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Moving Up The Ladder: The Influence of Heterogeneous Mentors and Research Orientations on Academic Careers

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Abstract

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Abstract

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Keywords: Academic Careers; Mentors; Cultural Heterogeneity; Disciplinary Heterogeneity; Research Orientation; Pasteur's Quadrant

1. Introduction

Academics have recently faced an increasingly protean environment due to substantial changes in the nature of knowledge (Etzkowitz, 2010). Yet, the career advancement of academics still follows the traditional tenure track suggesting a predictable linear and upward career ladder (Baruch and Hall, 2004). The resulting bifurcation between clear cut academic career ladders and academics' protean environment gives rise to the following two questions: How do academics' own heterogeneity, in terms of mentor-mentee heterogeneity and in terms of their research orientation, affect their career prospects? Whether and how does the academic tenure track accommodate the needs of academics and society in an increasingly protean environment?

Important changes in the academic landscape have been driven by technological progress as well as societal and economic requirements. Technological progress in today's knowledge intensive societies has led to a growing and increasingly specific, complicated and complex knowledge base that is scattered around the globe (Jones, 2009). An important driver of technological progress has been the development and deployment of all-encompassing fields, such as biotechnology, information and communication technologies, and nanotechnology. The emergence of these fields has set in motion a deeper integration of the academic and industrial world (Carayol, 2003; European Commission, 2012). Parallel to these developments, academics face requirements to link their research with societal and economic needs (European Commission, 2013; Martin, 2012). Particularly the general public, policy makers and university management expect academics to engage in activities of knowledge and technology transfer by collaborating with industrial and public partners (Martin, 2012; Perkmann et al., 2013).

Evidently, these contextual developments have reflected on universities, research teams and academics. In recent years, universities have been attributed a more central role in the innovation process (Etzkowitz and Viale, 2010) and have even served as nodes of inter- and intraregional knowledge transfer (Fromhold-Eisebith and Werker, 2013). Research groups increasingly rely on external knowledge and knowledge from other fields to inform their research, leading them to engage in intensified collaboration and to become interdisciplinary (Wuchty, Jones, and Uzzi, 2007). In face of the huge amount of knowledge available to academics, many have narrowed their area of expertise and broadened the scope of their networks in order to compensate for this (Wuchty, Jones, and Uzzi, 2007).

In the following we analyse two sources of heterogeneity that may affect academics' ability to build their careers in the increasingly protean environment illustrated above. The first source of heterogeneity of interest to us is *mentor-mentee heterogeneity*. We study whether differences from one's PhD supervisor, i.e. mentor, in terms of disciplinary and cultural background affect academics' ability to deal with their protean environment. In our analyses we disentangle mentor-mentee heterogeneity's influence on academics' careers in the short and long run. The second source of heterogeneity of interest to us is *heterogeneity emerging from research orientation*. In this respect, we look into the extent to which academics choose to deal with heterogeneity in their research environment. Thereby, we investigate how the balancing act between striving for fundamental understanding or directing efforts to find applications of economic and societal relevance affects academics' career success.

Our data covers academics in all career stages from junior post-docs to senior full professors. We collected the data at the departments of natural sciences and engineering at two European universities of technology. By combining a unique dataset with novel (and theoretically warranted) empirical estimation techniques our work reflects the theoretically hierarchical (and supposedly linear) career paths of academics, yet allows for heterogeneous transitions and leapfrogging in academic careers. Therefore, we believe that our theoretical framework and the empirical approach taken cover the fine-grained nuances of academic careers and are prudent.

Our results suggest that *mentor-mentee heterogeneity* exhibits a positive effect in early career stages. However, in the longer run cultural and disciplinary mentor-mentee heterogeneity diminish the likelihood that academics will secure tenured academic positions. *Heterogeneity emerging from research orientation* has a multifaceted effect on academics' career success. Academics mainly focusing on Bohr-type research, i.e. pure basic research, are least successful in climbing the academic ladder. Academics mainly focusing on Edison-type research, i.e. pure applied research, may thrive in mid-career stages but have lower chances to move beyond the associate professor level. Academics focusing on Pasteur-type research, i.e. use-inspired research, have the best chances of obtaining full professorships.

Our insights are relevant for policy makers, university managers and academics themselves. Policy makers and university managers can use our results to develop tailored support and stimulation strategies for academics as well as to hire those academics who are most likely to succeed in their careers. In turn, academics themselves benefit from insights into bottlenecks and chances of career progress. Our results may well inform their choice of research orientation and PhD supervisors.

With our analysis we go beyond former findings and calls for further investigations in two ways. First, previous studies have concentrated on early stages of academic careers only (e.g. Fox and Stephan, 2001; Roach and Sauermann, 2010; Van der Weijden, Teelken, De Boer, and Drost, 2015). In contrast, we investigate how specific factors affect academics' progress and success throughout their entire careers. Second, we do not only investigate how an increased emphasis on commercialization changes the nature of academia (Larsen, 2011), but systematically study whether and how research orientation affects academics' careers.

We continue our paper by setting out theory and hypotheses (Section 2) to then introduce our sample, variables and models (Section 3). Subsequently, we present our results in Section 4 and discuss their theoretical and practical implications in Section 5. The paper is completed with a brief summary of our findings and various future research avenues (Section 6).

2. Theory

2.1 Academic Career Paths

Academic career paths differ between countries but show similar flat hierarchy structures (e.g. Baruch & Hall, 2004). We picture an archetypical career path for academics in Figure 1, starting with the stage of an 'early career position'. In the years directly after obtaining their doctoral degree academics early stage career positions can typically take two forms (e.g. Bedeian et al., 2010, Baruch & Hall, 2004). In one of these positions the academic works as a postdoctoral researcher, i.e. postdoc, mainly focusing on research tasks. Postdocs likely obtain valuable research experience, whereas teaching is commonly not their primary task. Alternatively, early career academics can hold a junior teaching position that includes both research and teaching tasks. Usually academics with a preference for teaching tend to take on a junior teaching position fresh out of their doctoral training (Fox and Stephan, 2001). However, some young academics may also secure an assistant professorship right after obtaining their doctoral degree, while others qualify for an assistant professorship only after several years on a postdoc or teaching position. Hence, for some researchers the first career advancement might be characterized by successfully transitioning from postdoc to the next career level, while others may leap this very first stage and become assistant professors right away.

Subsequently, after a number of years academics may climb up the academic ranks to the subsequent levels of associate and full professor (Zumeta and Raveling, 2001). While academics usually still get tenure after several years of experience, there is a trend towards more flexible arrangements with short-term and part-time contracts (Baruch & Hall, 2004). Thus, academics may move from an assistant to an associate professorship and finally transition to a full professorship. Yet, again, there are academics who leapfrog the associate level and become full professors directly after their assistant professorships. That is, while the academic career path is clearly hierarchical, it is only theoretically linear with possibilities of jumps for some but not all academics. In the following, we are therefore interested in the transitions that occur between each level in the academic hierarchy and how individuals advance in their careers.

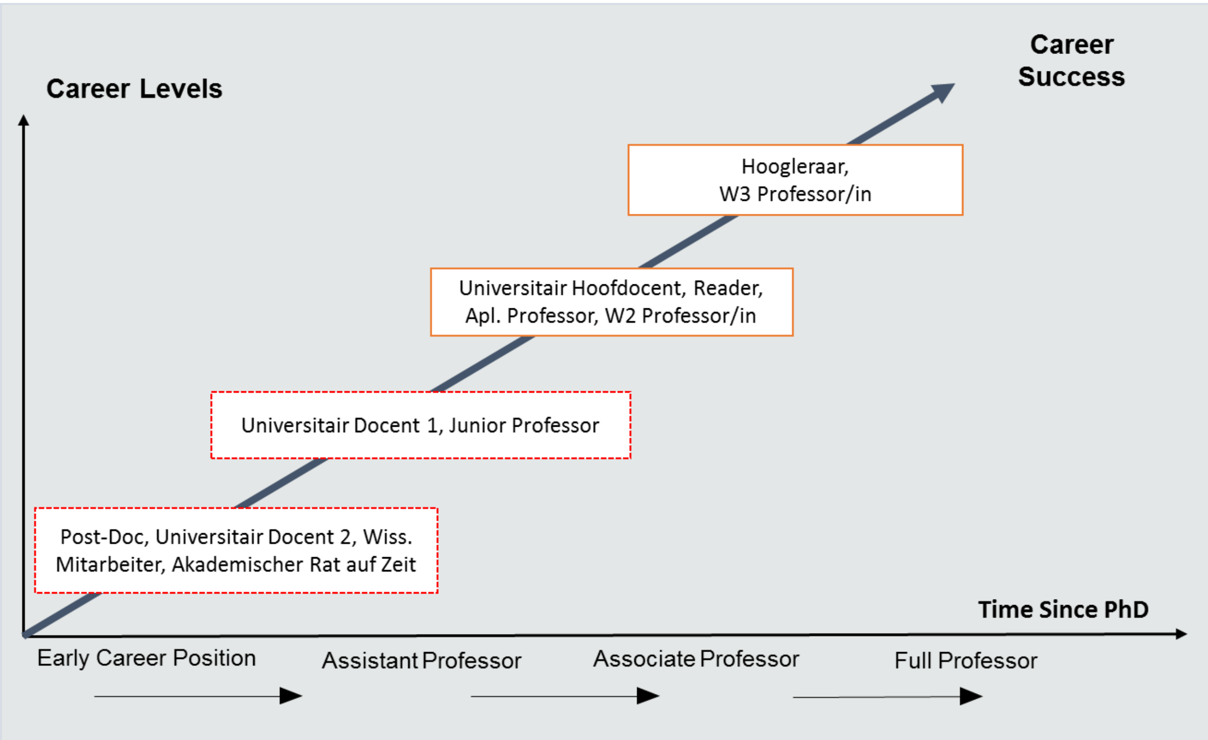

Figure 1 - Careers in German and Dutch Universities along the Archetypical Academic Career Path

