industry funding and its share over the total budget differed between institution types and research fields (see Table A.2). On average the share was 8.6% amounting to approximately 98,000 Euros. The share of research grants received from public sources is similar for universities and technical universities, but is considerably lower at universities of applied sciences. On average, research groups received 21.7% of their total budget from public research grants, which corresponds to about 127,000 Euros.

To gain information on the capabilities and dissemination preferences of the research group heads, we collected the number of publications and patents as well as their citations for each surveyed professor for the five year pre-sample period. We observe an average count of 11 publications and 237 publication citations (the median is much lower at about 24 citations), and an average count of 1.4 patents and 20 patent citations (the median is zero and the 75th percentile is just two citations). Thus, as is common for these types of measures, the distribution of publications and patents is highly skewed. We calculate at the professor level the average number of citations per publication and patents and include these variables as quality-weighted publication and patent indicators which proxy the mentor's capabilities and the research group's overall research performance.

[Insert Table 1 here]

3.4 Job destinations of departing researchers

The outcomes of research group socialization may become particularly visible when researchers leave their nests. The survey therefore asked a series of questions about researchers that had left the research group during the two years prior to the survey. On average, about six researchers left each group (median = 4). The survey asked about short-, medium- and long-term affiliation to the group and found that drop-out is highest after four to five years (see Table 2). Departure after more than five years occurs much less often. This indicates that the majority of departing researchers leave after completing their doctoral degrees, their *habilitation* (postdoc) or quit earlier. We see that this pattern is quite consistent for all institution types. University of Applied Sciences, however, have fewer departing researchers due to smaller overall team sizes (see Table A.1 in the Appendix).

[Insert Table 2 here]

Figure 1 shows the research group answers regarding the destinations of these departing researchers. The survey question was formulated such that group heads were asked to indicate the type of job (research or non-research job) leavers had taken up, the type of firm or institution, and whether leavers took up the new job in Germany or abroad. Multiple answers were possible and respondents could also indicate that they do not know. The survey did not ask how many members left for each of the destinations but only if anyone chose this destination. We can broadly classify the job destinations as jobs in industry and as employment at public institutions, e.g. universities, public research centers, and other public institutions, which include government. We further distinguish between different types of 'industry jobs': start-up companies, employment at small and medium-sized firms (SMEs), employment at large firms, and jobs in consulting firms.[4]

[Insert Figure 1 here]

The descriptive statistics already show that the higher education system provides an important source for highly qualified employees for both the public and the private sector. Only 6% of research groups trained researchers for public jobs alone, while 31% reported that all their departing researchers joined industry. The majority of groups, however, indicated destinations in both the public and the private sector. Academic start-ups occurred as a post-employment job choice in about 20% of the groups. Foundation of new firms by former employees was highest at technical universities as well as in the fields of physics and mechanical engineering (see Table A.2 for a disaggregation by field and institution type). The difference between SMEs and larger firms is not particularly pronounced, although researchers that go abroad tend to move to larger firms. A large share of departing researchers tend to stay in research jobs as indicated by the relatively small differences between the categories 'any' job and 'research' job. When comparing jobs domestically and abroad, we

[4] A further category was 'unemployment'. This category had been selected by 7% of the departments, however, always in combination with other categories.

find the overall distribution pattern to be quite similar, although going abroad is relatively less common. Finally, universities and public research institutions also constitute important destinations for leavers.

4. Results

In the following analysis, we study job destinations of departing researchers at different levels of aggregation. In doing so we consider these options to be interdependent, as researchers from one research group can enter into different types of employment and therefore estimate multivariate probit models.[5]

In the econometric set-up we also account for the fact that post-employment job choices are taken with different options in mind. Differences with regard to the work- and teaching loads or the level of competition within a field may differ by discipline and institution and could affect career aspirations of researchers. We therefore, in addition to the group characteristics presented in Table 1, control for institution type and subject area. We further control for institution size as measured by the number of students (on average about 18,000 during the year of the survey) and geographical characteristics, as local opportunities may affect the decision to start a new firm and geographical proximity to large firms or consulting companies may induce young researchers to move there. Specifically, we include three measures for regional economic activity at the district level (*Landkreis*)[6] in values referring to the pre-survey year: the gross domestic product to account for industrial activity in the region, income per capita to account for demand factors and firm net entry (new firm registrations minus exists) to control for regional structural change.