2.2 Mentor-Mentee Heterogeneity: The Role of PhD Supervisors

With the burden of ever-accumulating knowledge, preparation for a career in research takes longer and the job of academics has become more demanding. That is, individuals spend longer periods of time in the educational process in order to catch up with the frontier of scientific development (Jones, 2009). The so-called “knowledge burden” strains the cognitive abilities of aspiring scientists. In response, scientific research is organized ever more in teams (Wuchty et al., 2007).

An important early impetus for academics’ research is the PhD supervisor. It is likely that academics’ career progress hinges, at least in part, on what they take away from the mentoring experience with their PhD supervisors. PhD supervisors guide, support and socialize PhD students during their formative years of becoming an independent researcher (e.g. Austin, 2002). It is common-practice for experienced senior academics to mentor PhD students and the positive effects of such practices have long been recognized (Scaffidi & Berman, 2011; Singh, Ragins, and Tharenou, 2009). PhD supervisors proved to be particularly important for academics’ careers for three reasons. First, mentors serve as role models for their mentees (Eby et al., 2010; Marquis and Tilcsik, 2013). Second, the doctoral training period and early career stage are essentially sensitive periods in careers where influential imprints may be left (e.g. McEvily et al., 2012). Particularly, early stage imprints persist because of exaptation, implying that an imprinted characteristic may serve different purposes over time as the individual is exposed to different environments (Gould, 1991; Marquis and Huang, 2010). Thus, mentors do not only influence mentees during their formative years but likely affect their career paths lastingly. Third, the access to mentors’ network proves important for the career development of mentees, because mentees become visible in the mentors’ network of colleagues (Johnson, 2007).

As PhD supervisors form their students in their formative years we suggest that they influence the way in which academics deal with heterogeneity throughout their career. As knowledge generation has become more complex (see Section 1), the ability to deal with heterogeneity may benefit research outcomes. Flows of information, critical feedback loops for discussion, and access to new ideas are important to academics' work that is interdependent, complex, and often reciprocal. The experience of dealing with a diverse set of backgrounds allows individuals to share points of view and access critical information when needed. Intangible resources of other academics can be used to work jointly for the common goal especially in knowledge intensive areas (Azoulay et al., 2011). Hence, having had a supervisor with a heterogeneous background can offer advantages to one's career prospects. Exposure to novel knowledge and problem solving may one's abilities and opportunities to engage in independent research at a later stage. So, the question is whether mentor-mentee heterogeneity or a lack thereof affects academics' subsequent careers.

In general, mentors have proven to be important in early career stages (Azoulay et al., 2011). Early career mentoring affects academics' patenting behaviour throughout their careers and even offsets other factors that commonly predict patenting behaviour, e.g. gender influences (Azoulay, Ding, and Stuart, 2009). Hence, facets of the socialization process may be used as levers to mould, imprint and retain high potential academics.

In the following, we investigate whether more or less heterogeneity between academics and their PhD supervisors positively influences career success. In particular, we analyse whether mentor-mentee heterogeneity or homogeneity helps academics in climbing the academic career ladder? We build on earlier works that tried to disentangle the mixed and partly contradictory empirical evidence on the relationship between heterogeneity and success (e.g. Pull, Pferdmenges, and Backes-Gellner, 2015). In doing so, we emphasize two sources of heterogeneity, knowingly: cultural heterogeneity and disciplinary heterogeneity. Cultural mentor-mentee heterogeneity relates to differences in institutional background, e.g. differences in nationality. Disciplinary mentor-mentee heterogeneity points at differences in the knowledge base.

In cases of *cultural* mentor-mentee homogeneity shared formal institutions (such as laws and rules) and informal institutions (such as cultural norms and habits) enable knowledge transfer, interactive learning and innovation between mentor and mentee (Boschma, 2005; North, 1991; Porac et al., 2004). Theoretically, cultural homogeneity may be expected to give mentees advantages, because of processes of similarity-attraction (Williams and O'Reilly, 1998) and social categorization (Tajfel, 1982). General preferences to work with similar others as well as people's tendency to group and treat within-group others differently from outsiders (Stahl, Maznevski, Voigt, and Jonsen, 2010) may give culturally homogenous mentees a head start. At the same time, too much cultural homogeneity can lead to lock-ins and inertia that hamper the emergence of new ideas. Cultural mentor-mentee heterogeneity during doctoral training may help academics to develop capabilities enabling them to work within culturally heterogeneous research teams. Cultural heterogeneity of teams often leads to performance gains such as improved problem-solving and creativity (e.g. Watson, Kumar, and Michaelsen, 1993). Similar performance advantages may be expected for culturally heterogeneous mentors and mentees, ultimately affecting the mentees' career success.

Empirical evidence on cultural heterogeneity is sketchy and mixed. While Pull et al. (2015) find no relationship between cultural heterogeneity and the performance of research teams in the natural sciences, they do find a positive relationship for social sciences and humanities. At the same time, international mobility, most likely exposing academics to culturally heterogeneous research teams and mentors, is found to slow down rather than speed up career advancement (Cruz-Castro and Sanz-Menéndez, 2010). Postdocs with international experience, having worked with culturally heterogeneous advisors, are obstructed in their career progress, whereas their counterparts who were likely mentored by culturally homogenous senior academics are quicker to earn tenure (Cruz-Castro & Sanz-Menéndez, 2010).

Taking theoretical considerations and empirical evidence together we suggest the following hypothesis for cultural mentor-mentee heterogeneity influencing academics' careers:

H1 *Cultural mentor-mentee heterogeneity* between academics and their PhD supervisors reduces the chances of advancing in the academic career.

In cases of *disciplinary* mentor-mentee homogeneity, mentees may have better opportunities to learn from their PhD supervisors, because they share the same disciplinary language and have complementary knowledge bases and expertise that simplify learning processes (Boschma, 2005; Huber, 2012). Academics may benefit from having the same knowledge base as their PhD supervisor as this helps them to develop specific expertise in a well-defined, and perhaps even narrowly defined, knowledge field. However, too much homogeneity may come at a cost, as it leads to lock-ins which hamper learning and knowledge transfer (Boschma, 2005). Mentors and mentees using different but related knowledge bases may understand relevant synergies, identify challenging and relevant research problems, and come up with creative out-off the box solutions. Therefore, disciplinary mentor-mentee heterogeneity during doctoral training may help academics to develop capabilities enabling them to collaborate on interdisciplinary projects in later stages of their careers as well.

Empirical evidence on disciplinary heterogeneity is comprehensive and originates mostly from the substantial body of knowledge on cognitive proximity. This points at research success in cases where disciplinary heterogeneity is sufficiently large but not too large

(Cunningham and Werker, 2012; Huber, 2012). Nonetheless, Pull et al. (2015) find that disciplinary heterogeneity negatively affects the performance of PhD research teams in the natural sciences. Therefore, we suggest that disciplinary heterogeneity with their PhD supervisors negatively affect academics' likelihood of career advancement.

H2 *Disciplinary mentor-mentee heterogeneity* between academics and their PhD supervisors reduces the chances of advancing in the academic career

Cultural and disciplinary mentor-mentee heterogeneity may not evenly affect the transition between the different stages of the academic career ladder. Imprinted characteristics of academics may serve different purposes over time as the individual is exposed to different environments (Marquis and Huang, 2010). Studies on careers and inequality imply that "a given imprint might produce advantage for an individual in one environment and disadvantage in another" (Marquis and Tilcsik, 2013, p. 234). Academia traditionally grants scientists more freedom to pursue their upstream, more fundamental research interests and the reward for academic excellence is expressed primarily in peer recognition rather than money (Stephan, 1996). Empirical studies show that PhDs with a stronger "taste for science" – those who value freedom and opportunities for collaboration in their jobs – are the ones most likely to opt for a continued stay in academia (Roach and Sauermann, 2010). Furthermore, PhDs who stay in academia have usually also attained higher levels of scientific quality in their research output (Mangematin, 2000). Early career positions typically offer more freedom to explore and experiment. More specifically, Millar (2013) found that those finalizing a PhD thesis on an interdisciplinary topic found an academic position much more easily than those who had stayed within disciplinary boundaries. As PhD supervisors with areas of expertise that differ from their PhD students increase the likelihood of interdisciplinary work in the PhD thesis, we suggest that mentor-mentee heterogeneity may have a positive influence on academic careers directly after defending the PhD thesis. We therefore suggest the following hypothesis:

H3 *Both cultural and disciplinary heterogeneity* increase the chances of achieving early career advancements, yet both reduce the chances of achieving later career advancements.

2.3 Heterogeneity Emerging From Research Orientation: Bohr, Pasteur or Edison-type

Academics may have substantially different research orientations. Some academics focus on industrial, economic or societal needs, while others pursue fundamental advancement of the knowledge base (Azoulay et al., 2009; Fabrizio & Di Minin, 2008; Larsen, 2011). The choice of research orientation is made on a discretionary basis and largely depends on the academic's own preference. However, the general public, policy makers and university management increasingly expect academics to produce output with economic and societal relevance (Martin, 2012, Perkmann et al., 2013) and thereby exercise some control over research orientations.

Substantial heterogeneity may emerge from the research orientation of academics. Academics working on pure basic research can do so in a rather homogenous academic environment (Hessels and Van Lente, 2008; Nowotny, Scott, and Gibbons, 2003). In contrast, academics attending to more applied research problems face much more heterogeneity in the knowledge they use and produce as well as in the types of partners with whom they collaborate (Hessels and Van Lente, 2008). We compare academics with three different research orientations (see Figure 2) that come with varying degrees of heterogeneity. First, academics mainly focusing on Bohr-type research, i.e. doing pure basic research with the primary purpose of enhancing the knowledge base of their discipline (Stokes, 1997). These academics deal with little heterogeneity of goals, knowledge and partners (Nowotny et al., 2003). Second, academics mainly focusing on Edison-type research, i.e. pure applied research primarily targeted to contribute to solutions relevant to the economy and society (Stokes, 1997). Edison-type researchers collaborate with heterogeneous industrial and public partners and deal with heterogeneous goals which have proven to be difficult to handle (Porac et al., 2004). Third, academics with a Pasteur-type research orientation, i.e. doing use-inspired research and pursuing two types of goals in their research as they enhance the knowledge base of their field and provide applied solutions (Stokes, 1997). As a consequence, Pasteur-type academics deal with most heterogeneity in their goals, knowledge and partners. Although Edison-type academics also face some heterogeneity, compared to Pasteur-type academics their knowledge field is relatively well-defined (Stokes, 1997).

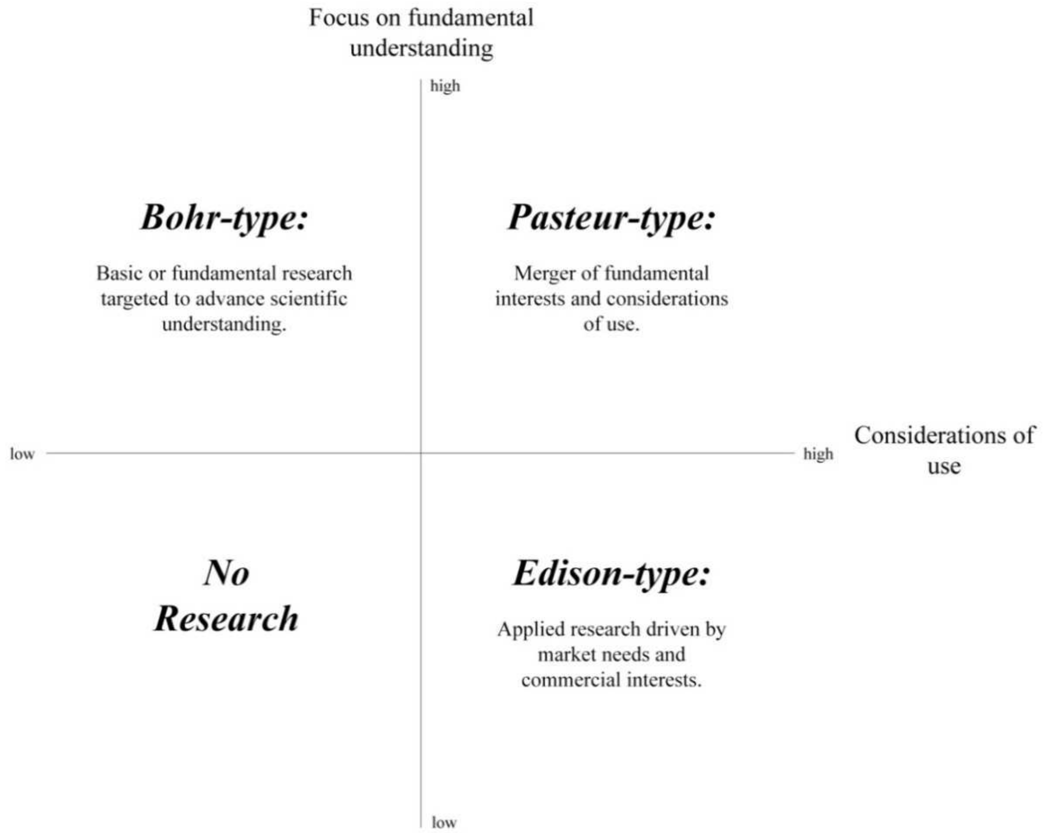

Figure 2 *- Research Orientation – Stokes' Quadrant Model*

Academics' output and thereby their success criteria depend on their research orientation (Abreu and Grinevich, 2013; Bekkers and Bodas Freitas, 2008; Philpott, Dooley, O'Reilly, and Lupton, 2011). Although publishing in academic journals is still an important aspect of academics' jobs commercial activities have become increasingly important (Bentley, Gulbrandsen, Kyvik, 2015). While almost all academics publish, the ones oriented towards practical application of their work are also active outside the academic realm (Ylijoki, Lyytinen, and Marttila, 2011). For example, they offer consultancy services and contribute to product and process innovations or patents (Perkmann et al., 2013; Phillpott et al., 2011; Wright, Clarysse, Lockett, and Knockaert, 2008). Academics focusing on either Bohr-type, Edison-type, or Pasteur-type research contribute differently to the various kinds of output (Stokes, 1997). Academics focusing on Bohr-type research extend the knowledge base by publishing. Academics concentrating on Edison-type research help to solve socio-economically relevant problems (Lam, 2010). They want to make things work and are less interested in the underlying theoretical mechanisms. Academics focusing on Pasteur-type research try to meet both scientific and socio-economic goals by transforming their scientific insights into solutions for practical problems and vice versa (Stokes, 1997; Lam, 2010). Thus, the type of research orientation influences the type of output: Bohr-type research leads mainly to publications, Edison-type research leads mainly to innovations, and Pasteur-type research leads to both above average publication and above average innovation output.

In order to climb the academic career ladder it is important to recognize that the criteria for assessing academics' performance have changed with the roles of universities and the requirements of academics' jobs. We see the remains of a social contract for universities emphasizing basic research as their main task. This contract is a derivative of the seminal report by Bush (1945) meant to strengthen basic research. As a consequence, substantial public funding supported basic research at U.S. universities in the period after the Second

World War. Following the U.S. example, European countries assigned basic research as an important task to universities as well (Martin, 2012). However, we are noticing a change in the social contract of universities, as it seems to increasingly reflect the contract that was valid before the second half of the 20th century. In this former contract universities were responsible for both the quest for fundamental understanding and for development of socio-economically relevant applications (Martin, 2012).

As academics' success criteria[1] have evolved in the last six decades their career success increasingly depends on their research orientation. While contributions to the knowledge base remain an important task of academics, they have the opportunity to stand out from others by their contributions to applied research (Ylijoki et al., 2011). Given that the general public, policy makers and university management expect academics to contribute to socio-economic problem-solving (Martin, 2012; Perkmann et al., 2013), we suggest that career success is most difficult to attain for academics focusing on Bohr-type research. At the same time, we recognize that universities' core task is still to build and extend the knowledge base (Jones, 2009; Martin, 2012). Therefore, we suggest that academics focusing on Pasteur-type research have the best chances of career success, as they combine both the quest for fundamental understanding and applied interests. In turn, as academics focusing on Edison-type research primarily provide solutions to socio-economic problems, their contribution to the scientific knowledge base is likely less than that of Pasteur-type academics. Hence, their career opportunities are better than those of academics focusing on Bohr-type research, but worse than those of academics focusing on Pasteur-type research.