4.1 Aggregate destinations

Table 3 presents the results of the first set of probit models distinguishing between industry jobs and public jobs. We report marginal effects at the means of all other variables. Model 1 includes publication and patent counts, whereas citation-weighted publication and patent measures are included in Model 2. Models 1 and 2 both show that groups with a more experienced (older) leader are more likely to see leavers move to public sector jobs, while it

[5] We employ a Maximum Simulated Likelihood Method using the GHK simulator to estimate our models. See Roodman (2009) for details on the implementation of this method.

[6] Germany has 295 of these districts of which our sample covers 38.

is a weaker predictor for industry jobs. The gender of the group leader has no significant influence. We find no strong difference for either destination type with regard to the group's research orientation. Research groups that give high importance to joint publishing and patenting with industry have a higher probability of their researchers leaving for industry. The relevance of contract research also has a positive, but slightly weaker effect. When splitting up the group's grant-based financing into public grants and industry sponsoring, we find that as expected industry grants predict industry jobs and public grants predict public jobs.

A higher publication count during the five-years prior to the survey is associated with a higher likelihood of research groups sending their researchers to other public institutions. Whereas the patent count is not a good predictor for any of the destination options, citation counts to patents filed in the five-years prior to the survey are positively associated with industry jobs and to a smaller extent with public jobs.

Both models show that institution type and scientific field are important factors in shaping the job destinations of departing researchers, while regional characteristics do not have a significant effect. Researchers in physics and chemistry, for example, are more likely to remain in public sector jobs, while leavers from the engineering sciences are more likely to take up a job in industry.[7]

[Insert Table 3 here]

Previous research suggests that more differences may be observed when comparing research to non-research job destinations (Table 4). Model 1 looks at research and non-research jobs in industry. The results for research jobs are similar to those reported in Table 3, but refining our previous results, we observe that a basic research orientation within a group has a positive marginal effect for research jobs in industry but not for other jobs in the private sector. Model 2 distinguishes between research and non-research jobs taken in the public sector. The results

[7] If we repeat Models 1 and 2 of Table 3 for research jobs in industry and/or public institutions, thus excluding all non-research job destinations, we find that research groups with a higher share of industry grants are more likely to see their researchers move to industry, while public grants are associated with public sector jobs. The group head's publication numbers have a positive effect on the propensity of departing researchers to take up jobs in public institutions, while citations do not. Patent numbers have a positive effect on research jobs in industry, but the patent citation measure turns insignificant. Results are reported in Table S1.

show that publication performance matters for research jobs in the public sector[8], but not for non-research jobs. Similarly basic research orientation and public grants of the group matter only for research jobs. Contract research, on the other hand, predicts non-research public jobs, which could suggest that these researchers have the skills to move into project management. However, a group's patenting activity does not predict non-research jobs in the private or public sector. Subject area is also an important predictor of job destinations with leavers in physics and chemistry more likely to remain in research.

[Insert Table 4 here]

4.2 Disaggregate destinations

Table 5 shows the results for all seven disaggregate destinations. The academic age of the research leader is positively associated with researchers leaving to higher education and public research institutions, but also for start-ups. For movements to SMEs the importance of contract research is highly significant, while for large firms joint research links are a more important predictor. This confirms earlier research by Mangematin (2000) and Lam (2007) who stressed the role of such links for scientists to move to industry.

Research units with a focus on experimental development are more likely to see their former employees move to start-up firms, while for SMEs and larger firms a focus on basic research appears to be attractive. This in line with the notion that entrepreneurial spirit may be formed within the socialization environment (Nabi et al. 2006; Lam and de Campos 2014), however, it does not confirm that companies may be looking for more applied researchers.