H4 Academics focusing on Pasteur-type research are most likely to climb the academic career ladder, those focusing on Edison-type research are less likely to do so, while

[1] Of course teaching is another important assessment criteria for academics' work. However, there is no indication that the social contract for universities has changed in this respect (Martin, 2012). Therefore, we do not include teaching in our analysis.

academics focusing on Bohr-type research have the lowest chances of career advancement.

3. Methods

3.1 Sample

Our sample contains data from a survey amongst faculty members at two leading European universities of technology: RWTH Aachen University (Germany) and Delft University of Technology (The Netherlands). We applied two sampling criteria. The first criterion was that there were faculty members conducting research in disciplines present in both universities. This criterion ensures sufficient similarity between the samples from both universities. The disciplines practiced at both universities were chemistry, design and industrialization, energy and processes, environment science and technology (also including geoscience and sustainable development), fluids, information and communication science and technology, life and health science and technology, materials science, mathematics and their applications, mechanics, physical chemistry and chemical engineering, physics and optics, and urban planning and transport. The second criterion was that the faculty members held a PhD degree. This ensured that academics were able to do independent research. Because of the organization of the email distribution lists at both universities, scientific staff without a doctoral degree could not be excluded completely. That held particularly for the RWTH Aachen University where the list of scientific staff members included doctoral students. To make sure that we only received responses from those with a PhD degree we asked about this at the very beginning and excluded the respondents not holding a PhD. However, this restriction considerably affected the questionnaire’s response rate, i.e. about 11% for the RWTH Aachen University and about 19% for the Delft University of Technology. We approached 4,496 academics at RWTH Aachen University and 1,490 academics at Delft University of Technology, adding up to 5986 potential respondents. We got 491 responses from RWTH Aachen University and 279 responses from Delft University of Technology, adding up to 770 responses. 246 and 239 respondents held a doctoral degree at the time of data collection respectively. So, for our study the answers of 485 academics were relevant. 265 academics gave sufficient information on their research orientation of which 17 provided insufficient information on cultural and disciplinary heterogeneity. Therefore, our final sample comprises 248 respondents, 109 working at RWTH Aachen University and 139 working at Delft University of Technology.

Data collection took place through a web-based questionnaire between November 2012 and March 2013. All questionnaire responses were anonymized. To establish credibility and to guarantee privacy, the questionnaires were sent from within the universities.

3.2 Variables

3.2.1 Dependent Variable: Career Success

There are some minor differences in the career stages on the academic ladder between the higher education systems of Germany and the Netherlands with respect to the types of academic positions that are available. In Germany three alternative types of early career positions are available after receiving the doctoral degree: either postdoc positions or a qualification position to become a full professor, i.e. positions as a *Wissenschaftlicher Mitarbeiter* or *Akademischer Rat auf Zeit* that are both temporary contracts (while the maximum duration depends jurisdictions). This is similar to the Dutch system that distinguishes two types of early career positions, i.e. postdocs (*Onderzoeker*) or lecturer / assistant professor (*Universitair docent 2*), the latter often consisting of a four to five year tenure-track. Subsequently, the Dutch system offers the first advancement option to an assistant professorship, although for some this may theoretically even constitute the first career position after obtaining the doctoral degree, while the German system offers the equivalent position of a junior professor (representing the new qualification system).

Thereafter, individual academics may be promoted to an associate professorship (Germany: *W-2 Professor*; Netherlands: *Universitair Hoofddocent*) and finally some may become full professors (Germany: *W-3 Professor*; Netherlands: *Hoogleraar*). We present the differences between the two systems and organize the different positions along our typology of career stages in Figure 1 (see Section 2.1).

In order to capture career success we calculated a variable based on the responses to two questions. First, a categorical variable allowed respondents to indicate their current career stage choosing from: postdoc, assistant professor, associate professor, full professor or other. Second, they indicated the year of their PhD defence so that we could calculate the time elapsed since academics obtained their PhD degrees. The variable capturing career success was calculated using both the current career stage as well as the time elapsed since obtainment of the PhD degree. To accurately represents the different academic career structures in The Netherlands and Germany (Figure 1) we considered the respondents from the Delft University of Technology reporting an assistant professor position within less than 5 years since the completion of their PhD studies to be in the early career stage, because it is likely that they are formally in a *universitair docent 2* position and have not yet received tenure. Likewise, respondents from the RWTH Aachen University reporting an assistant professor position were reassigned to the early career stage when they were within less than 5 years of their PhD defence, as it is likely that academics with more than 5 years since their PhD completion are in a more senior role (based on prior experience as postdoc or in the private sector).

3.2.2 Independent Variables: Mentor-Mentee Heterogeneity and Research Orientation

Cultural heterogeneity was measured by a dichotomous variable. In line with the existing literature (Stahl et al., 2010), we used (dis)similarity in nationality as a proxy to measure cultural heterogeneity. Accordingly, we asked the respondents the following question: "Did the main supervisor of your PhD thesis have the same nationality as you?" A positive answer to this question implies cultural homogeneity, while a negative answer to this question implies cultural heterogeneity. We operationalized the variable as one (1) if there was cultural heterogeneity between PhD student and supervisor and zero (0) for cultural homogeneity.

Disciplinary heterogeneity was also measured by a dichotomous variable. We asked the respondents: “Did the main supervisor of your PhD thesis have the same professional education as you?” A positive answer to this question implies disciplinary homogeneity, while a negative answer to this question implies disciplinary heterogeneity. The variable takes on the value of one (1) if there was disciplinary heterogeneity between PhD student and supervisor, while zero (0) indicates disciplinary homogeneity.

In order to measure *research orientation* we asked respondents to position themselves in Stokes’ (1997) quadrant model (see Figure 2). Specifically, we asked respondents to indicate how their activities were distributed over three quadrants (Bohr, Pasteur, and Edison)[2] in the last five years. In order to do so respondents assigned a percentage to each category adding up to 100%. This approach yields a detailed picture of the academic’s research orientation. In our analyses, we standardize the scores for research orientation with the standard deviation. This results in a mean research orientation of zero (0) and standard deviation of one (1). By doing so, we avoid misrepresentation of research orientations that would occur when using cut-off points in a simple dichotomous distinction of the research orientations. Consequently, interpretations capture as to how a one-unit increase in a particular research orientation (relative to the scores of others in this dimension) affects career success in academia.

[2] We illustrated the differences between the categories of Bohr-type, Pasteur-type and Edison-type research in the web-based survey. Moreover, earlier interviews carried out about related research questions indicated that academics at these two universities are either aware of this categorization or easily included it in their own perception of their research orientation.

3.2.3 Control variables

The richness of our dataset allows us to use a wide range of control variables. Considering the differences between the structure of academic careers in Germany and the Netherlands (see Section 3.1), we control for the location using a dummy variable that takes on the value of one (1) if respondents work at the Delft University of Technology and zero (0) if respondents work at RWTH Aachen University. Furthermore, female academics may experience different opportunities to build a research career. Hence, we include a variable that takes on the value of one (1) if the respondent is male and zero (0) for females. Additionally, given the importance of family influence in academic career choices (Lindholm, 2004) we control for the effects of parental experience in the private sector. Likewise, experience in industry jobs (Dietz & Bozeman, 2005) may influence whether or not individuals progress in academic careers. Therefore, we control for private sector experience of the respondents in the past five years. Finally, as academic and commercial output strongly influence academic career success, we include the number of peer-reviewed publications and the number of other scientific publications as well as the number of product and process innovations[3] reported by respondents for the time period 2007-2011 as control variables.

3.3 Two Models

In order to develop a comprehensive understanding, we focus on all transitions individually, but also allow for unequal transitions and truncations at all levels. As we have laid out before, leapfrogging might be observed for transitions to either associate or full professorships. That is, theoretically there is linearity but in practice we may also observe individuals moving directly to full professor positions. For this reason we use two types of models. First, we estimate a multinomial model that makes no implicit assumption about the

[3] We did not include patents for measuring commercial output as academics patent as an exception rather than as a rule (Agrawal and Henderson, 2002). The findings in our survey support these former findings as 222 respondents report zero patents in the five year period.

order of outcomes (Wulff, 2015). The multinomial model therefore accounts for the possibility that academics may leap particular career stages (accounting for a more protean career path). In addition to interpreting the signs of the estimation coefficients in the multinomial logit model, we plotted the predicted probabilities for being in each career stage for different degrees of disciplinary and cultural heterogeneity as well as different relative degrees of each research orientation. This aids the interpretation of the results of the multinomial logit model, as merely interpreting the sign of estimated coefficients may lead to misinterpretation of the direction of the effect (Wulff, 2015).

Second, we complement the results from the multinomial model with the use of a sequential logit model (Buis, 2011; 2015). The starting levels in academic careers also do not necessarily represent a natural ordering, as some may start as assistant professor while others start as postdoc. Subsequently, moving up the ladder is possible from both starting positions. In addition, we may see sample truncations at various levels, as those that have not made the initial transition are not available for subsequent career advancements. Hence, apart from the ordering in outcomes, we need to attenuate differences in transition probabilities across career stages. The sequential logit model decomposes the overall transition effect to become a full professor (the highest attainable career outcome) and models the likelihood of transitions for each consecutive career stage (mirroring a hierarchical academic career path). In sum, individual effects for the explanatory variables on passing the interdependent transitions that precede the final outcome can accumulate over transitions (and may do so at varying degrees). This is important, as transition effects might vary for different career stages. In particular, while one might, for example, not find effects for the likelihood of passing the initial transition, e.g. a transition from postdoc to assistant professor, an explanatory variable may still show effects for the accumulation of transitions, e.g. for the subsequent trajectory from associate to full professor. Hence, later transitions may be affected by earlier transitions (and non-transitions). The sequential logit model accounts for these variations and complements the multinomial results reported. We therefore believe our modelling approach to be prudent. In Section 4 we compare and analyse the results derived from both types of models together.

4. Results

4.1 Descriptive Statistics

Table 1 presents the descriptive statistics and bivariate correlations. As to the personal characteristics, respondents are by and large male (72%), twenty percent of the respondents have private sector experience and about one third report entrepreneurial/self-employment experience within the family. On average respondents have about ten peer reviewed publications, five other scientific publications, and about two process/product innovations for the period from 2007 until 2011. Academics place themselves on average quite evenly across the research orientation spectrum (33 percent Bohr-type, 36 percent Pasteur-type, and 31 percent Edison-type), yet standard deviations vary (32 percent for Bohr-type, 24 percent for Pasteur-type, and 25 percent for Edison-type). Consequently, Figure 3a depicts that research orientation is over-dispersed at the very low and high of each distribution, resulting in high (and unevenly distributed) variances. We therefore account for the differences in dispersion of each category by standardizing the percentage answers with the standard deviation (Figure 3b). This results in a mean research orientation of zero and standard deviation of one. The mean values depicted are relative to all other research orientations using standardized (normalized) research orientation measures. Subsequently, the coefficient estimate of these variables indicates in which way a one-unit increase in Bohr-/Edison-/Pasteur-type research orientation, respectively, affects career success. All interpretations are made relative to how other academics perceive themselves.

In our sample we included 24 full professors, 6 associate professors, 5 assistant professors and 74 post-docs for RWTH Aachen University as well as 21 full professors, 22 associate professors, 16 assistant professors and 80 post-docs for Delft University of Technology.

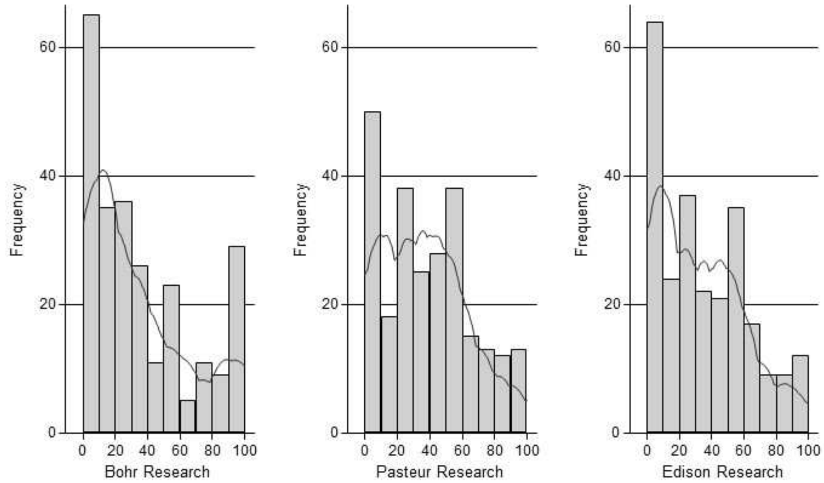

Figure 3a *- Unadjusted Distribution of Research Orientation Measure*

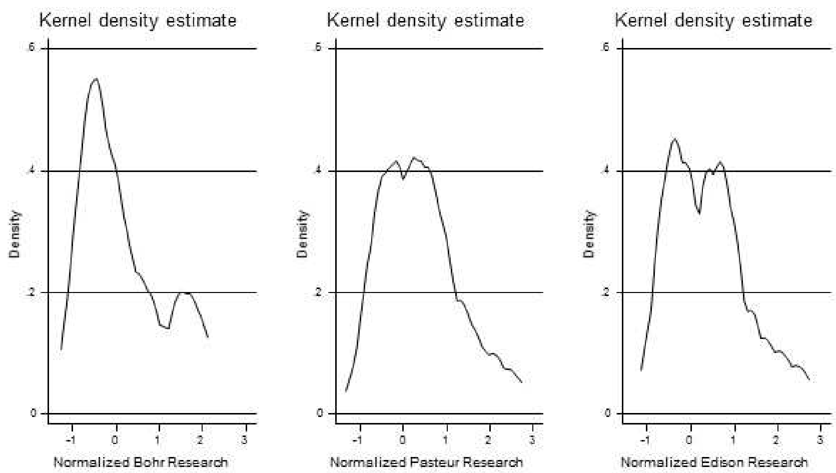

Figure 3b *- Normalized Distribution of Research Orientation Measure*

Table 1: *Summary Statistics and Correlation Matrix*

Variables	**Mean**	**SD**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1 Career success	1.85	1.20												
2 Disciplinary heterogeneity	0.33	0.47	-0.133*											
3 Cultural heterogeneity	0.32	0.47	-0.193*	0.063										
4 Bohr-type	-0.10	0.95	-0.127*	-0.150*	-0.009									
5 Edison-type	0.05	1.00	0.014	0.045	0.015	-0.573*								
6 Pasteur-type	0.08	1.03	0.127*	0.126*	-0.006	-0.580*	-0.303*							
7 Location	1.56	0.50	-0.020	0.134*	0.182*	-0.274*	0.073	0.239*						
8 Gender	0.72	0.45	0.273*	-0.059	0.002	-0.197*	0.093	0.123	0.187*					
9 Parental private sector experience	0.29	0.45	-0.003	0.069	-0.065	-0.083	0.170*	-0.051	0.058	0.064				
10 Private sector experience	0.18	0.39	0.092	0.015	-0.017	-0.172*	0.267*	-0.034	0.028	-0.006	0.125*			
11 Innovation	2.13	5.27	0.131*	-0.004	-0.114	-0.182*	0.183*	0.023	-0.039	0.136*	0.021	0.109		
12 Peer-reviewed publications	10.48	14.20	0.417*	-0.105	-0.106	-0.025	-0.043	0.062	-0.004	0.205*	-0.092	0.031	0.076	
13 Other scientific publications	5.31	10.90	0.282*	-0.096	-0.109	-0.132*	0.062	0.091	-0.097	0.083	0.042	0.137*	0.253*	0.301*

Summary statistics and correlation matrix are based on 248 observations. *$p < .05$

4.2 Disciplinary and Cultural Mentor-Mentee Heterogeneity Affecting Academic Career Success

We report the results of the multinomial logit model for our hypotheses on mentor-mentee heterogeneity (H1, H2 and H3) in Table 2 and the results concerning the marginal effects as suggested in Hoetker (2007) in Table 3. In addition, we depict the effects graphically, in Figure 4 (following Wiersema and Bowen, 2009). Furthermore, to assess the robustness of our findings in light of the underlying distributional assumption of nested transitions, we report the coefficient estimates from a sequential logit model in Table 4 (as suggested by Buis, 2015).

Our results show that the relationship between mentor-mentee heterogeneity and career success is multifaceted. While we can find partial support for H1 on a negative direct effect of cultural mentor-mentee heterogeneity on career success, we cannot find any support for H2, i.e. find a direct effect of disciplinary mentor-mentee heterogeneity on career success. However, we do find substantial support for H3, which suggests that the effect of mentor-mentee heterogeneity varies across career transitions.

With regard to H1, we find a negative and significant effect of cultural heterogeneity only for the final transition to a full professorship position (ß=-1.156, p<0.05). Because it proves to be difficult to interpret output from non-linear models (Hoetker, 2007) we also report the marginal effects in Table 3. The marginal effects corroborate the effects for cultural heterogeneity (ß=-0.1106, p<0.05). Transitions to academic positions involve a sequence of choices, in which those that did not transition early cannot possibly transition later. Using a sequential logit model in cases with interdependent transitions allows us to estimate the relationship between explanatory variables and the odds of passing each transition (Buis, 2015). The individual effect of an explanatory variable on the final outcome (becoming a full professor) is then a weighted sum of the effects on passing transitions (see Table 4).