Previous insights that public grants and publications are a good predictor of public sector research employment are confirmed. Researchers from groups that perform well on these indicators may indeed have a reputation and publication advantage that facilitates intra-academia moves (Long and McGinnis 1987; Petersen et al. 2014) or a stronger preference for such careers (Stern 2004). The effects from industry grants disappear, however, in the disaggregate model. Interestingly, we find the publication performance of the group head to be important for employment in industry, in particular in start-ups, large firms and in consulting. This indicates that institutional or research group reputation is also important for non-academic employers. Patent numbers of the research group leader are only significantly

[8] Publication quality in terms of citations does not matter. Results for quality measures are reported in Table S2.

positive for researchers' employment in SMEs but not for start-up foundation thus not confirming Lam and de Campos (2014). The results instead support the view that researchers socialized in more commercially oriented groups may not only favor jobs in industry, but particularly those in smaller firms that may grant them higher levels of autonomy. When accounting for industrial relevance of the patents[9], we find a significant positive impact of citation-weighted patents for SMEs, large firms and public research institutions, but the marginal effect is largest for the first destination.

As in the models presented above, research field and institution type matter. For instance, research groups at both universities and technical universities are more likely than research groups from Universities of Applied Sciences to see former employees move to large firms; technical universities are more likely to see employees moving to start-up firms; and research groups at universities and technical universities are more likely to produce future university researchers. With regard to subject areas we find that leavers in physics and chemistry are more likely to remain in higher education; those with a background in mechanical engineering are more likely to start their own firm; all engineering backgrounds are closer associated to large firms; consulting is more often a career destination for those with a mechanical engineering or computer science background; and a bioscience background is negatively associated with large firm or consulting jobs, but is more likely to lead to employment in small firms instead. In addition, we now find that regional factors are jointly significant confirming that external factors are also important in deciding the next destination of early career researchers.

[Insert Table 5 here]

5 Discussion and Conclusions

In this paper we studied the importance of the socialization environment for the career destinations of departing researchers. Socialization processes affect research performance, researchers' attitudes towards science, as well as their careers. By providing early career researchers with a certain skill set and by giving access to professional networks, research groups shape the careers of their members.

[9] Results using the quality-weighted publication and patent measures are reported in Table S3.

Understanding the factors behind the job destinations of early career researchers is crucial because of the importance of their mobility for knowledge and technology transfer between different academic institutions, but also between science and industry. As early career researchers present a valuable work force, their movement from university to industry is crucial for feeding the demand for skilled labor in the private sector. At the same time, previous literature has mourned the potential brain drain from academia to industry that may impede knowledge production within universities (Aghion et al. 2008).

This paper explored the research group characteristics that affect different types of destinations based on survey data from 676 science and engineering research groups at 46 universities in Germany. We add to the previous literature on career destinations by differentiating between research and non-research career paths in newly formed firms, SMEs, large firms, consulting companies, public research institutes and universities. We also add to the socialization discussion by differentiating between a series of departmental socialization factors, including their performance, orientation, inter-organizational networks, and funding sources. The results from multiple simultaneous equations models on the likelihood that researchers from a focal group take a specific follow-on career confirm the important role of the socialization environment in determining the careers of researchers. We find that a research group's network with industry partners, especially when established through contract research or joint research outputs, increases the propensity of its staff to move to industry. Research orientation, instead, is not a precise predictor of academic or industry job destinations. Basic research orientation is, however, positively associated with research jobs in industry, especially in large firms, while publication performance is a factor for research jobs in the public sector. On the other hand, applied groups are more likely to send their researchers into non-research consulting jobs, whereas groups with a focus on experimental development are more likely to have departing researchers starting their own firm. The share of a research group's total budget coming from public grants as well as its publication performance increases the probability that departing researchers move to a research job in the public sector, while grants from industry increase the likelihood that the nest trains researchers for a job in industry. Patents correlate positively with research jobs in SMEs, indicating that such firms value the acquisition of technological knowledge from former university employees.