Table 2: *Multinomial Logit Regression*

	Model A			Model B		
Variables	(1) Assistant Professor	(2) Associate Professor	(3) Full Professor	(4) Assistant Professor	(5) Associate Professor	(6) Full Professor
Location	0.926 (0.576)	1.370** (0.540)	-0.168 (0.412)	1.088* (0.574)	1.406*** (0.535)	-0.107 (0.412)
Gender	0.459 (0.627)	0.291 (0.567)	1.830** (0.716)	0.465 (0.626)	0.345 (0.570)	1.915*** (0.718)
Parental private sector experience	0.103 (0.534)	-0.008 (0.495)	0.169 (0.432)	0.078 (0.535)	-0.076 (0.499)	0.065 (0.435)
Private sector experience	1.06* (0.581)	0.838 (0.539)	0.336 (0.523)	1.062* (0.581)	0.837 (0.543)	0.339 (0.531)
Innovation	-0.032 (0.074)	0.025 (0.035)	-0.005 (0.037)	-0.036 (0.073)	0.017 (0.035)	-0.015 (0.037)
Peer-reviewed publications	0.090*** (0.023)	0.086*** (0.021)	0.090*** (0.020)	0.089*** (0.022)	0.086*** (0.021)	0.089*** (0.020)
Other scientific publications	-0.008 (0.046)	0.046* (0.026)	0.057** (0.024)	-0.005 (0.045)	0.046* (0.026)	0.057** (0.024)
Disciplinary heterogeneity	**0.209 (0.510)**	**-0.460 (0.493)**	**-0.534 (0.462)**			
Cultural heterogeneity				**-0.390 (0.526)**	**-0.696 (0.508)**	**-1.156** (0.496)**
Constant	-4.936*** (1.096)	-5.316*** (1.058)	-3.680*** (0.903)	-4.970*** (1.113)	-5.283*** (1.053)	-3.626*** (0.900)
R^2 Nagelkerke	0.362	0.362	0.362	0.375	0.375	0.375
Akaike Information Criterion	1.956	1.956	1.956	1.939	1.939	1.939
χ^2 Correctly classified	95.09	95.09	95.09	99.35	99.35	99.35
N	248	248	248	248	248	248
Change in χ^2 base model	2.518*	2.518*	2.518*	6.772*	6.772*	6.772*

* p<0.1, ** p<.05, *** p<.01; the table reports coefficients from a multinomial logit model using maximum likelihood. Standard Errors are reported in parentheses.

The results for cultural heterogeneity derived from the multinomial model suggest a negative effect of heterogeneity on the likelihood of eventually becoming a full professor. The sequential logit model highlights that academics who are culturally heterogeneous from their PhD supervisors are less likely to make it to an assistant professorship in the first place (ß=-0.788, p<0.05). This means that cultural mentor-mentee heterogeneity already hampers academics' careers at an early stage.

Table 3: *Marginal Effects from Multinomial Logit Regression*

	Disciplinary heterogeneity	**Cultural heterogeneity**
Marginal effect on the probability of	Average Marginal Effect (AME)	Average Marginal Effect (AME)
Assistant Professor	0.0302 (0.0355)	0.0006 (0.0362)
Associate Professor	-0.0311 (0.0433)	-0.0281 (0.0442)
Full Professor	-0.0551 (0.0521)	-0.1106** (0.0548)

* p<0.1, ** p<.05, *** p<.01; coefficients in column correspond to the marginal effects for the independent variables calculated at the mean levels of the remaining variables. Standard errors are shown in parentheses.

Table 4: *Coefficient Estimate from Sequential Logit Model*

	Sequential Logit Model		
Variables	(1) Assistant Professor	(2) Associate Professor	(3) Full Professor
Disciplinary heterogeneity	**-0.320** **(0.318)**	**-0.948*** **(0.578)**	**0.019** **(0.612)**
Cultural heterogeneity	**-0.788**** **(0.379)**	**-0.502** **(0.619)**	**-0.506** **(0.632)**

* p<0.1, ** p<.05, *** p<.01; the table reports coefficients from a sequential logit model following Buis (2015). Robust standard errors are reported in parentheses. The model reporting has been abbreviated to preserve lucidity. The full model is available upon request from the authors.

With respect to H2, we find that for disciplinary heterogeneity none of the coefficients is significantly different from zero for individual marginal transitions in the multinomial logit model. However, the results of the sequential logit model in Table 4 reveal a negative effect of disciplinary heterogeneity on the likelihood of becoming a full professor. While those academics differing from their PhD supervisor in their disciplinary profile have similar chances of getting a position as an assistant professor, they have less chances of obtaining associate professor positions (ß=-0.948, p<0.1). Subsequently, academics that manage to transition to the associate level nonetheless are equally likely to reach the full professor level. However, taking the two previous transitions together, only few academics exhibiting disciplinary heterogeneity with their PhD supervisors will actually become full professors. Instead, most of them are likely to be stuck in assistant professor positions.

In order to better illustrate our results, we graphically depict the effect of heterogeneity by reporting the predicted probabilities for disciplinary and cultural heterogeneity in Figure 4. Hoetker (2007) and Wiersema and Bowen (2009) emphasize that non-linear models likely benefit from such graphical representations of individual effect sizes. Figure 4 reports similar effects as the individual marginal effects and it confirms that probabilities are strongly decreasing for the first and last transition. The negative effect on the final outcome reported in Tables 2 and 3 is mainly driven by two groups of academics. The first group consists of academics who are culturally different from their PhD supervisors and unable to make the first transition to assistant professorship positions. The second group consists of academics differing from their PhD supervisors in disciplinary terms and unable to make the transition to associate professorship positions. Consequently, academics from both groups are not eligible for any subsequent transition to a full professorship thereafter. There are exceptional culturally and disciplinary heterogeneous academics who do manage to get to the next level early on and their subsequent chances to obtain full professorship positions are similar.

Hence, cultural and disciplinary mentor-mentee heterogeneity hampers academics in early and mid-career stages.

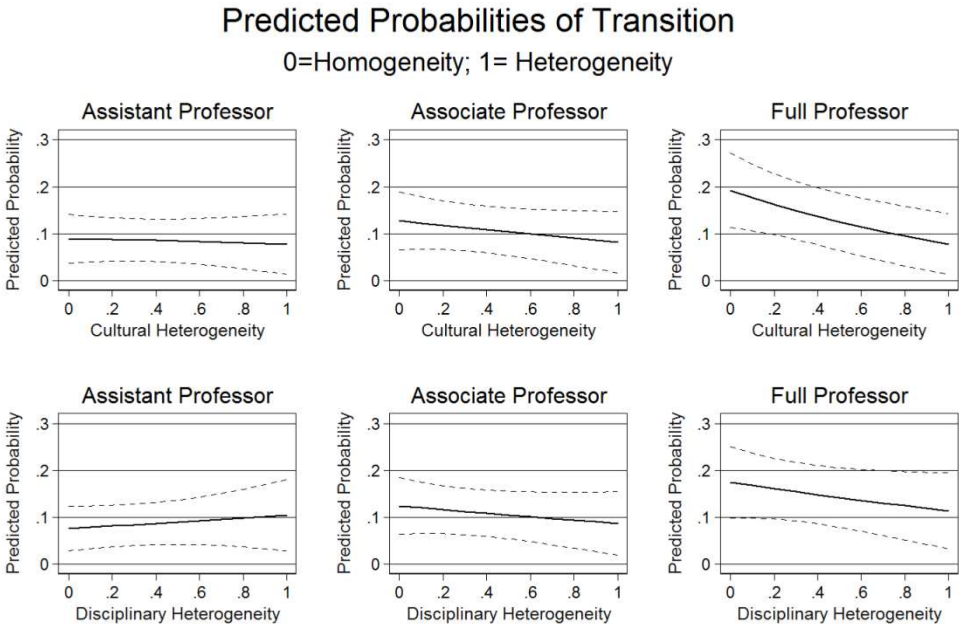

Figure 4 *- Predicted Probabilities of Career Transition for Disciplinary and Cultural Heterogeneity*

With respect to our control variables, we find that the universities differ slightly in transition patterns, such that the Delft University of Technology has more respondents making the transition to the associate professor level in particular. The coefficient is positive and significant (ß=1.406, p<0.01). Delft University of Technology also has more respondents making the transition from the early career stage into assistant professorships (ß=1.088, p<0.1). Furthermore, for the control variable Gender we find that career success of males and females does not differ significantly in early career stages. However, male academics have much higher probabilities to transition into full professorship positions (ß=1.915, p<0.01).

Private sector experience has a positive and significant effect on making the transition to the assistant professor level (ß=1.062, $p<0.1$). We do not find significant differences between the career stages in terms of commercial output. At the same time, output in terms of peer-reviewed publications increases the likelihood of transition across all stages. The coefficient is positive and significant for the transition to assistant professor (ß=0.089, $p<0.01$), associate professor (ß=0.086, $p<0.01$), and full professor (ß=0.089, $p<0.01$). In contrast, other scientific publications are more important in later career transitions. That is, we find a positive and significant effect of other scientific publications on transitioning to associate (ß=0.046, $p<0.1$) and full professorships (ß=0.57, $p<0.05$).

4.3 Impact of Research Orientations on Academic Career Success

We test our hypothesis about the effect of heterogeneity emerging from research orientation on career success (H4) using the same two models as in Section 4.2. Once again, we provide the results from the multinomial logit model (Table 5), the marginal effects (Table 6), the sequential logit model serving as our robustness assessment (Table 7), and the corresponding graphical depiction of predicted probabilities (Figure 5).

Hypothesis 4 stated that Pasteur-type academics are most likely to obtain full professorships, while expecting that Edison-type academics had intermediate chances of career success, and posing that Bohr-type academics had the least chances of attaining career success. This hypothesis is supported by the results. In particular, Edison-type academics are more likely to transition to associate professorships (in comparison with Bohr-type and Pasteur-type academics), while Pasteur-type academics are more likely to finally transition to full professor positions. Heterogeneity in terms of ambidextrously combining industry and

Table 5: *Multinomial Logit Regression*

Variables	Model A (1) Assistant Professor	(2) Associate Professor	(3) Full Professor	Model B (4) Assistant Professor	(5) Associate Professor	(6) Full Professor	Model C (7) Assistant Professor	(8) Associate Professor	(9) Full Professor
Disciplinary heterogeneity	0.222 (0.516)	-0.515 (0.498)	-0.554 (0.472)	0.194 (0.514)	-0.466 (0.499)	-0.530 (0.473)	0.262 (0.522)	-0.422 (0.501)	-0.563 (0.476)
Cultural heterogeneity	-0.391 (0.528)	-0.695 (0.509)	-1.155** (0.499)	-0.429 (0.531)	-0.769 (0.515)	-1.080** (0.495)	-0.393 (0.531)	-0.725 (0.510)	-1.075** (0.500)
Location	1.051* (0.597)	1.392** (0.558)	-0.051 (0.437)	1.034* (0.589)	1.511*** (0.550)	-0.003 (0.427)	01.187** (0.603)	1.560*** (0.558)	-0.180 (0.446)
Gender	0.497 (0.634)	0.261 (0.576)	1.849** (0.725)	0.454 (0.633)	0.238 (0.573)	1.960*** (0.736)	0.538 (0.632)	0.355 (0.571)	1.784** (0.727)
Parental private sector experience	0.035 (0.542)	-0.040 (0.500)	0.091 (0.440)	-0.011 (0.546)	-0.113 (0.504)	0.135 (0.448)	-0.072 (0.554)	-0.085 (0.505)	0.118 (0.448)
Private sector experience	1.094* (0.595)	0.772 (0.546)	0.285 (0.539)	0.914 (0.602)	0.649 (0.559)	0.469 (0.557)	1.055* (0.592)	0.815 (0.549)	0.368 (0.545)
Innovation	-0.033 (0.072)	0.014 (0.035)	-0.015 (0.037)	-0.051 (0.083)	0.008 (0.037)	-0.007 (0.036)	-0.036 (0.073)	0.014 (0.036)	-0.015 (0.037)
Peer-reviewed publications	0.090*** (0.023)	0.086*** (0.021)	0.090*** (0.020)	0.091*** (0.023)	0.087*** (0.021)	0.088*** (0.020)	0.090*** (0.023)	0.085*** (0.021)	0.088*** (0.020)
Other scientific publications	-0.007 (0.046)	0.042 (0.026)	0.054** (0.024)	-0.008 (0.046)	0.047* (0.026)	0.059** (0.025)	-0.004 (0.045)	0.048* (0.026)	0.055** (0.025)
Bohr-type	**0.081 (0.289)**	**-0.272 (0.297)**	**-0.140 (0.247)**						
Edison-type				**0.282 (0.255)**	**0.369 (0.224)**	**-0.264 (0.227)**			
Pasteur-type							**-0.381 (0.278)**	**-0.156 (0.229)**	**0.326 (0.205)**
Constant	-5.009*** (1.145)	-5.073*** (1.089)	-3.495*** (0.941)	-4.898*** (1.115)	-5.324*** (1.068)	-3.771*** (0.929)	-5.274*** (1.131)	-5.384*** (1.070)	-3.335*** (0.936)
R^2 Nagelkerke	0.386	0.386	0.386	0.403	0.403	0.403	0.403	0.403	0.403
Akaike Information Criterion	1.972	1.972	1.972	1.950	1.950	1.950	1.949	1.949	1.949
χ^2 Correctly classified	103.10	103.10	103.10	108.55	108.55	108.55	108.77	108.77	108.77
N	248	248	248	248	248	248	248	248	248
Change in χ^2 base model	1.279	1.279	1.279	6.725*	6.725*	6.725*	6.942*	6.942*	6.942*

* p<0.1, ** p<.05, *** p<.01; the table reports coefficients from a multinomial logit model using maximum likelihood. Standard Errors are reported in parentheses.

academia (Pasteur-type research) is generally rewarded with full professorships, while a pure focus on industry application is chosen over pure basic research for mid-career transitions.

Correspondingly, Bohr-type academics do not differ significantly in terms of their transition probabilities across successive stages. None of the coefficients reported is significant, neither for the coefficient estimates in the multinomial or sequential logit models nor for the average marginal effects.

While the coefficient estimates for Edison-type academics report insignificant effects for all transitions, the average marginal effects for the transitions to associate professorships and to full professorships are significant (Table 6). In particular, we observe that Edison-type academics are more likely to transition to associate professorship positions (ß=0.0359, $p<0.1$), but less likely than others to consequently obtain full professorships (ß=-0.0439, $p<0.1$). These effects are also evident graphically, when depicting the predicted probabilities in Figure 5. While for mid-career stages we find that Edison-type academics are more likely to transition, they do not seem to make the transition to full professorships in the end. This effect is supported by the decomposition results from the sequential logit model (Table 7). Decomposing the probability to become a full professor into the tree sub-transitions we find that the main effect stems from the non-transition in the final stage (ß=-0.909, $p<0.01$). Individually, we find positive transitions based on the individual marginal effects, yet, cumulatively speaking, Edison-type academics do not make the transition to a full professorship. They may be likely to arrive at the associate professor level, but they have considerably lower chances to transition to a full professorship conditional on making it to the penultimate stage.

Table 6: *Marginal Effects from Multinomial Logit Regression*

	Bohr-type	**Edison-type**	**Pasteur-type**
Marginal effect on the probability of	Average Marginal Effect (AME)	Average Marginal Effect (AME)	Average Marginal Effect (AME)
Assistant Professor	0.0117 (0.0205)	0.0196 (0.0175)	-0.0300 (0.0191)
Associate Professor	-0.0222 (0.0264)	0.0359* (0.0188)	-0.0173 (0.0191)
Full Professor	-0.0103 (0.0277)	-0.0439* (0.0239)	0.0463** (0.0209)

* p<0.1, ** p<.05, *** p<.01; coefficients in column correspond to the marginal effects for the independent variables calculated at the mean levels of the remaining variables. Standard errors are shown in parentheses.

Table 7: *Coefficient Estimate from Sequential Logit Model*

	Sequential Logit Model		
	(1) Assistant Professor	(2) Associate Professor	(3) Full Professor
Variables			
Bohr-type	**-0.102** **(0.181)**	**-0.249** **(0.321)**	**0.342** **(0.474)**
Edison-type	**0.083** **(0.168)**	**-0.273** **(0.264)**	**-0.909***** **(0.314)**
Pasteur-type	**0.003** **(0.153)**	**0.535*** **(0.273)**	**0.604**** **(0.303)**

* p<0.1, ** p<.05, *** p<.01; the table reports coefficients from a sequential logit model following Buis (2015). Robust standard errors are reported in parentheses. The model reporting has been abbreviated to preserve lucidity. The full model is available upon request from the authors.