Our results thus show that different socialization elements can explain different job destinations of early career researchers, and are particularly indicative of the importance of departmental links and research capabilities for the career prospects of departing researchers. The competencies and capabilities that researchers gain differ depending on their mentor and research group and thus prepare them for different career paths. Advisors often have a fundamental impact on research focus and research content and their skills and experiences may be directly transferred to the young scientists with whom they work. In addition, socialization could shape the preferences of departing researchers resulting in stronger disposition to take up a specific type of job. For example, Gemme and Gingras (2012) found that more exposure to the non-academic sector skews preferences in that direction while nest rewards such as internal scholarships skew preferences in the direction of academic careers, which suggests that socialization affects leavers' destinations primarily through direct interaction with institutions and people. It is therefore important to stress the responsibility that research groups and their leaders have for the careers of their members. As suggested by McAlpine and Emmioglu (2014) it is important to inform future members of the career paths chosen by departing members to make them aware of the potential options they have available upon completion of their studies. As the majority of early career researchers still favor a career in academia, the tendency of research group leaders to accumulate more funding to employ research students and postdocs supports academic aspirations. This support may be unwise as it may only delay the departure of researchers to other sectors. Instead, groups with a primary academic focus should also offer additional training for non-academic careers to their members to open up relevant career paths (McAlpine and Emmioglu, 2014). Although competencies and preferences have been shown to be closely correlated (Stern 2004; Gemme and Gingras 2012), we cannot answer the question of whether socialization builds competencies in relation to specific jobs or whether it shapes researchers' preferences. We encourage future research on these dynamics in the context of career choices.

Moreover, little is still known about which nest designs may contribute to keeping the most able scientific researchers in academe, while at the same time facilitating knowledge transfer to industry and public institutions. While our study focused solely on the research group, future studies may in addition consider individual characteristics of researchers. The same research group sends early career researchers onto different career paths, so additional investigation is warranted into the individual characteristics of leavers and their role within the group, as well as socialization factors that lie outside the academic training environment. It would therefore be of great value to study more explicitly the mechanisms that shape career decisions and how individual career preferences change or do not change during initial academic socialization.

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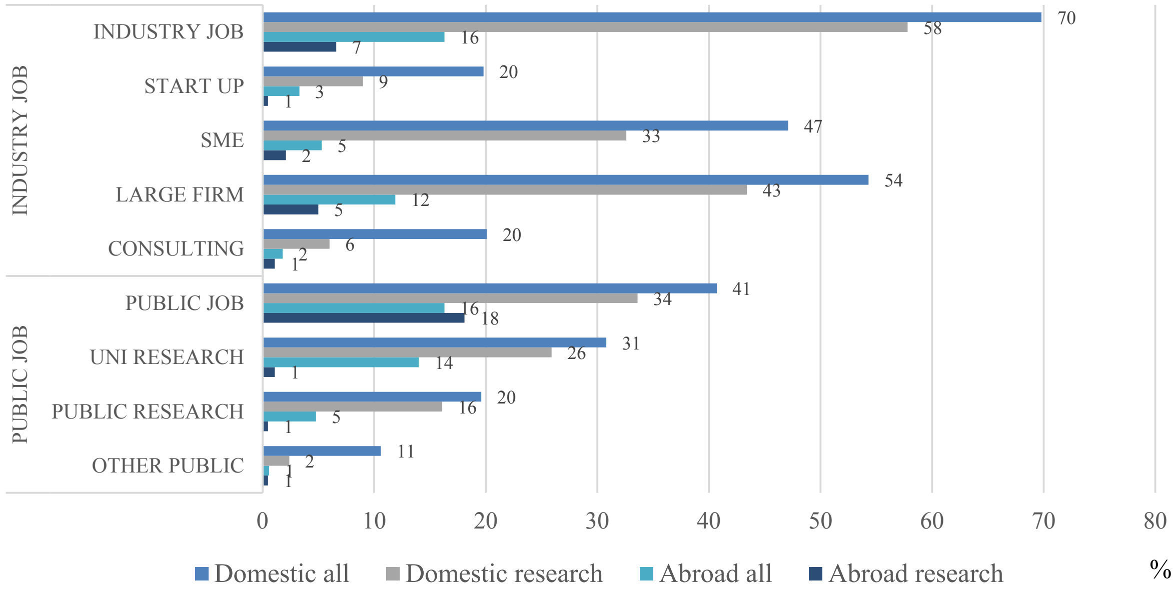
Figures

Figure 1: Job destinations of departing researchers by type of destination (n = 676, multiple answers possible*)



* Unemployment and unknown destination / unknown job type not presented.

Tables

Table 1: Summary statistics (n = 676)

Variable description	Variable name	Mean	Std. Dev.	Min	Max
Research group head and group composition					
Number of years since PhD	*EXPERIENCE*	21.869	8.720	1	43
Gender of unit head	*FEMALE*	0.033	0.178	0	1
Number of researchers	*LABSIZE*	7.573	9.537	0	71
Share of technical staff (in % of total)	*TECHS*	9.943	13.710	0	80
Group's research orientation / industry links					
Basic research (in %)	*BASIC*	41.707	26.357	0	100
Applied research (in %)	*APPLIED*	40.598	26.357	0	100
Experimental development (in %)	*DEVELOPEMENT*	17.695	21.519	0	100
Head's former job in industry	*FORMER_JOB*	1.371	1.184	0	3
Contract research for industry	*CONTRACT_RESEARCH*	1.348	1.116	0	3
Joint patenting/publishing with industry	*JOINT_RESEARCH*	0.851	0.920	0	3
Group's research funding					
Public grants (in % of total budget)	*PUBLIC GRANTS*	21.779	20.123	0	100
Industry grants (in % of total budget)	*INDUSTRY GRANTS*	8.580	13.435	0	100
Head's research output					
Number of publications	*PUBLICATIONS*	11.167	20.448	0	243
Number of citations to publications	*PUB_CITATIONS*	236.709	608.970	0	5907
Number of patents	*PATENTS*	1.402	3.463	0	32
Number of citations to patents	*PAT_CITATIONS*	20.054	124.968	0	2634

* Seven scientific field dummies not presented. See Table A.2 in the Appendix for details.

Table 2: Departing researchers (n = 676 obs.)

Variable description	Median	Mean	Std. Dev.	Min	Max
Number of departing researchers	4	6.30	9.56	0	132
by duration of employment					
1-3 years	1	2.63	6.65	0	105
4-5 years	1	2.89	4.68	0	40
> 5 years	0	1.01	3.50	0	60

Table 3: Simultaneous bivariate probit estimation results on industry versus public sector employment (n = 676)

	Model 1				Model 2			
	INDUSTRY_JOB		*PUBLIC_JOB*		*INDUSTRY_JOB*		*PUBLIC_JOB*	
	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.
Research group head and group composition								
EXPERIENCE	0.004	0.037	0.009 ***	0.003	0.004 *	0.002	0.009 ***	0.003
FEMALE	-0.070	0.104	-0.066	0.117	-0.072	0.101	-0.080	0.116
TECHS	-0.003 *	0.002	0.001	0.002	-0.003 *	0.002	-0.001	0.002
Group's research orientation / industry links								
BASIC	0.016 **	0.007	0.011 *	0.006	0.016 **	0.007	0.012 **	0.006
APPLIED	-0.011 *	0.006	-0.001	0.007	-0.011 *	0.006	-0.001	0.007
DEVELOPEMENT	0.004	0.011	-0.001	0.012	0.004	0.011	-0.002	0.025
FORMER_JOB	0.010	0.021	-0.023	0.021	0.008	0.021	-0.030	0.021
CONTRACT_RESEARCH	0.036 *	0.021	0.035	0.025	0.037 *	0.021	0.035	0.025
JOINT_RESEARCH	0.051 **	0.025	-0.034	0.026	0.051 **	0.026	-0.033	0.027
Group's research funding								
PUBLIC GRANTS	0.002 **	0.001	0.004 ***	0.001	0.002 **	0.001	0.004 ***	0.001
INDUSTRY GRANTS	0.004 *	0.002	-0.002	0.002	0.003 *	0.002	-0.002	0.002
Head's research output								
ln(PUBLICATIONS)	0.019	0.017	0.057 ***	0.021				
ln(PATENTS)	0.048	0.030	0.025	0.030				
ln(PUB_CITATIONS)					0.016	0.015	0.023	0.019
ln(PAT_CITATIONS)					0.044 **	0.020	0.039 *	0.020
Log likelihood	-685.75				-687.04			
rho (s.e.)	0.454 (0.060)***				0.451 (0.062)***			
Joint sign. field dummies	26.50***				33.13***			
Joint sign. of inst. type dummies	36.02***				36.52***			
Joint sign. of regional variables	4.07				4.23			
Institution size control	Yes				Yes			

Note: Institution type and field dummies not presented. All models contain a constant. Standard errors clustered by institution type, field and region (171 clusters). Marginal effects are calculated at means of all other variables. * (**, ***) indicate significance levels of 1% (5%, 10%).