Similarly, although Table 5 reports no significant differences across the transitions for Pasteur-type academics, the average marginal effects (Table 6) report a positive and significant effect for Pasteur-type academics transitioning to full professor positions (ß=0.0463, p<0.05). The same picture emerges when inspecting the results graphically in Figure 5, in terms of the predicted probabilities in each transition stage. Decomposing the overall effect to transition to a full professorship, the sequential logit model reports that when cumulating the individual effects, Pasteur-type academics do not differ much in their probabilities when being considered for an assistant professorship, yet they are increasingly likely to be promoted to associate professorships (ß=0.535, p<0.1) and consequently full professorships (ß=0.604, p<0.05). In other words, the transition to the associate professor level carries most weight when it comes to achieving the final outcome (i.e., obtaining a full professorship) and Pasteur-type researchers are at an advantage in securing such positions. Therefore, they are also most likely to reach the full professor level.

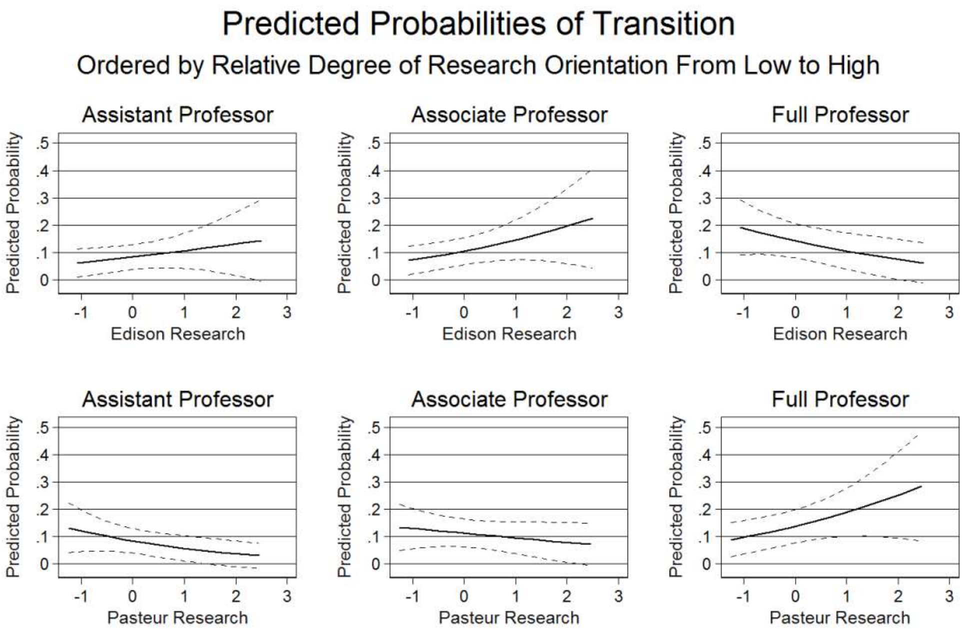

Figure 5 *- Predicted Probabilities of Career Transition for Edison-type and Pasteur-type Research Orientations*

5. Discussion

Academics trying to climb the career ladder benefit from cultural and disciplinary homogeneity with their supervisors and from heterogeneity in their own research orientation. It is under these circumstances that academics are most likely to attain career success.

Mentor-mentee heterogeneity works in early career stages but does not improve academics' career prospects in the long run. Early in their career academics with culturally and disciplinary heterogeneous PhD supervisors successfully make the initial step up the academic ladder. Possibly, mentor-mentee heterogeneity inspires novel academic output – as would be expected considering creativity and problem-solving benefits suggested by information-processing theory (Watson, Kumar, and Michaelsen, 1993) – and thereby contributes to the researcher's attractiveness as a job candidate. However, mentor-mentee heterogeneity obstructs academics when trying to secure tenured positions in academia. We suggest that two mechanisms explain these findings. First, academics with homogenous mentors have more opportunities to build their careers on the knowledge base and the networks of their mentors. Second, mentors particularly support mentees similar to themselves, because of processes of similarity-attraction and social categorization (Stahl et al., 2010; Tajfel, 1982; Williams and O'Reilly, 1998). Taken together, this gives academics with homogeneous mentors an advantage over others when it comes to building their academic careers. While our findings are in line with some adjacent evidence, for example, on international mobility and career success (e.g. Cruz-Castro and Sanz-Menéndez, 2010), we are uniquely able to decompose the effect of mentor-mentee heterogeneity for subsequent career transitions by using sequential logit models.

Heterogeneity emerging from research orientation has a multifaceted effect on academics' career success. Academics mainly focusing on Bohr-type research, i.e. pure basic research, deal with the least heterogeneity in their goals, knowledge and partners. They are also least successful in climbing the academic ladder. Academics mainly focusing on Edison-type research, i.e. pure applied research, deal with intermediate levels of heterogeneity. They may thrive in mid-career stages, but are also likely to have reached the limit of their career success at the associate professor level. Academics focusing on Pasteur-type research, i.e. use-inspired research, deal with most heterogeneity and have the best chances of obtaining full professorships. We suggest the considerable career success advantages of academics with a Pasteur-type research orientation are rooted in the changing role of universities and the increasing pressure on academics to contribute to economic and societal goals. Presumably, Pasteur-type academics are more successful in securing funds for their research, as eligibility for funds depends increasingly on societal relevance and impact (e.g. Bridle, Vrieling, Cardillo, Araya, and Hinojosa, 2013), which enables them to secure their academic positions. To some degree, this may also hold for Edison-type academics. Similarly, other scholars already observed that indications of Pasteur-type and Edison-type research orientation (e.g. patent output) increasingly inform hiring decisions for early career academics in some fields of research (Hessels and Van Lente, 2011). Hence, we gather that the higher education system facilitates careers that fit the changing nature of academia, but it has not necessarily sacrificed its basic research by doing so. The most successful academics in terms of climbing the career ladder, i.e. those focusing on Pasteur-type research, still contribute substantially to the knowledge base of their field, suggesting that their academic freedom faces less challenge than suggested by some (e.g. Davies, 2015).

Our findings hold some essential practical implications for policy makers, university management and academics themselves. One may infer that policy promoting interdisciplinary research on the PhD level may come at a cost, as mentor-mentee heterogeneity in PhD projects limits the mentee’s chances of career success. On the other hand, one needs to consider that the career advantage observed for those mentored by homogenous supervisors may also be cause for concern in light of ‘academic inbreeding’ (e.g. Horta, 2013). Generally, academic inbreeding is argued to be detrimental for scientific productivity and the advancement of science. Thus, policy makers and university management may consider whether it is desirable to reward mentor-mentee homogeneity in the first place. Furthermore, our findings regarding heterogeneity in research orientation imply that successful academics may need to change their orientation during the course of their career. Specifically, academics can choose to focus on Edison-type research until their mid-career stages and shift to Pasteur-type efforts in later stages or develop a Pasteur-type research orientation from the start. Both strategies would prevent them from getting stuck in mid-career stages or from being shaken out of academia entirely. University managers may employ specific incentives and performance measures to promote either mid-career reorientation or the development of Pasteur-type research orientations from the early career stage onwards.

Our study comes with two limitations. First, we should recognize that our findings can be generalized to other European universities of technology, but may not necessarily hold for universities with a broader disciplinary focus. Particularly with regard to research orientation, the orientation of universities of technology in Europe traditionally integrates fundamental interests with applied interests. Various typical disciplines at this type of university are simply more application-oriented by default, such as engineering, life and health sciences, and industrial design. Future research may explore whether Pasteur-type academics are also more likely to realize career success at other types of universities. Second, for our measures we used self-reports by academics so that respondents might over- or underestimate figures or not remember them correctly. In related interviews with academics at the two universities we experienced that academics are aware that they contribute to a research project and try to be as accurate as possible. Despite these two limitations and within the boundaries thereof, our data provide detailed insights into heterogeneity affecting academic careers and allows us to control for other career relevant characteristics.

6. Conclusion

Academics climbing the career ladder in an increasingly protean environment inspired us to study whether more heterogeneity or more homogeneity emerging from either the mentor-mentee relationship or the choice of research orientation positively influences academics' career success. Our results suggest that academics at European universities of technology are most likely to attain career success when they exhibit cultural and disciplinary homogeneity with their PhD supervisors. Additionally, they are particularly successful when they are able to deal with heterogeneity in their research. Academics have the best chances of climbing the academic ladder all the way to the top when they succeed at bridging between the quest for fundamental understanding and socio-economically relevant applications of their research, i.e. when they do Pasteur-type research.

At least two fruitful avenues for future research arise from our findings. First, our findings regarding the effect of mentor-mentee heterogeneity on career success raise questions as to the specific capabilities or characteristics that successful academics derive from their homogenous mentors. Alternatively, studies may also explore whether mentees mentored by heterogeneous supervisors turn out to lack specific capabilities or characteristics. Second, while we purposefully focus on disciplinary heterogeneity and cultural heterogeneity, other sources of mentor-mentee heterogeneity may also affect career success (e.g. heterogeneity in gender, social background, etc.).

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