Table 4: Simultaneous bivariate probit estimation results on type of job in the private or public sector (n = 676)

	Model 1				Model 2			
	RESEARCH INDUSTRY		*OTHER INDUSTRY*		*RESEARCH PUBLIC*		*OTHER PUBLIC*	
	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.
Research group head and group composition								
EXPERIENCE	0.003	0.003	0.004	0.002	0.009 ***	0.002	0.001	0.001
FEMALE	-0.060	0.129	0.008	0.110	-0.029	0.108	-0.022	0.052
TECHS	-0.004 **	0.002	0.001	0.002	-0.001	0.002	0.001	0.001
Group's research orientation / industry links								
BASIC	0.018 ***	0.006	0.006	0.005	0.013 **	0.005	0.002	0.002
APPLIED	-0.006	0.006	0.008	0.007	0.002	0.006	0.003	0.002
DEVELOPEMENT	-0.008	0.013	0.004	0.011	-0.001	0.009	0.002	0.004
FORMER_JOB	0.006	0.023	0.006	0.023	-0.015	0.020	0.007	0.009
CONTRACT_RESEARCH	0.036 *	0.021	0.001	0.022	0.035	0.024	0.026 ***	0.009
JOINT_RESEARCH	0.033	0.025	0.032	0.023	-0.025	0.023	-0.024 *	0.012
Group's research funding								
PUBLIC GRANTS	0.002	0.001	0.002 **	0.001	0.003 ***	0.001	-0.001 *	0.000
INDUSTRY GRANTS	0.004 ***	0.002	-0.001	0.002	-0.001	0.002	-0.001	0.001
Head's research output								
ln(PUBLICATIONS)	0.015	0.019	0.036 *	0.021	0.044 **	0.019	0.007	0.008
ln(PATENTS)	0.051	0.034	-0.033	0.028	0.028	0.027	-0.006	0.013
Log likelihood	-771.31				-512.47			
rho (s.e.)	0.195 (0.068)***				0.254 (0.097)**			
Joint sign. field dummies	41.77***				32.01***			
Joint sign. of inst. type dummies	41.71***				3.73			
Joint sign. of regional variables	13.77**				6.86			
Institution size control	Yes				Yes			

Note: Institution type and field dummies not presented. All models contain a constant. Standard errors clustered by institution type, field and region (171 clusters). Marginal effects are calculated at means of all other variables. * (**, ***) indicate significance levels of 1% (5%, 10%).

Table 5: Multi-equation simultaneous probit estimation results on separated destinations (n = 676)

	START_UP		*SME*		*LARGE FIRM*		*CONSULTING*		*UNI_RESEARCH*		*PUBLIC_RESEARCH*		*OTHER_PUBLIC*	
	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.
Research group head and group composition														
EXPERIENCE	0.005 ***	0.002	0.004	0.003	-0.001	0.003	0.002	0.002	0.008 ***	0.002	0.004 **	0.002	0.001	0.001
FEMALE	0.156	0.123	-0.012	0.138	-0.199 *	0.112	0.087	0.094	-0.022	0.100	-0.129 ***	0.041	-0.045	0.037
TECHS	0.002	0.001	-0.001	0.002	-0.001	0.002	-0.001	0.001	-0.002	0.002	-0.001	0.001	0.002 *	0.001
Group's research orientation / industry links														
BASIC	0.005 *	0.003	0.016 ***	0.005	0.018 ***	0.007	0.006 *	0.003	0.012 **	0.005	0.008 ***	0.003	0.002	0.002
APPLIED	0.006	0.018	0.005	0.007	-0.007	0.007	0.009 *	0.005	-0.001	0.007	0.002	0.005	0.001	0.003
DEVELOPEMENT	0.017 *	0.009	-0.001	0.016	0.009	0.013	-0.011	0.009	0.001	0.012	-0.002	0.009	0.005	0.005
FORMER_JOB	0.002	0.015	-0.030	0.022	0.022	0.026	0.005	0.016	-0.024	0.020	0.007	0.016	-0.003	0.012
CONTRACT_RESEARCH	0.014	0.017	0.065 ***	0.023	0.028	0.023	-0.008	0.015	0.009	0.024	0.028 *	0.017	0.027 ***	0.011
JOINT_RESEARCH	-0.006	0.018	0.012	0.027	0.052 *	0.029	0.027	0.017	0.005	0.024	-0.003	0.018	-0.018	0.016
Group's research funding														
PUBLIC GRANTS	0.001	0.001	0.002 *	0.001	0.002	0.001	0.001	0.001	0.003 **	0.001	0.002 **	0.001	-0.001	0.001
INDUSTRY GRANTS	0.002	0.001	-0.001	0.002	0.003	0.002	0.001	0.001	-0.002	0.001	-0001	0.002	-0.001	0.001
Head's research output														
ln(PUBLICATIONS)	0.031 **	0.014	0.001	0.019	0.060 ***	0.019	0.029 **	0.014	0.032 *	0.017	0.018	0.015	0.011	0.010
ln(PATENTS)	0.001	0.020	0.063 **	0.029	0.036	0.033	-0.023	0.022	0.014	0.030	-0.008	0.019	-0.007	0.015
Institution type														
UNI	0.084	0.060	0.107	0.082	0.533 ***	0.068	0.173 ***	0.066	0.211 **	0.082	0.086	0.067	0.043	0.041
TU	0.120 *	0.072	0.145	0.090	0.445 ***	0.062	0.195 *	0.107	0.201 **	0.098	0.091	0.093	0.051	0.052
UAS							*Reference category*							
Log likelihood							-2051.471							
Joint sign. field dummies							152.61***							
Joint sign. of inst. type dummies							56.71***							
Joint sign. of regional variables							67.80***							
Institution size controls							Yes							

Note: Field dummies not presented. All models contain a constant. Standard errors clustered by institution type, field and region (171 clusters). Marginal effects are calculated at means of all other variables. * (**, ***) indicate significance levels of 1% (5%, 10%). See Table A.3 for correlations between equations.

APPENDICES

Table A.1: Departing researchers by institution type (means, n = 676)

Variable description	**UNI**	**TU**	**UAS**
Number of researchers	8.53	10.55	1.74
Number of departing researchers	7.61	7.52	1.46
by duration of employment			
1-3 years	3.46	2.25	0.86
in %	34.38	22.61	27.90
4-5 years	3.34	4.21	0.25
in %	42.22	50.14	7.47
> 5 years	1.14	1.36	0.29
in %	10.94	15.78	9.70

Table A.2: Job choices by field and institution type (n = 676)

Field	**#**	**%**	*INDUSTRY JOBS*				*PUBLIC JOBS*		
			START_UP	*SME*	*LARGE_ FIRM*	*CON- SULTING*	*UNI_ RESEARCH*	*PUBLIC_ RESEARCH*	*OTHER_ PUBLIC*
by field									
Physics	106	15.68	0.26	0.55	0.65	0.30	0.58	0.42	0.15
Mathematics / Computer Science	107	15.83	0.12	0.36	0.46	0.23	0.31	0.12	0.06
Chemistry	95	14.05	0.15	0.62	0.65	0.23	0.52	0.31	0.23
Biology	58	8.58	0.17	0.47	0.26	0.05	0.45	0.19	0.05
Electrical Engineering	101	14.94	0.19	0.45	0.60	0.09	0.20	0.13	0.08
Mechanical Engineering	108	15.98	0.24	0.51	0.58	0.22	0.21	0.08	0.05
Other Engineering	101	14.94	0.21	0.36	0.50	0.18	0.29	0.19	0.12
by institution type									
University	377	57.32	0.20	0.52	0.65	0.24	0.47	0.27	0.13
Technical University	157	23.68	0.29	0.54	0.63	0.25	0.35	0.20	0.11
University of Applied Sciences	142	19.00	0.08	0.27	0.17	0.02	0.08	0.04	0.04